Learning from Life, Learning about Plants: Biology Lecturers' Perceptions of Life-Based Learning in Plant Physiology

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Abstract

Plant Physiology is a core subject in the biology curriculum, but it remains challenging due to its abstract and complex nature. Life-Based Learning (LBL) has emerged as a pedagogical approach that connects theoretical concepts with students' real-life experiences. This study explored Indonesian biology lecturers' perceptions of LBL implementation in Plant Physiology courses. Using an explanatory sequential mixed-methods design, data were collected through a survey of 43 lecturers and semi-structured interviews with eight participants from different regions. The results show that lecturers strongly support active learning strategies such as problem-based, project-based, inquiry-based, contextual, experiential, and discovery learning as relevant to LBL. They also emphasized the importance of real-life orientation, exploration, scientific reflection, and application in enhancing meaningful learning. Lecturers reported positive student engagement but highlighted challenges, including limited facilities, time constraints, and contextualization of abstract concepts. LBL is perceived as a relevant and transformative approach in Plant Physiology education.

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Introduction

Plant Physiology is a fundamental component of the higher education biology curriculum (Krtková, 2024). It encompasses key physiological processes in plants, including photosynthesis, transpiration, water and nutrient transport, and responses to environmental stimuli (Ma et al., 2022). The subject matter is inherently abstract and complex, requiring a deep understanding of molecular to systemic interactions within plants. Since many of these processes are not directly observable, students often struggle to connect theoretical knowledge with real-life contexts (Molina et al., 2023; Rahmi, 2021). This limitation poses significant challenges in fostering meaningful and contextual learning. Consequently, there is a pressing need for instructional approaches that effectively bridge theoretical concepts of plant physiology with students' lived experiences (Molina et al., 2023).

Life-Based Learning (LBL) offers a strategic alternative for addressing the abstract nature of plant physiology by linking scientific concepts to students' everyday experiences, such as crop cultivation, environmental management, or local food security issues. Through LBL, learning becomes more applicable by activating students' life experiences as learning resources and encouraging reflective and solution-oriented thinking (Mawangi & Pramudhita, 2023). As a pedagogical approach, LBL positions real-life contexts as the primary foundation of learning, emphasizing the integration of academic content with students' personal, social, and ecological realities to foster relevance, meaning, and applicability (Fachrunnisa et al., 2020; Praherdhiono & Prihatmoko, 2019). LBL is believed to cultivate critical thinking, decision-making, and social empathy, as students are encouraged to reflect on scientific knowledge within real-world contexts they encounter daily. Its implementation is viewed as a pedagogical strategy that not only strengthens academic competence but also prepares graduates to adapt to the complex challenges of contemporary and future life (Sohag, 2020; Umamah et al., 2020).

Life-Based Learning (LBL) holds significant potential to enhance meaningful and contextual learning; however, its implementation in higher education, particularly in science courses such as plant physiology, remains limited. Many lecturers continue to rely on conventional approaches that emphasize theoretical delivery with minimal connection to students' lived experiences (Hardianto et al., 2024; Schwichow, 2016). Barriers such as limited training in LBL pedagogy, inadequate contextual learning resources, and heavy administrative workloads further constrain its adoption (Shang, 2010; Sumampouw, 2019). As a result, science education often remains disconnected from students' social and ecological realities, reducing opportunities to develop critical and reflective competencies. A life-based approach is essential for fostering ecological awareness, scientific ethics, and social sensitivity—attributes that are increasingly vital for graduates in the twenty-first century (Mystakidis et al., 2019; Rosana et al., 2023).

Empirical studies have demonstrated that the implementation of Life-Based Learning (LBL) positively influences both the quality of learning processes and student outcomes. LBL has been shown to enhance students' reflective thinking skills and their awareness of local environmental issues (Tuwoso et al., 2020). Students also exhibit greater ability to connect scientific concepts with everyday practices when LBL is applied (Mawangi & Pramudhita, 2023). These findings suggest that LBL is effective not only in fostering cognitive achievement but also in shaping character, social empathy, and student awareness (Suwono, 2019; Umamah et al., 2020). Moreover, LBL has proven effective in promoting collaboration and interdisciplinary learning. Biology education students engaged in project-based LBL integrated with local communities demonstrated increased motivation and improved scientific communication skills (Fachrunnisa et al., 2020). These outcomes reinforce prior evidence that LBL provides students with opportunities to interact directly with real-world problems, thereby strengthening both the meaning of learning and the relevance of scientific knowledge (Nurjanah et al., 2020). Collectively, these findings indicate that life-based learning is not only feasible but also highly relevant for conceptually and contextually rich courses such as Plant Physiology.

