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Development of Allexium Pteridophyta, Bryophyta, and Spermatophyta to Develop Student Identification Skills

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Abstract

The limitations of direct observation-based learning media often hinder the development of prospective teachers' identification skills. This study aims to develop students' identification skills in Allexium Pteridophyta, Bryophyta, and Spermatophyta. This developmental research uses the Borg and Gall research model. Data collection uses observation and interview sheets, questionnaires, and post-test questions on students' identification skills. The sampling technique was convenience sampling, with a population of 56 prospective teachers. The study found that the Allexium media was declared valid by experts using STEM improvements as a reference, and the media was equipped with original plant parts. The results of the practicality test based on responses from lecturers and students showed that Allexium was rated practical, with an average score of 90%. The results of the trial of use using the t-test showed that the Sig. (2 tailed) value < α (0.05), then Ha was accepted. This shows that the use of real plant parts in Allexium media is effective for students' identification skills. In further research, it is expected that the addition of plant collections and analysis of the application of question cards can be carried out so that its effectiveness in supporting the completeness of Allexium can be determined.

Keywords: *Allexium, Herbarium, Plant Identification, Learning Media, Identification Skills*.

Pengembangan Allexium Pteridophyta, Bryophyta, dan Spermatophyta untuk Mengembangkan Keterampilan Identifikasi Mahasiswa

Abstrak

Keterbatasan media pembelajaran berbasis observasi langsung seringkali menghambat perkembangan keterampilan identifikasi calon guru. Penelitian ini bertujuan untuk mengembangkan keterampilan identifikasi siswa pada tumbuhan Allexium Pteridophyta, Bryophyta, dan Spermatophyta. Penelitian pengembangan ini menggunakan model penelitian Borg dan Gall. Pengumpulan data menggunakan instrumen lembar observasi dan wawancara, lembar angket, serta soal *post-test* keterampilan identifikasi mahasiswa. Teknik pengambilan sampel adalah

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convenience sampling, dengan populasi sejumlah 56 mahasiswa. Penelitian ini menemukan bahwa media Allexium dinyatakan valid oleh para ahli dengan menggunakan perbaikan STEM sebagai referensi, dan media tersebut dilengkapi dengan bagian tanaman asli. Hasil uji praktikalitas berdasarkan tanggapan dosen dan mahasiswa menunjukkan bahwa Allexium dinilai praktis dengan nilai rata-rata 90%. Hasil uji coba pemakaian menggunakan uji-t yang menunjukkan bahwa nilai Sig.(2 tailed) < α (0,05), maka Ha diterima. Hal ini menunjukkan penggunaan real bagian tumbuhan dalam media Allexium efektif terhadap keterampilan identifikasi mahasiswa. Pada penelitian selanjutnya diharapkan penambahan koleksi tumbuhan serta analisa penerapan kartu soal sehingga dapat mengetahui keefektifannya dalam mendukung kelengkapan Allexium.

Kata kunci: *Allexium, Herbarium, Identifikasi Tumbuhan, Media Pembelajaran, Keterampilan Identifikasi.*

INTRODUCTION

Basic skills, such as identification skills, play a crucial role in science education at the university level. These skills enable students to observe, analyze, and understand natural phenomena systematically, which is the core of the scientific process (Liunokas, 2020). The identification approach trains students to develop these abilities. Mastering identification skills allows students to enhance their critical and analytical thinking, exploration, communication, and cooperation, which are essential for deeply exploring scientific concepts (Goldin, 2014). Plants are one of the learning objects that require identification skills due to their diverse variations. Identification skills are essential for recognizing plant morphology, utilizing determination keys, and applying mnemonic techniques for effective classification and understanding of plant taxonomy (Kusumawardani et al., 2019). Students tend to classify plants using online resources without engaging in analysis and identification processes (Manzura & Kizi, 2024). Research by Nurmilawati & Rahmawati (2018) indicates that most students rely solely on the internet for plant identification and classification, rather than referring to books. Students' plant identification skills remain very limited (Susilaswati & Sugandi, 2019), thus indicating the need for more intensive practice to develop these skills through direct observation. (Pliushch, 2022).

Preliminary research on the Structure and Function of Plants (SPT) course in the Science Education Program at IAIN Kudus indicates that 24% of students have low

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identification skills, 67% fall into the moderate category, and the remaining students demonstrate high identification skills. In this course, students observe and identify plants in the surrounding environment of IAIN Kudus, which offers limited variation. Enhancing students' plant identification skills can be achieved through the use of learning media such as herbariums (Borosova et al., 2024). A herbarium is a collection of dried plant species accompanied by their identification details (Nurwanti, 2020). It provides a tangible representation of plants, allowing students to observe real plant specimens rather than relying on illustrations or visual images. The use of herbarium media in the learning process can enhance students' academic performance in both emotional and psychomotor aspects (Saadillah et al., 2025). The use of herbarium media in education has been explored in previous studies. Research by Handayani et al., (2016) found that student learning outcomes were significantly better when using herbarium media compared to picture-based media. The implementation of a herbarium book in the Higher Plant Structure course was considered practical, and student learning outcomes were deemed satisfactory (Dikrullah et al., 2018). Further studies indicate that students showed great interest in herbarium books as learning media, as evidenced by their increased motivation. Herbarium books were found to be practical and helpful in studying leaf morphology (Dahlia, 2020). However, these studies also highlight that existing herbarium development is still limited to a few plant specimen types.

