

**DEVELOPMENT OF FLIPBOOK-BASED INSTRUCTIONAL  
MATERIALS INTEGRATED WITH VIRTUAL REALITY  
FOR LOWER PLANT BOTANY LEARNING**

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**ABSTRACT**

This study aimed to develop flipbook-based instructional materials assisted by Virtual Reality (VR) for the Lower Plant Botany. The research employed a Research and Development (R&D) approach using the 4D model, consisting of *define*, *design*, *develop*, and *disseminate* stages. At the define stage, a preliminary field exploration and identify lower plant species as learning content. Data were obtained through direct observation and morphological identification of lower plant. The design stage involved developing instructional materials using flipbook and Virtual Reality media based on field data. The development stage included expert validation, product revision, and limited trials with Biology Education students to evaluate feasibility and practicality. The disseminate stage was carried out through limited implementation in lectures and distribution of the developed materials. The results indicated that the developed instructional materials were feasible based on expert validation. Expert validation indicated that the instructional materials were feasible across content, presentation, language, and scientific aspects (75–88.3%), while media validation demonstrated a very high feasibility level (99.07%). These findings indicate that flipbook-based instructional materials integrated with Virtual Reality offer an engaging and immersive learning solution that enhances students' understanding of abstract and microscopic concepts in Lower Plant Botany while supporting scientific and digital literacy.

**Keywords:** Digital Instructional Materials, Flipbook, Lower Plant Botany, Research and Development, Virtual Reality

**INTRODUCTION**

The development of digital technology has brought significant changes in various aspects of life, including in the world of education. The use of information and communication technology in learning has become a major requirement in 21st century education to create a more interactive, flexible, and learner-centered learning process (Hodges et al., 2024). The integration of technology in learning not only serves as a tool for delivering material, but also as a means to improve the quality of learning, student engagement, and strengthen science and digital literacy.

Science learning literacy can no longer rely solely on text-based materials, as monotonous presentations reduce learning motivation and hinder students' understanding of abstract concepts (Lin et al., 2017). Therefore, teaching materials need to be developed by integrating various forms of information representation, such as images from direct observation, learning videos, and interactive visualizations. The use of visual and audiovisual media in science education has been proven to improve students' conceptual understanding, observation skills, and scientific thinking abilities (Kurniawan et al., 2020).

One emerging technology with strong potential to address these challenges is Virtual Reality (VR), which enables immersive and interactive learning experiences that support conceptual visualization by providing a simulated environment that closely resembles real-world phenomena. Previous studies have reported that VR can enhance student engagement, motivation, and conceptual understanding in science learning.

Botany of lower plants is a basic course in biology education that studies the structure, classification, and life cycle of lower plants, including the process of metagenesis. Metagenesis is a complex and abstract concept because it involves the alternation of generations between the gametophyte and sporophyte phases, which are difficult to observe directly and require good visualization skills (Raven et al., 2022). Based on interviews with students, it was found that students had difficulty understanding the concept of metagenesis in lower plants because the material was presented conceptually and limited to textual explanations and two-dimensional images.

Ideally, the study of lower plant botany should be carried out through practical activities and direct observation to help students build meaningful conceptual understanding (Susilo et al., 2021). However, the interview results showed that the implementation of practical activities has not been optimal due to limited laboratory facilities and incomplete observation objects. Not all stages of metagenesis can be observed directly due to limitations in available preparations and specimens. In addition, space and time constraints are obstacles to conducting field observation activities, considering that not all low plants are easily found in the surrounding environment and some biological processes require a relatively long observation time (Nurhayati & Prasetyo, 2022).

Based on condition, a clear research gap can be identified: there is a lack of instructional materials that integrate Virtual Reality into structured digital learning resources to specifically support the visualization and understanding of metagenesis in lower plant botany. To date, no study has explicitly developed and evaluated VR-

integrated flipbook-based instructional materials tailored to lower plant botany learning, particularly to overcome limitations in practical activities and direct observation.

## RESEARCH METHOD

This study employed a Research and Development (R&D) approach using the Four-D (4D) model consisting of Define, Design, Develop, and Disseminate, which is widely used for developing instructional materials through systematic needs analysis, prototyping, expert appraisal, and implementation (Indaryanti et al., 2025). The target users were Biology Education students taking the Lower Plant Botany course. Product evaluation involved (1) expert validators (content and media expert), and (2) third-semester Biology Education students in a limited-scale trial (n = 15).

The Define stage focused on identifying instructional requirements and learning conditions through: (1) front-end analysis (learning constraints and problems), (2) learner analysis (student characteristics and readiness), (3) task analysis (learning tasks aligned with course outcomes), (4) concept analysis (core concepts and sequencing), and (5) specifying instructional objectives (operational learning objectives). In addition, a contextual field exploration was conducted at waterfall Taeno to collect authentic learning objects to be embedded in the flipbook and VR scenes (Wahrini & Peng, 2023).