Several studies have emphasized the importance of structured and contextualized instructional steps. Such approaches go beyond theoretical understanding by integrating real-life experiences as primary learning resources (Cecep et al., 2024; Russell et al., 2013). Effective steps in Life-Based Learning (LBL) typically include real-life orientation, exploration, scientific reflection, and application. Real-life orientation connects learning topics to contexts closely related to students' personal or social experiences, thereby enhancing motivation and relevance (English & Kitsantas, 2013; Shongwe, 2024). Exploration encourages students to investigate authentic issues through observation, literature review, interviews, or field studies, enriching their understanding of phenomena (Großmann & Wilde, 2019; Moura & Jetz, 2021). Scientific reflection underscores the importance of critical and evidence-based reasoning in analyzing information and relating it to scientific concepts and interdisciplinary perspectives (Daya et al., 2021; Lew & Schmidt, 2011). pplication represents a crucial stage in which knowledge and skills are implemented in real life, whether through social projects, campaigns, product development, or solutions to local problems (Kim, 2024; Muharni et al., 2025). Collectively, these steps foster meaningful and transformative learning while equipping students to address real-world complexities.

Given the inherently abstract nature of Plant Physiology and its limited connection to students' daily experiences, the integration of LBL offers a relevant and strategic pedagogical solution. It enables students not only to understand physiological concepts theoretically but also to connect them with real-life issues such as local crop cultivation (Hall et al., 2025), climate change (McCright, 2013), food security (Palupi et al., 2024) and environmental degradation (Kołecka et al., 2017). Students are encouraged to build holistic understanding through direct experience, critical reflection, and value-based decision-making (Newton et al., 2012). The objectives of Plant Physiology education thus extend beyond cognitive mastery to the development of practical competencies and scientific attitudes (Vila & Sanz, 2018). Moreover, LBL transforms the role of lecturers from transmitters of knowledge into facilitators of meaningful learning experiences. They can design project-based, case-based, or field-based activities directly connected to real-world physiological issues, such as nutrient transport or plant adaptation to stress. This approach fosters active, contextual, and participatory learning while positioning students as reflective and responsible learners(Alsaad, 2024; Desrani et al., 2023). The adoption of LBL is therefore not only a response to the pedagogical challenges of Plant Physiology but also aligns with the evolving demands of contemporary higher education.

Theoretical Foundation

The philosophy of Life-Based Learning (LBL) is rooted in the notion that life itself serves as the source, context, and ultimate goal of education (Suwono, 2019; Tjiptady, 2022). LBL positions students not merely as active participants in the learning process but also situates real-life contexts as authentic learning environments (Fachrunnisa et al., 2020). Learning within this framework goes beyond the acquisition of theoretical knowledge, aiming to cultivate meaningful understanding, life values, adaptive skills, and reflective attitudes for addressing real-world challenges. Consequently, LBL promotes holistic student engagement—cognitive, affective, and psychomotor through authentic experiences drawn from daily life (Praherdhiono & Prihatmoko, 2019).

Philosophically, LBL is grounded in humanistic and contextual approaches, asserting that education must be closely connected to learners' lived experiences and relevant to surrounding social, cultural, and ecological issues (Hwang & Hariyanti, 2020; Xue & Li, 2022). t positions learning as a transformative process that equips students not only with academic competence but also with social awareness, empathy, and value-based decision-making skills. Thus, LBL seeks to produce graduates who are intellectually capable while also being wise in navigating real-life dynamics as individuals and as members of society (Fachrunnisa et al., 2020). The integrated LBL model can be theoretically framed through constructivist learning theory, meaningful learning theory, and experiential learning theory.

Constructivist learning theory

Constructivist learning theory posits that individuals actively construct knowledge through interactions with their environment and the internalization of meaning (Vygotsky, 1978). Learning is not a passive reception of information but an active process in which students construct their own understanding through experience, reflection, and social interaction (Liu & Matthews, 2005). Constructivism also emphasizes the role of authentic contexts and experiences as the foundation for developing deep and meaningful understanding (Adams, 2006). This perspective is both philosophically and practically aligned with Life-Based Learning (LBL), which prioritizes contextual and life-oriented experiences as the basis for knowledge construction.

Each stage of LBL reflects the principles of constructivism. Real-life orientation activates students' prior knowledge by linking learning topics to personal or social experiences (Gupta, 2024). Exploration offers students opportunities to build understanding through direct investigation of authentic issues (Olusegun, 2015). Scientific reflection serves as a space for elaborating and reorganizing knowledge by critically connecting field findings with scientific concepts (Enyedy et al., 2015). Application strengthens the construction process through relevant, real-life actions, enabling students to test and apply their learning within broader social contexts (Terwel, 1999; Valdes-Vasquez & Clevenger, 2015). Through these stages, LBL facilitates active, reflective, and meaningful learning, in line with the core tenets of constructivism.