Similar findings were observed in the environment of IAIN Kudus. The observations revealed that the available herbarium collection is still limited, with low plant diversity, predominantly consisting of species from the division Pteridophyta. Additionally, the existing herbariums are either mounted on walls or stored merely as collections, rather than being actively utilized as learning media. These limitations prevent the current herbarium from fully meeting the needs of an effective educational resource. The development of a more comprehensive and flexible herbarium is necessary to enhance students' identification skills. In terms of completeness, this development can be achieved by adding various components that support the effectiveness of learning media (Ediyani et al., 2020). The flexible aspect of herbarium media development can be achieved by incorporating detachable sheets, allowing specimens to be observed either collectively or alternately. Additionally, flexible learning media can support active

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learning among students (Sangiuliano et al., 2023).

The novelty of this research lies in the development of Allexium, a flexible and detachable herbarium-based learning medium that integrates identification components, including a determination key, student worksheets (LKM), and question cards. Unlike previous herbarium media that serve merely as collections or static references (Figueira & Lages, 2019; Flannery, 2015), Allexium allows direct interaction with specimens individually or collaboratively, making it explicitly designed to enhance students' plant identification skills. The development of Allexium offers advantages over conventional herbaria because it is comprehensive and flexible, allowing its use both individually and collaboratively in plant identification learning. Allexium contains real preserved plant specimens, LKM, determination keys, and question cards, which help students practice recognizing morphological traits and systematically classifying plants. Previous research has shown that the use of real herbarium media can improve students' learning outcomes and identification skills compared to picture-based media (Dikrullah et al., 2018; Handayani et al., 2016). Furthermore, flexible and interactive learning media have been found to enhance student engagement and observation skills when examining biological objects (Ediyani et al., 2020; Sangiuliano et al., 2023). However, no study has developed a flexible herbarium equipped with identification components like Allexium, particularly in the context of higher education plant structure and function courses. Therefore, the development of Allexium for Pteridophyta, Bryophyta, and Spermatophyta needs to be carried out. This study aims to (1) develop Allexium as an innovative learning medium for plant identification, and (2) analyze the effectiveness of Allexium in improving students' plant identification skills.

RESEARCH METHOD

This study employed Research and Development (R&D) using the Borg and Gall model, which consists of ten stages (Sugiyono, 2010). Due to time and resource constraints, only eight simplified stages were implemented, adjusted to the research context (Hasyim, 2016). The research steps based on the Borg and Gall development model used in this study are illustrated in Figure 1. The research followed eight stages. The first stage, Potential and Problem Identification, involved field analysis to identify

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needs and existing issues. This step guided the selection of suitable learning media (Haq & Raida, 2023). The Data Collection stage gathered supporting information to ensure that the development of Allexium was based on relevant educational needs.

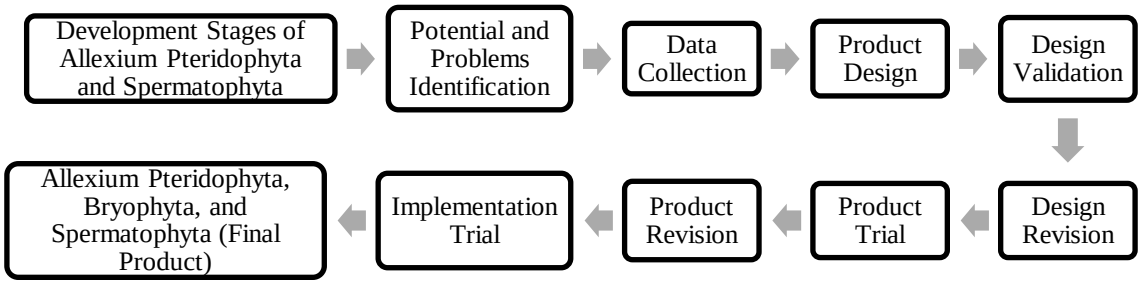

Figure 1. Flowchart of the Allexium Development Research

In the Design stage, Allexium Pteridophyta, Bryophyta, and Spermatophyta were developed as learning tools to enhance students' identification skills. The development was aligned with educational media criteria such as goal alignment, usability, and effectiveness (Sutiah, 2018), and tailored to plant identification skill indicators shown in Table 1. In development research, learning media are considered feasible when they meet three criteria: validity through expert judgment, practicality based on user responses, and effectiveness in improving learning outcomes (Andriyani et al., 2024; Rahmawati et al., 2024).

Table 1. Indicators of Plant Identification Skills (Liunokas, 2020)

No	Aspect	Indicator
1	Identifying plants	• Understanding the characteristics of plants • Recognizing plants based on observed characteristics
2	Identifying similarities and differences among plants	• Identifying similarities and differences based on observed characteristics • Comparing similarities and differences using identification media
3	Formulating plant classification	• Ability to use a determination key • Ability to formulate plant classification using a determination key
4	Determining scientific names	• Ability to formulate the scientific name of a plant based on its classification • Ability to write the scientific name using correct formatting

The Validation stage consisted of expert reviews by one biology lecturer from UIN Walisongo Semarang and two lecturers from IAIN Kudus. Assessments were conducted using a 4-point Likert scale, and results were categorized as very good (85.01–

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100%), good (70.01–85.00%), fair (50.01–70.00%), or poor (below 50%).

The Product Trial involved feedback from three lecturers and 15 Science Education students at IAIN Kudus using a 5-point Likert scale questionnaire. The Implementation Trial tested the effectiveness of Allexium in the Structure and Function of Plants (SPT) course in September 2023. The study adopted a posttest-only control design with third-semester students from the Science Education Department. Class A (28 students) served as the control group, while Class B (28 students) was the experimental group. A post-test on plant identification skills was administered, and data were analyzed using an Independent T-test to determine significant differences between the two groups. A significance value of Sig. (2-tailed) < 0.05 indicated that Allexium effectively improved students' plant identification skills.