The Develop stage consisted of expert appraisal and developmental testing, followed by iterative revisions. Expert validation was conducted by content and media experts (n = 2). Quantitative data from expert validation and user questionnaires were analyzed descriptively using percentage scores, while qualitative feedback was summarized to guide further revisions (Gunawan et al., 2020).

$$Score = \frac{Obtained\ Score}{Maximum\ Score} \times 100$$

The product was disseminated in a limited manner through the course platform and shared with the course lecturer for use in Lower Plant Botany learning. Due to time and resource constraints, dissemination was limited to the immediate target context.

## FINDINGS AND DISCUSSION

The results of the identification of low-growing plants around Taeno Waterfall, Ambon City, show the diversity of low-growing plant groups, including lichens, fungi, mosses, and ferns. The presence of species such as *Parmotrema* sp., *Usnea* sp., *Auricularia* sp., *Marchantia* sp., and *Nephrolepis exaltata* indicates that the environment around the study site has a level of humidity and ecological conditions that support the growth of low plants. These findings are in line with (Tjitrosoepomo, 2010) opinion that low plants

generally thrive in humid environments rich in organic matter. The use of local biodiversity in science education is considered to be able to improve students' understanding of concepts and their connection to the material being studied (Az Zahra et al., 2024).

**Table 1.** Results of the Identification of Low-Growing Plants around the Taeno Waterfall, Ambon City

No	Kelompok Tumbuhan	Nama Spesies yang Ditemukan	Habitat
1	Lichenes	<i>Parmotrema</i> sp	Tree Trunks
		<i>Usnea</i> sp.	Tree Trunks
		<i>Graphis</i> sp.	Rocks and Tree
2	Fungi	<i>Auricularia</i> sp	Rotten Wood
		<i>Ganoderma</i> sp	Dead Tree Trunks
		<i>Trametes</i> sp	Rotten Wood
3	Bryophyta	<i>Marchantia</i> sp	Moist Soil
		<i>Funaria</i> sp.	Soil and Rocks
		<i>Anthoceros</i> sp	Damp Soil
4	Pteridophyta	<i>Nephrolepis exaltata</i>	Soil
		<i>Pteris vittata</i>	Open Soil
		<i>Selaginella</i> sp	Moist Soil
		<i>Pteris Vittata</i>	Soil
		<i>Asplenium nidus</i>	Soil

Source: Author's Result.

### Design Stage: Prototype of VR-Assisted Flipbook and VR Learning Environment

The develop Virtual Reality environment was designed as an interactive digital museum that present contextual biological learning content. The VR product includes three-dimensional virtual spaces that simulate natural habitats of low-growing plants, integrated with high resolution plant images, 360-degree environmental visualization, and instructional video documenting the identification process

From a technical perspective, the VR media was developed using spatial scene construction features, multimedia embedding, and interactive hotspot integration. The system is accessible via desktop computers, mobile devices, and VR headsets, allowing flexible use in both immersive and non-immersive modes. In addition, the VR content is linked to structured learning materials and integrated into a digital flipbook format to enable offline access and support independent learning (Radianti et al.,2020).

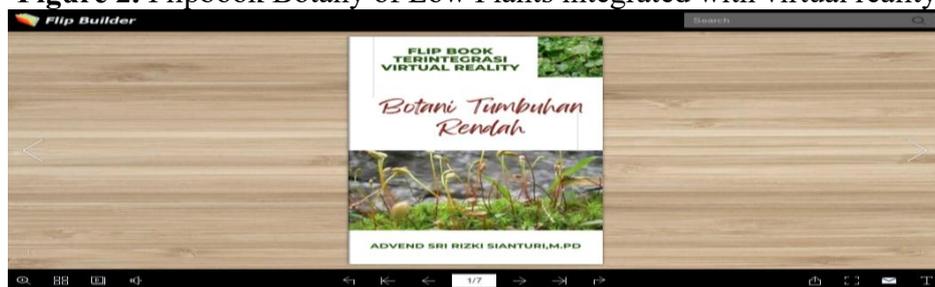
**Figure 1.** Virtual reality botany of low-growing plants using spatial.Io



Source: Authors' Result.

Furthermore, the virtual reality products that have been developed are integrated into the PDF flipbook media, so that they can be accessed offline by students. This integration aims to increase the flexibility of learning media use without relying on an internet connection, while also expanding access to the digital learning resources that have been developed. The flipbook is designed with an interactive layout that combines text explanations, high resolution images, instructional videos, and embedded links that connect directly to the Spatial-based virtual reality environment.