Meaningful learning theory

Ausubel's theory of meaningful learning emphasizes that learning becomes more effective and enduring when new information is substantively connected to the learner's existing cognitive structures (Barron & Chen, 2008). Meaningful learning does not occur through rote memorization but through the association of new concepts with prior knowledge already present in the individual's mind (Mubarok et al., 2022). For meaningful learning to take place, instructional materials must be relevant, clearly contextualized, and supported by learners' readiness and mental engagement. Life-Based Learning (LBL) aligns closely with Ausubel's principles as it anchors instruction in students' lived realities and familiar experiences.

Each stage of LBL embodies the tenets of meaningful learning. Real-life orientation provides authentic contexts that serve as "advance organizers" within students' cognitive structures (da Silva, 2020). Exploration allows learners to construct understanding by investigating issues drawn from their immediate environment or everyday life (Huang & Chiu, 2015). Scientific reflection facilitates the integration of new concepts into broader scientific frameworks, reinforcing meaningful cognitive structures (Novak, 2002). Finally, application provides practical experiences through which students can manifest and operationalize their understanding in real-world contexts (Pedrera et al., 2024). Thus, LBL serves as an ideal framework for fully enacting the principles of meaningful learning.

Experiental learning theory

Kolb's experiential learning theory asserts that effective learning occurs through a four-stage cycle: concrete experience, reflective observation, abstract conceptualization, and active experimentation (Dopico et al., 2021).

Learning begins with direct experience, followed by reflection on that experience, the development of concepts or theories, and ultimately their application in new situations. This theory emphasizes that genuine learning emerges when individuals are actively engaged in the process rather than passively receiving information (Gosselin et al., 2016).

The philosophy of experiential learning is highly consistent with Life-Based Learning (LBL), which positions real-life contexts as the primary source of learning experiences. Each stage of LBL reflects Kolb's experiential learning cycle. Real-life orientation provides the initial concrete experience that serves as the entry point to the learning process (Gosselin et al., 2016). Exploration encourages learners to conduct observations, gather information, and actively engage in authentic contexts, corresponding to reflective observation (Cecep et al., 2024). Scientific reflection supports abstract conceptualization by facilitating students' theoretical understanding based on their reflections and findings. Finally, application represents active experimentation, where students implement ideas or solutions in real-world settings (Boppre et al., 2023). LBL thus offers a highly suitable framework for integrating experiential learning theory into meaningful and transformative higher education practices.

The relationship of LBL with plant physiology

Each stage of Life-Based Learning (LBL) strengthens meaningful understanding of plant physiology. Real-life orientation enables students to connect physiological phenomena with agricultural practices, urban farming, or climate change (C.D. et al., 2007; Jha, 2021; Newton, 2020). Exploration encourages them to investigate physiological processes through simple experiments or field studies. Scientific reflection provides a space for critical analysis, linking exploratory findings with theoretical frameworks in plant physiology. At the application stage, students may design solution-based projects such as hydroponic systems, local crop management, or environmental awareness campaigns (Collins & Donahue, 2019). Integrating LBL into plant physiology not only strengthens conceptual mastery but also fosters scientific attitudes, critical thinking skills, and ecological awareness among students (Mawangi & Pramudhita, 2023).

Research Objectives

This study aims to examine the perceptions of Indonesian biology lecturers regarding the implementation of Life-Based Learning (LBL) in the context of teaching plant physiology in higher education. Specifically, it seeks to identify learning strategies considered relevant and integrable with the LBL approach. The study also explores instructional stages aligned with the principles of LBL, including real-life orientation, exploration, scientific reflection, and application in real-world contexts. In addition, it investigates lecturers' teaching experiences in delivering plant physiology courses through LBL, focusing on instructional practices, challenges, and opportunities for fostering meaningful and contextual learning. As educators, lecturers are expected to contribute to the development of plant physiology instruction that is more life-integrated, contextually relevant, and capable of cultivating students' holistic competencies.

Methods And Materials

Research Design

This study employed an explanatory sequential mixed-methods design (Creswell, 2012). This design was selected to obtain a comprehensive understanding of Indonesian biology lecturers' perceptions regarding the implementation of Life-Based Learning (LBL) in plant physiology instruction. In the first phase, quantitative data were collected through a survey to identify learning strategies perceived as relevant to LBL principles and to map instructional stages considered integrable with the approach. These quantitative findings provided a general overview of lecturers' perceptions, including their preferred strategies and teaching experiences.