RESULTS AND DISCUSSION

The development of Allexium Pteridophyta, Bryophyta, and Spermatophyta to enhance students' identification skills was carried out through eight stages of the Borg and Gall model. Problem identification was conducted through observations in the *SPT* course for Science Education (Tadris IPA) students at IAIN Kudus. The results showed that 24% of students had low identification skills, 67% moderate, and 9% high. This limitation was influenced by the low diversity of plant species around the campus and the minimal herbarium collection, which consisted mainly of Pteridophyta specimens. The existing herbariums were mostly mounted or stored as collections rather than used actively as learning media (Syamsiah et al., 2020)

These findings indicate that students' identification skills are constrained by the lack of varied and functional herbarium media. In plant-based courses like SPT, learning is more effective when students directly observe real plants (Kirchoff et al., 2014; Salamah et al., 2023). Therefore, there is potential to develop a more diverse and functional herbarium to support identification skill development. The next stage was data collection, which involved selecting plant species suitable as herbarium specimens. The researcher collaborated with Tadris IPA students during the herbarium preparation process. This direct involvement encouraged active learning and engagement, enabling students to apply their knowledge and strengthen their understanding of plant structure

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and classification (Adriati & Rooroh, 2024; Saepudin Kanda & Rustini, 2024)

After identifying the problem, the researchers developed Allexium, a detachable herbarium album containing Pteridophyta, Bryophyta, and Spermatophyta specimens as an innovative learning medium to strengthen students' identification skills. The design process followed the Borg & Gall development model and consisted of five stages that illustrated in Figure 2.

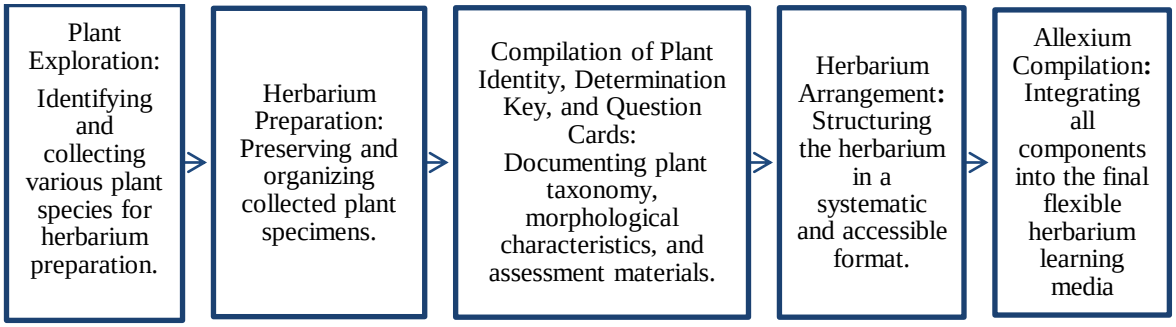

Figure 2. Stages of Allexium Development.

Each herbarium sheet includes specimen identity, taxonomy, morphological characteristics, habitat, and benefits, serving as an identification reference (Ali et al., 2024). The determination key is equipped with illustrative images to support observation and improve recognition accuracy (Kemijan, 2018). During evaluation, specimen descriptions are concealed, requiring students to identify the plants independently using the key and worksheets.

The design validation aimed to determine the feasibility of Allexium as instructional media through two stages of expert review: media validation and content validation. Media validation focused on evaluating the cover design and content layout, while content validation assessed the accuracy, clarity, and relevance of the material. Each validation involved three experts using a structured questionnaire. The results are presented in Table 2.

Table 2. Validation Results by Media and Content Experts

Validator Type	Focus of Assessment	Average Score	Category
Media Experts (n = 3)	Cover design, layout, readability	91%	Very Feasible
Content Experts (n = 3)	Accuracy, presentation, language clarity	94%	Very Feasible

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The validation results show that media experts rated Allexium at 91%, indicating that the visual structure (cover design, color consistency, layout) is suitable and ready for implementation. This supports the idea that aesthetic and well-designed learning media can increase students' motivation and engagement (Dewi & Raida, 2022; Hazmi & Kurnia, 2022). Meanwhile, content experts rated Allexium at 94%, indicating strong accuracy and relevance of content. These results show that Allexium fulfills the criteria of effectiveness, efficiency, relevance, and productivity as stated by (Sutiah, 2018), and aligns with instructional media principles that support competency achievement (Fadilah et al., 2024; Liu et al., 2020; Lubis et al., 2023).

After scoring, experts provided qualitative suggestions to improve product quality. Feedback from media experts indicated visual and usability adjustments, as shown in Table 3.

Table 3. Media Experts' Revision Input and Improvements

No	Display Before Revision	Display After Revision
1	 Text on the album cover was cut off	 Text on the album cover is displayed in a single line
2		