**Figure 2.** Flipbook Botany of Low Plants integrated with virtual reality



Source: Author's Result

### Develop Stage: Expert Appraisal, Revision, and Developmental Testing (Limited-Scale Trial)

The study then entered the Develop stage, in which the designed media were produced, refined, and validated by experts. This stage included expert appraisal, iterative revision based on expert feedback, and developmental testing through a limited-scale student trial. The use of field-based authentic content supports experience-based learning. Recent studies show that integrating virtual field trips into biology learning can help overcome fieldwork limitations while still providing exploratory experiences (Makransky & Mayer, 2022; Petersen et al., 2020). Below are the validation results from subject matter and media experts:

**Table 2.** Results of Content and Media Expert Validation

No	Assessment Aspect	Percentage (%)	Criteria
<b>Content Expert</b>			
1	Content Suitability	88,3	Suitable
2	Presentation	77,5	Suitable
3	Language	75,0	Suitable
4	Scientific	82,14	Suitable
<b>Media Expert</b>			
1	Visual Display	99,07	Very Suitable
2	Interactivity	99,07	Very Suitable
3	Media Integration	99,07	Very Suitable

Source: Author's Result

The results of subject matter expert validation show that the teaching materials developed are in the acceptable category, with a content acceptability percentage of 83.3%,

presentation 77.5%, language 75%, and scientific aspects 82.14%. These results indicate that the material is in line with learning outcomes, has scientific accuracy, and is presented systematically. These findings are in line with the research (Noviyanita, 2018; Syukur et al., 2025) which states that flipbook-based digital teaching materials can improve concept clarity and support student science literacy. The validation results and input from the validators have been revised so that the Virtual Reality (VR)-assisted Flipbook on Low Plants has been distributed to students of the Biology Education Study Program on a small scale.

The media expert validation obtained a percentage of 99.07% with a very feasible category, indicating that the visual display, interactivity, and media integration aspects have met the standards for digital learning media. These results support the findings of (Radianti et al., 2020; De Bruin et al., 2020), which state that Virtual Reality-based learning media can increase learning engagement and provide an immersive learning experience, thereby helping students understand abstract concepts in science learning.

After revision based on validator feedback, the study proceeded to the disseminate stage, in which the developed product was implemented through a limited trial. The validated results were revised by the validator, and improvements were made and tested on a small scale. The following are the results of the small-scale trial of the Virtual Reality (VR)-assisted Flipbook:

**Table 3. Small-Scale Trial Results (Disseminate Stage)**

No	Assessment Aspect	Percentage(%)	Category
1	Interest	85,67	Positive
2	Material	86,67	Positive
3	Language	83,3	Positive
	Average	85,21	Positive

*Source: Author's Result*

The limited-scale trial indicates positive student responses to the developed teaching materials. The interest score (85.67%), material aspect (86.67%), and language clarity (83.30%) suggest that the materials are perceived as engaging, understandable, and communicative. These findings are consistent with studies reporting that VR and interactive digital media can enhance motivation, interest, and learning experiences in biology learning (Safarati & Zuhra, 2024; Ningrum & Wahyuni, 2021).

### **Disseminate Stage: Packaging and Limited Distribution**

Finally, the study proceeded to the Disseminate stage through limited implementation within the immediate target context. The finalized VR-assisted flipbook was packaged as a digital file accompanied by access guidance (QR/link) to the Spatial.io environment and

shared through the course platform and the course lecturer for instructional use.

## CONCLUSION

This study developed Virtual Reality–assisted flipbook teaching materials for Lower Plant Botany that were rated acceptable to highly acceptable by experts in terms of content, presentation, language, scientific accuracy, visuals, interactivity, and media integration. Small-scale trials showed positive student responses, indicating the materials were engaging, clear, and communicative. The flipbook can serve as an alternative to support field learning and enhance scientific and digital literacy. Future research should involve larger-scale trials and measure learning outcomes to better assess its impact.