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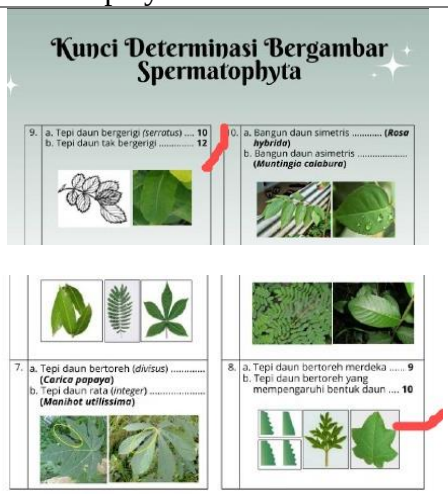
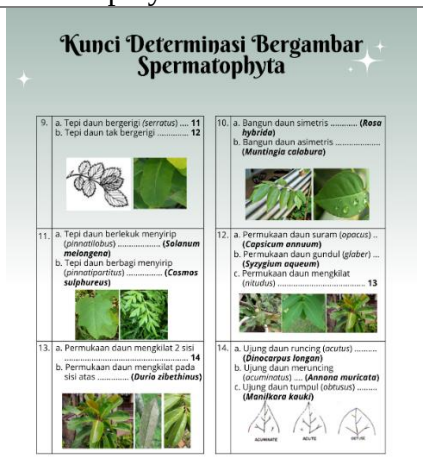
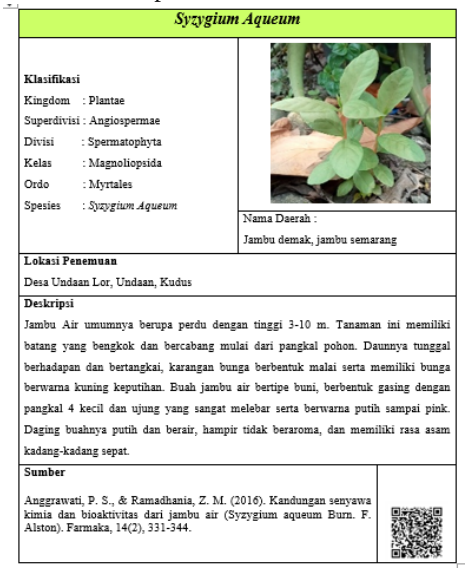
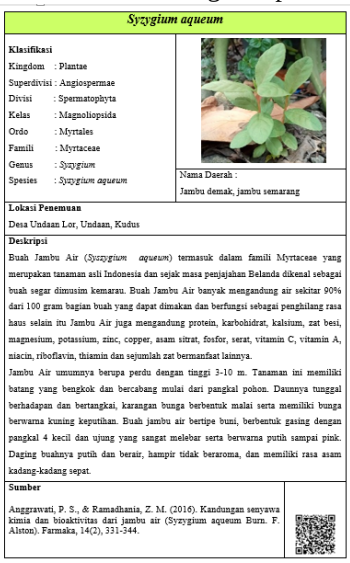
No	Display Before Revision	Display After Revision
	• Bullets in the worksheets were cartoon animations • Student identity column was included	• Bullets in the worksheets have been replaced with plant symbols • Student identity column has been removed

Content experts also provided academic corrections regarding scientific accuracy and completeness of taxonomy elements, as presented in Table 4.

Table 4. Content Experts' Revision Input and Improvements

No	Display Before Revision	Display After Revision
1	 Duplicate number 10	 Number 10 is no longer duplicated
2	 Family and genus not listed, scientific name incorrect, and description too brief	 Family and genus included, scientific name corrected, and description completed

Tabel 4 shows that the implemented revisions improve scientific accuracy, clarity, and

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usability. Through validation and revision, Allexium now integrates herbarium specimens, plant descriptions, determination keys, worksheets, and question cards into a flexible album format that enables students to actively analyze plant morphology. This encourages active learning and facilitates identification skill development (Rahmawati et al., 2024). Thus, Allexium is declared valid, feasible, and ready for field testing.

After the revision stage, Allexium underwent a product trial involving lecturers and students of the Tadris IPA program at IAIN Kudus. The aim of this stage was to evaluate its practicality and acceptance based on user experience. The lecturers' average score of 89% indicates that Allexium is very good and feasible for classroom use. Lecturers highlighted that Allexium is complete, flexible, and easy to understand, making it suitable for plant taxonomy–based courses. Students were also asked to evaluate the practicality and attractiveness of Allexium. Their responses are presented in Table 5.

Table 5. Student Responses to Allexium

No	Aspect Evaluated (Summary of 14 Statements)	Average Score
1	Ease and flexibility of using Allexium (clarity of guide, complete specimens, readable descriptions, detachable)	93–99%
2	Attractiveness (novel medium, curiosity-triggering cover, completeness of herbarium, identification support)	89–100%
3	Overall Average	94% (Very Good)

Table 5 shows that students responded very positively, giving Allexium an average score of 94%, categorized as very good. They reported that Allexium is easy to use individually or collaboratively, enables observation of real plant specimens, increases motivation because the medium is novel and visually interesting. Prospective teachers recommended increasing the contrast of the cover text for better readability. Based on this feedback, minor revisions were made to the cover design and user guide before moving on to classroom implementation trials. Students responded very positively, giving Allexium an average score of 94%, categorized as very good. They reported that Allexium is easy to use individually or collaboratively, enables observation of real plant specimens, increases motivation because the medium is novel and visually interesting. Using real herbarium specimens encourages engagement and strengthens conceptual understanding (Asadulloh et al., 2024; Hasanah et al., 2024; Jablonski, 2023). The flexibility of the detachable

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album format also supports different learning modes—whole-class, group, or individual activities. This finding aligns of Kholid & Darmawan (2023) and Age et al., (2024), who state that comprehensive and attractive learning media enhance student motivation and involvement.

During three learning sessions, students in the experimental class used Allexium to observe herbarium specimens (bryophytes, pteridophytes, and seed plants). Allexium's detachable structure allowed every student to access and manipulate herbarium sheets, enabling active participation and collaboration. This finding supports Sangiuliano et al. (2023) and Cortes (2020), who stated that flexible learning media encourage active learning and increase student engagement.

Prospective teachers performed identification tasks using the revised worksheets that contains clear instructions, morphological observation tables, and a determination key (Figure 3). The improvement in worksheets design increased clarity and guided students sequentially through the identification process. According to Rey et al. (2019), learning materials with coherent instructions enhance student focus and information retention. Furthermore, the use of a determination key promotes analytical thinking and taxonomy classification skills, which supports scientific literacy development (Howe et al., 2025).

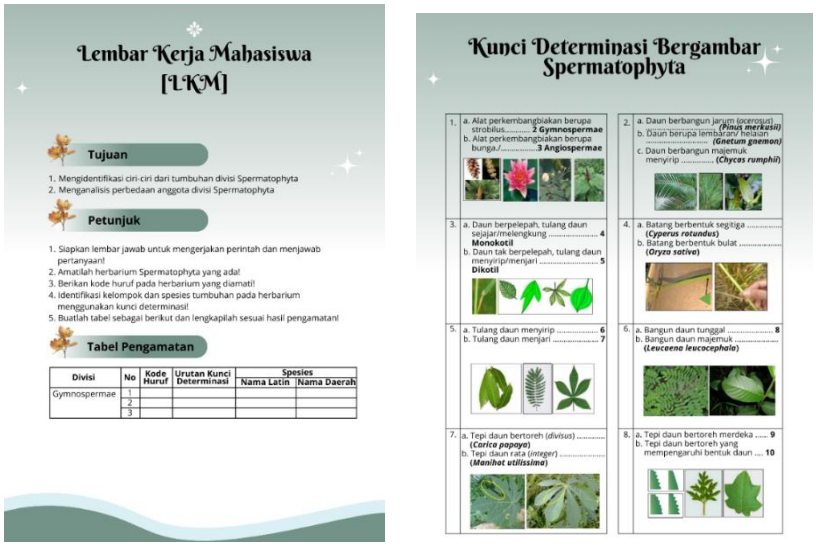

Figure 3. Revised worksheets containing a determination key for herbarium identification

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Figure 3 shows that Students then identified plant specimens using Allexium in small groups. All students were actively involved no passive participants were observed (Figure 4). This aligns with Raida & Jamaludin (2020), who reported that worksheets-based learning increases student engagement through active learning activities.

Figure 4. Students identifying plant specimens using Allexium during the implementation trial

Figure 4 shows that after completing observation and identification, prospective teachers classified plant taxonomy, characteristics, and scientific names using information provided in Allexium. This process strengthened scientific literacy related to biodiversity and plant structure. Learning through direct observation fosters deeper conceptual understanding and conservation awareness (Buck et al., 2019; Finger et al., 2022).

A post-test was used to compare identification skills between the two classes. The experimental class obtained a higher average score (88.19) than the control class (76.81), indicating better plant identification performance.

Table 8. Independent T-test Result

	Levene's Test		**t-test**			
	F	Sig.	T	df	Sig. (2-tailed)	
Score	Equal variances assumed	1.287	.262	-5.968	52	.000
	Equal variances not assumed			-5.968	47.461	.000

Table 8 shows that these findings are consistent with inquiry-based learning theory, where real observation and direct interaction with learning objects enhance conceptual mastery (Krosnick & Moore, 2025). Students successfully met identification indicators—identifying similarities and differences, classifying plants, and determining scientific names—supporting prior studies that comprehensive learning media accelerate

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competency achievement (Haq & Raida, 2023; Nasution et al., 2024; Puspita & Raida, 2021). Although question cards are included as evaluation tools in Allexium, time limitations prevented their use during implementation. Therefore, the implementation trial confirms that Allexium is effective, flexible, and enables authentic inquiry, making it appropriate for improving plant identification skills in the SPT course.

After the implementation and discussion stages, final revisions were made to improve the readability and usability of Allexium. Feedback from classroom use led to revisions in three aspects: (1) enhancing color contrast on the cover, (2) clarifying the user guide, and (3) refining the determination key layout. The final version of Allexium—showing the cover, usage guide, and herbarium specimen display—can be seen in Figure 5.

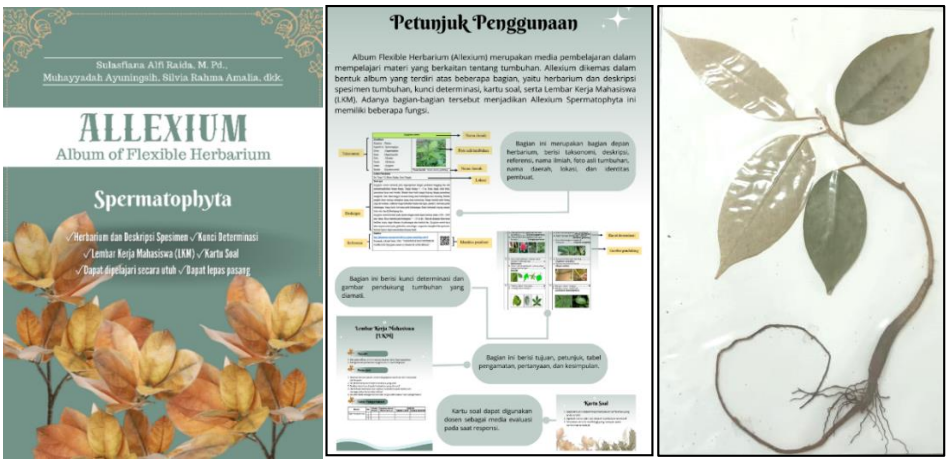

Figure 5. Final Design of Allexium (cover, usage guide, and herbarium display)

As shown in Figure 5, the revised cover features improved color contrast and a more balanced visual composition. Enhancing visual clarity aligns with multimedia learning principles, which emphasize readability and visual focus to reduce cognitive overload (Mayer & Fiorella, 2021). The user guide provides clear instructions and explains the components of Allexium—herbarium specimens, identification keys, worksheets, and question cards—supporting student autonomy and aligning with learner-centered media design (Wong, 2021). The herbarium layout allows students to observe complete plant structures (roots, stems, and leaves), enabling accurate identification and classification, consistent with observation-based inquiry learning (Raida & Jamaludin, 2020). Overall, the final version of Allexium demonstrates improved readability,

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completeness, and usability, ensuring that the media effectively supports plant identification activities. Therefore, based on validation, practicality testing, implementation results, and final revisions, Allexium is declared feasible, practical, and effective as a plant identification learning media.