## REFERENCES

- Az Zahra, L. D., Santi, M. L., Adhani, N., Normalisa, S., Annur, S., & Sya'ban, M. F. (2024). Pemanfaatan Keanekaragaman Hayati untuk Meningkatkan Pembelajaran Sains di Pulau Bakut Kabupaten Anjir Muara. *Hamzanwadi Journal of Science Education*, 1(1), 10–15. <https://doi.org/10.29408/hijase.v1i1.25603>
- De Bruin, A. B. H., Roelle, J., Carpenter, S. K., Baars, M., Ackerman, R., Biwer, F., Endres, T., Hoogerheide, V., Hui, L., van Gog, T., Janssen, E., van Merriënboer, J., Paas, F., Podolskiy, A., Renkl, A., Richter, J., Saveleva, D., Scheiter, K., Sepp, S., Waldeyer, J. (2020). Synthesizing Cognitive Load and Self-regulation Theory: a Theoretical Framework and Research Agenda. *Educational Psychology Review*, 32(4), 903–915. <https://doi.org/10.1007/s10648-020-09576-4>
- Gunawan, G., Kosim, K., Lestari, P. A. S., & Master Student, Universitas Mataram, Indonesia, p.ayusucilestari@gmail.com. (2020). Instructional Materials for Discovery Learning with Cognitive Conflict Approach to Improve Vocational Students' Achievement. *International Journal of Instruction*, 13(3), 433–444. <https://doi.org/10.29333/iji.2020.13330a>
- Hodges, C. B., Moore, S., Locke, B. B., Trust, T., & Bond, M. A. (2024). The difference between emergency remote teaching and online learning. *Handbook of Research in Online Learning: Insights and Advances*, 511–522. [https://doi.org/10.1163/9789004702813\\_021](https://doi.org/10.1163/9789004702813_021)
- Indaryanti, R. B., Murtiyasa, B., & Soemardjoko, B. (2025). Model Penelitian dan Pengembangan 4D: Tinjauan Tren, Tantangan, dan Peluang. *Jurnal Kajian Ilmiah*, 25(1), 91–98. <https://ejurnal.ubharajaya.ac.id/index.php/JKI/article/view/3430>
- Kurniawan, I. K., Parmiti, D., & Kusmariyatni, N. (2020). Pembelajaran IPA dengan Model Problem Based Learning Berbantuan Media Audio Visual Meningkatkan Pemahaman Konsep Siswa. *Jurnal Edutech Undiksha*, 8(2), 80. <https://doi.org/10.23887/jeu.v8i2.28959>
- Lin, M. H., Chen, H. C., & Liu, K. S. (2017). A study of the effects of digital learning on learning motivation and learning outcome. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(7), 3553–3564. <https://doi.org/10.12973/eurasia.2017.00744a>

- Makransky, G., & Mayer, R. E. (2022). Benefits of Taking a Virtual Field Trip in Immersive Virtual Reality: Evidence for the Immersion Principle in Multimedia Learning. *Educational Psychology Review*, 34(3), 1771–1798. <https://doi.org/10.1007/s10648-022-09675-4>.
- Ningrum, A. P. S., & Wahyuni, S. (2021). *Studi Literature: Pemanfaatan Virtual Reality Sebagai Media Pembelajaran Untuk Meningkatkan Pemahaman Konsep IPA*. 32(3), 167–186.
- Noviyanita, W. (2018). Pengembangan Bahan Ajar Elektronik Berbasis Flipbook Maker Materi Program Linear Kelas X SMK. *Jurnal Ilmiah Pendidikan Matematika*. 6(2), 41–49.
- Nurhayati, N., & Prasetyo, A. P. B. (2022). Kendala praktikum dan pengamatan lapangan pada pembelajaran botani. *Jurnal Pendidikan Sains*, 10(1), 23–31. <https://doi.org/https://doi.org/10.xxxx/jps.v10i1.xxx>
- Petersen, G. B., Klingenberg, S., Mayer, R. E., & Makransky, G. (2020). The virtual field trip: Investigating how to optimize immersive virtual learning in climate change education. *British Journal of Educational Technology*, 51(6), 2098–2114. <https://doi.org/10.1111/bjet.12991>
- Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers and Education*, 147, 103778. <https://doi.org/10.1016/j.compedu.2019.103778>
- Raven, P., Evert, R. F., & Eichhorn, S. E. (2022). *Biology of plants (9th ed.)*. New York: W. H. Freeman and Company Publisher.
- Safarati, N., & Zuhra, F. (2024). Media Digital Berbasis Virtual Reality dalam Pembelajaran. *Fatma Zuhra INNOVATIVE: Journal Of Social Science Research*, 4, 8717–8725.
- Susilo, H., Amin, M., & Rohman, F. (2021). Improving biology learning through laboratory and field-based activities. *International Journal of Instruction*, 14(3), 457–472. <https://doi.org/https://doi.org/10.29333/iji.2021.14327a>
- Syukur, A., Ratnasari, Y., Bintoro, H. S., & Jayaram, N. (2025). Development of Ekoterin E-Modules to Improve Learning Outcomes of Fifth Grade Elementary School Students. *Jurnal Pendidikan Sains Indonesia*, 13(4), 1067–1093. <https://doi.org/10.24815/jpsi.v13i4.48463>
- Tjitrosoepomo, G. (2010). *Taksonomi tumbuhan (Schizophyta, Thallophyta, Bryophyta, Pteridophyta)*. Gadjah Mada University Press.
- Wahrini, R., & Peng, C. G. (2023). Development of Interactive Learning Media in Occupational Health and Safety Subjectin Vocational High School. *Jurnal Pendidikan Teknik Sipil*, 5(1), 31–41. <https://doi.org/10.21831/jpts.v5i1.59820>.