CONCLUSION

This study successfully developed *Allexium*, a flexible herbarium-based learning medium designed to enhance students' plant identification skills. The feasibility test results indicated that *Allexium* was highly feasible for use, with an average feasibility rating of 91% from media experts and 94% from content experts. Product trials involving lecturers and students also showed very good responses, with lecturers giving a 89% rating and students giving a 94% rating. Furthermore, the implementation trial using a paired t-test showed that the Sig. (2-tailed) value was < α (0.05), leading to the acceptance of Ha. These results demonstrate that *Allexium* is both feasible and effective as a learning medium for improving students' plant identification skills. Further research is needed to expand the collection of Pteridophyta and Bryophyta specimens in Allexium, allowing students to develop their scientific literacy regarding the structure, function, and benefits of these plants. Additionally, it is essential to analyze the implementation of question cards during the evaluation or response stage to determine their effectiveness in enhancing the completeness and functionality of Allexium as a learning tool.

REFERENCES

Adriati, ., & Rooroh, A. (2024). Meningkatkan Minat Belajar Peserta Didik Melalui Model Problem Based Learning (PBL) Pada Kelas X SMAN 1 Tolitoli Utara Tahun Pelajaran 2023/2024. *Literacy: Jurnal Pendidikan Ekonomi*. https://doi.org/10.53682/jpeunima.v5i1s.8690

Age, D., Morisson, B., Sutisna, U., & Umam, R. A. (2024). *Penerapan Metode Pembelajaran Video Based Learning Untuk Meningkatkan Keterlibatan Siswa di Era Digital Application of Video Based Learning Method to Increase Student Engagement in the*. *02*(2), 51–60. https://doi.org/1055656/wjp.v1i2.338

Ali, M., Fajriatin, M., & Firdausi, A. (2024). Edukasi Pembuatan Herbarium Kering Sebagai Media Pembelajaran Biologi Berbasis Konservasi Lingkungan di SMA Terpadu Insan Hanifa Sumber Payung Ganding. *ABDISUCI : Jurnal Pengabdian*

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Dan Pemberdayaan Masyarakat, *02*(01), 1–7. https://doi.org/10.59005/j-abdisuci.v2i01.147

Andriyani, F., Suryanda, A., Ristanto, R. H., Biologi, P., Matematika, F., & Alam, P. (2024). *Phenomenon : Jurnal Pendidikan MIPA Development of Integrated Biodiversity Student Worksheets With Computational Thinking Pengembangan Lembar Kerja Peserta Didik (LKPD) Keanekaragaman Hayati Terintegrasi Berpikir Komputasi*. *14*(1), 139–155. https://doi.org/https://doi.org/10.21580/phen.2024.14.1.23303

Asadulloh, Bahtiar, R. S., & Santoso, E. (2024). Penggunaan Media Benda Konkret untuk Meningkatkan hasil Belajar Matematika Siswa Kelas 1 Sekolah Dasar. *Journal of Science and Education Research*, *3*(2), 43–49. https://doi.org/10.62759/jser.v3i2.129

Borosova, R., Rita, A., Simoes, G., Tang, C., & Ameka, G. K. (2024). *Enhancing Taxonomic Skills in West Africa and Supporting the Growth of GC Herbarium (Ghana)*. 8–10. https://doi.org/10.3897/biss.8.139237

Buck, T., Bruchmann, I., Zumstein, P., & Drees, C. (2019). Just a small bunch of flowers: The botanical knowledge of students and the positive effects of courses in plant identification at German universities. *PeerJ*, *2019*(3). https://doi.org/10.7717/peerj.6581

Cortes, S. T. (2020). Flexible Learning as an Instructional Modality in Environmental Science Course during COVID-19. *Aquademia*, *4*(2), ep20024. https://doi.org/10.29333/aquademia/8444

Dahlia, D. (2020). Development of Herbarium Book as Biology Instructional Media in Plant Morphology Subject for Biology Education Undergraduate Students, University of Pasir Pangaraian. *Bioeducation Journal*, *4*(1), 10–19. https://doi.org/10.24036/bioedu.v4i1.252

Dewi, A. A., & Raida, S. A. (2022). Development of E-Quiz in Online Learning for Class VII Junior High School Ecosystem Materials. *QUANTUM: Jurnal Inovasi Pendidikan Sains*, *13*(1), 36–48. https://doi.org/10.20527/quantum.v13i1.12730

Dikrullah, D., Rapi, M., & Jamilah, J. (2018). Pengembangan Herbarium Book Sebagai Media Pembelajaran Biologi pada Mata Kuliah Struktur Tumbuhan Tinggi. *Jurnal Biotek*, *6*(1), 15. https://doi.org/10.24252/jb.v6i1.4426

Ediyani, M., Hayati, U., Salwa, S., Samsul, S., Nursiah, N., & Fauzi, M. B. (2020). Study on Development of Learning Media. *Budapest International Research and Critics Institute (BIRCI-Journal): Humanities and Social Sciences*, *3*(2), 1336–1342. https://doi.org/10.33258/birci.v3i2.989

Fadilah, A. M., Muhlisin, A., & Ismawati, R. (2024). Development of an Ethnoscience-

Email: sulasfiana@uinkudus.ac.id ISSN: 2088-7868, e-ISSN 2502–5708

Based Integrated Science Module with RIAS Learning Model to Improve Students' Critical Thinking Ability. *Phenomenon : Jurnal Pendidikan MIPA*, *13*(2), 264–282. https://doi.org/10.21580/phen.2023.13.2.16931

Figueira, R., & Lages, F. (2019). Museum and Herbarium Collections for Biodiversity Research in Angola. In *Biodiversity of Angola* (pp. 513–541). https://doi.org/https://doi.org/10.1007/978-3-030-03083-4_19 513

Finger, A., Groß, J., & Zabel, J. (2022). Plant Identification in the 21st Century—What Possibilities Do Modern Identification Keys Offer for Biology Lessons? *Education Sciences*, *12*(12). https://doi.org/10.3390/educsci12120849

Flannery, M. C. (2015). *Moonstruck by Herbaria Biology Today Moonstruck by Herbaria*. *May 2011*. https://doi.org/10.1525/abt.2011.73.5.11

Goldin, I. (2014). *Open Learning and Teaching in Educational Communities*. *8719*(September). https://doi.org/10.1007/978-3-319-11200-8

Handayani, P., Napitupulu, M., & Hadap. (2016). Perbedaan Hasil Belajar dengan Menggunakan Media Herbarium dan Media Gambar pada Materi Tumbuhan Berbiji (Spermathopyta) di Kelas X SMA Swasta Eria Medan Putri. In *Medan State University*. Undergraduate Thesis.

Haq, F. D., & Raida, S. A. (2023). Development of the Research Based Learning Module for Making Natural Foot Sanitizer on the Topic Eubacteria for Class VII IPA Middle School. *Journal Of Biology Education*, *6*(1), 63. https://doi.org/10.21043/jobe.v6i1.19551

Hasanah, D. A., Usmiyatun, & James, M. L. (2024). *Use of Real Object Media to Improve Students' Multiplication Learning Outcomes in Elementary School Classes*. *2*(1), 31–36. https://doi.org/10.21580/phen.2024.14.1.23303

Hasyim, A. (2016). *Metode penelitian dan pengembangan di sekolah* (Cetakan I). Media Akademi.

Hazmi, N., & Kurnia, A. (2022). Hubungan media pembelajaran dan minat siswa pada mata pelajaran IPS. *Jurnal Pendidikan Sejarah Dan Riset Sosial Humaniora (KAGANGA)*, *5*(2), 159–178. https://doi.org/10.31539/kaganga.v5i2.4035

Howe, A. G., Nguyen, T. T. T., O'Connor, P., Woodward, A., Clarke, S., Ducker, N., Dilger, K., & Fagan-Jeffries, E. P. (2025). Catching 'the bug': Investigating insects through school-based citizen science increases intentions for environmental activities in students and teachers. *Austral Entomology*, *64*(2), 1–19. https://doi.org/10.1111/aen.70004

Jablonski, S. (2023). Real objects as a reason for mathematical reasoning – A comparison of different task settings. *International Electronic Journal of Mathematics*

Email: sulasfiana@uinkudus.ac.id ISSN: 2088-7868, e-ISSN 2502–5708

Education, *18*(4), em0758. https://doi.org/10.29333/iejme/13859

Kemijan, K. (2018). Pemanfaatan Media Gambar untuk Meningkatkan Kemampuan Siswa dalam Mengidentifikasi Hewan yang Hampir Punah bagi Kelas VI Di SD Inpres 48 Kasim Sele. *Biolearning Journal*, *5*(2), 35–40. https://doi.org/10.36232/jurnalbiolearning.v5i2.274

Kholid, K., & Darmawan, D. (2023). The Influence of Digital Literacy and Learning Media Utilization on Student Learning Motivation. *Fitrah: Journal of Islamic Education*, *4*(2), 393–403. https://doi.org/10.53802/fitrah.v4i2.622

Kirchoff, B. K., Delaney, P. F., Horton, M., & Dellinger-Johnston, R. (2014). Optimizing learning of scientific category knowledge in the classroom: The case of plant identification. *CBE Life Sciences Education*, *13*(3), 425–436. https://doi.org/10.1187/cbe.13-11-0224

Krosnick, S., & Moore, K. (2025). Rooting students in their botanical history: A method to engage students in botany and herbaria. *Plants People Planet*, *7*(3), 838–849. https://doi.org/10.1002/ppp3.10595

Kusumawardani, W., Muzzazinah, & Ramli, M. (2019). Plant taxonomy learning and research: A systematics review. *AIP Conference Proceedings*, *2194*(December). https://doi.org/10.1063/1.5139783

Liu, R., Ding, X. H., Yang, Z., Wu, J., & Yang, J. (2020). Media selection in knowledge transfer: A decision model. *Journal of Global Information Management*, *28*(1), 86–102. https://doi.org/10.4018/JGIM.2020010105

Liunokas, A. (2020). Analisis Kemampuan Mahasiswa dalam Mengidentifikasi Tumbuhan di Lingkungan STKIP Soe. *Jurnal Inovasi Pendidikan Dan Sains*, *01*(01), 8–12. https://doi.org/10.51673/jips.v1i1.220

Lubis, L. H., Febriani, B., Yana, R. F., Azhar, & Darajat, M. (2023). The Use of Learning Media and its Effect on Improving the Quality of Student Learning Outcomes. *IJESSM*, *3*(2), 7–14. https://doi.org/10.31326/jisa.v6i1.1661

Manzura, Z., & Kizi, V. (2024). Enhancing Botanical Education : Exploring. *International Journal of Advance Scientific Research*, *04*(04), 129–137. https://doi.org/https://doi.org/10.37547/ijasr-04-04-22

Mayer, R. E., & Fiorella, L. (2021). The Cambridge Handbook of Multimedia Learning. *The Cambridge Handbook of Multimedia Learning*, *February 2022*. https://doi.org/10.1017/9781108894333

Nasution, F. H., Pramudia Ananda, Siti Fadilla, & Juni Sahla Nasution. (2024). Hakikat Media Pembelajaran Menulis di Kelas Tinggi. *Jurnal Arjuna : Publikasi Ilmu Pendidikan, Bahasa Dan Matematika*, *2*(4), 130–138.

Email: sulasfiana@uinkudus.ac.id ISSN: 2088-7868, e-ISSN 2502–5708

https://doi.org/10.61132/arjuna.v2i4.1098

Nurmilawati, M., & Rahmawati, I. (2018). Keterampilan mengidentifikasi pada mata kuliah morfologi tumbuhan berbasis mini project. *Prosiding Seminar Nasional SIMBIOSIS III.*

Nurwanti, S. (2020). *Mengenal Herbarium Flora*.

Pliushch, A. (2022). Hands-On Practice as Part of Professional Training for Natural Science Teachers. *Academic Notes Series Pedagogical Science*, *1*(204), 57–61. https://doi.org/10.36550/2415-7988-2022-1-204-57-61

Puspita, I., & Raida, S. A. (2021). Development of Video Stop Motion Graphic Animation Oriented STEAM (Science, Technology, Engineering, Arts, And Mathematics) on Global Warming Materials in Junior High School. *Thabiea : Journal of Natural Science Teaching*, *4*(2), 198. https://doi.org/10.21043/thabiea.v4i2.11895

Rahmawati, T., Zalisca, Z. S., Mahera, P., Ramandhika, M. F., Susanti, E., Meryamsumayeka, M., & Zulkardi, Z. (2024). Development of Ludo Math Props to Improve Student Learning Interest in Logarithm Material. *Phenomenon : Jurnal Pendidikan MIPA*, *14*(1), 103–122. https://doi.org/10.21580/phen.2024.14.1.22486

Raida, S. A., & Jamaludin, D. N. (2020). The Effectiveness of Constructivist Learning Using Guided Discovery Models on The Concept of A Regulatory System for Curiosity and Anti-Narcotics Attitudes. *Thabiea : Journal of Natural Science Teaching*, *3*(1), 41. https://doi.org/10.21043/thabiea.v3i1.7023

Rey, G. D., Beege, M., Nebel, S., Wirzberger, M., Schmitt, T. H., & Schneider, S. (2019). *A Meta-analysis of the Segmenting Effect*. Educational Psychology Review. https://doi.org/https://doi.org/10.1007/s10648-018-9456-4

Saadillah, A., Sabila, L. C., Isma, Y., Surianti, Hamiati, Sasdila, W., & Ruhiba. (2025). Pemanfaatan Tumbuhan Sebagai Media Pembelajaran Herbarium Pada Materi Plantae. *Journal of Human And Education*, *5*(2), 672–676. https://doi.org/https://doi.org/10.31004/jh.v5i2.2460

Saepudin Kanda, A., & Rustini, R. (2024). Implementasi pembelajaran aktif dalam meningkatkan motivasi siswa pada pembelajaran di ma nurul iman. *Jurnal Ilmiah Research Student*, *1*(3), 566–579. https://doi.org/0.61722/jirs.v1i3.676

Salamah, U., Nurul Khasanah, H., Suwarto, S., & Pardi, P. (2023). Identification of Plant Species Diversity at SMAN 1 Nguter as Source of Learning Based on Local Potential. *Jurnal Biologi Tropis*, *23*(2), 422–426. https://doi.org/10.29303/jbt.v23i2.4433

Sangiuliano, F. I., Nasti, C., Massaro, R., Perretta, A. J., Di Girolamo, A., Brighi, A., &

Email: sulasfiana@uinkudus.ac.id ISSN: 2088-7868, e-ISSN 2502–5708

Biroli, P. (2023). Flexible Learning Environments for a Sustainable Lifelong Learning Process for Teachers in the School Context. *Sustainability (Switzerland)*, *15*(14). https://doi.org/10.3390/su151411237

Sugiyono. (2010). *Metode penelitian kuantitatif, kualitatif, dan R&D*. Alfabeta.

Susilaswati, Y., & Sugandi, M. K. (2019). Keterampilan Mahasiswa Dalam Mengidentifikasi Tumbuhan di Lingkungan Universitas Majalengka Sebagai Kompetensi Mata Kuliah Morfologi Tumbuhan. *Bioedusiana*, *4*(2), 29–37. https://doi.org/10.34289/277887

Sutiah. (2018). *Pengembangan Media Pembelajaran Pendidikan Agama Islam*. nizamia learning centre.

Syamsiah, S., B., N., & Hiola, S. F. (2020). Pemanfaatan spesimen herbarium sebagai media pembelajaran bagi Guru-Guru IPA/Biologi di Kabupaten Enrekang. *Dedikasi*, *22*(1), 99–103. https://doi.org/10.26858/dedikasi.v22i1.13831

Wong, K. M. (2021). "A design framework for enhancing engagement in student-centered learning: own it, learn it, and share it" by Lee and Hannafin (2016): an international perspective. *Educational Technology Research and Development*, *69*(1), 93–96. https://doi.org/10.1007/s11423-020-09842-w

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