The second phase involved semi-structured interviews, which were developed based on the quantitative results. This qualitative stage aimed to deepen the understanding of survey findings by exploring lecturers' experiences in applying LBL to plant physiology teaching, including the challenges encountered, practices implemented, and opportunities for further development. Qualitative data were analyzed using content analysis (Bengtsson, 2016), allowing for richer interpretation of numerical results and generating more comprehensive insights.

Participant

The subjects of this study were biology lecturers in Indonesia who teach or have teaching experience in Plant Physiology courses at the higher education level. Participants were selected using purposive sampling, based on criteria relevant to the research objectives. The criteria included: (1) holding at least a master's degree in biology or biology education, (2) having teaching experience in Plant Physiology, and (3) willingness to participate in both the survey and interview stages of the study.

In the quantitative phase, the participants were biology lecturers who met the inclusion criteria and agreed to complete the questionnaire. A total of 43 biology lecturers participated, providing sufficient data to capture general perceptions. From this group, a subset of lecturers who expressed willingness for further involvement was selected for the qualitative phase. In this stage, eight lecturers were interviewed semi-structurally to gain deeper insights into their views and experiences regarding the implementation of Life-Based Learning in Plant Physiology instruction.

Data Collection and Analysis
Quantitative level: survey
Quantitative data were collected through an online questionnaire specifically designed to explore biology lecturers' perceptions of implementing Life-Based Learning (LBL) in Plant Physiology instruction. The questionnaire contained items addressing three main aspects: (1) lecturers' understanding of LBL concepts and principles, (2) perceptions of instructional strategies relevant to LBL, and (3) awareness and experiences of integrating LBL into teaching practices. Content validity was established through expert judgment by specialists in biology and pedagogy, and a pilot test was conducted to ensure item clarity and readability.
Quantitative data were analyzed using descriptive statistics to illustrate participant profiles, perception trends, and the frequency of instructional strategies considered relevant. The analysis produced percentages and mean scores for each aspect, thereby providing an overview of the extent to which LBL is understood, perceived, and implemented by biology lecturers in Indonesia.

Qualitative level: interview
From the survey results, a subset of lecturers who expressed willingness to participate further were selected for the qualitative phase. Semi-structured interviews were conducted to gain deeper insights into their teaching experiences, instructional strategies, challenges, and opportunities for developing LBL in the context of Plant Physiology instruction. The interview protocol was designed based on the three main aspects of the questionnaire, thereby enabling a more detailed exploration of the quantitative findings.
Qualitative data were analyzed using content analysis, which followed four stages: (1) decontextualisation – reading interview transcripts, breaking them into meaning units, and assigning codes; (2) recontextualisation – reorganizing meaning units relevant to the research focus; (3) categorisation – grouping codes into categories, sub-themes, and overarching themes; and (4) compilation – synthesizing the conclusions.

Data Integration
Data integration was conducted at the final stage by linking the quantitative and qualitative findings. Quantitative data from the questionnaire provided an overview of biology lecturers' perceptions regarding the concepts, strategies, and application of Life-Based Learning (LBL) in Plant Physiology instruction. These descriptive results revealed general patterns, such as which instructional strategies were perceived as most relevant and which LBL stages were most frequently implemented.
In contrast, qualitative data from the interviews offered deeper explanations of the quantitative results by presenting lecturers' real experiences, challenges, and reflections in integrating LBL principles into teaching practice. Integration followed an explanatory sequential model, in which the quantitative findings guided the formulation of interview questions and subsequent qualitative interpretation. In this way, the qualitative data enriched and clarified the quantitative outcomes, generating a more comprehensive understanding of LBL implementation in higher education Plant Physiology courses.

Results
Quantitative Level: Survey
The demographic analysis revealed that most respondents were female (62.8%), while males accounted for 37.2%. In terms of educational background, most participants held a Master's degree (83.7%), whereas 16.3% had completed a Doctoral degree. With respect to institutional affiliation, respondents were predominantly from public universities (65.1%) compared to private universities (34.9%). The geographical distribution of respondents was also diverse, although most were based on Java Island (37.2%). Other participants came from Sumatra (18.6%), Kalimantan (11.6%), Sulawesi (11.6%), Nusa Tenggara (9.3%), Papua (7%), and Maluku (4.7%). These findings indicate that the sample reflects diversity in terms of gender, educational background, institutional affiliation, and regional representation, although females, Master's graduates, public university lecturers, and respondents from Java Island were dominant (**Table 1**).

Table 1. Demographic Profile of Respondents (N = 43)

Demographic Variable	Category	n	%
Gender	Female	27	62.8
	Male	16	37.2
Highest Education	Master's Degree	36	83.7
	Doctoral Degree	7	16.3
Institutional Affiliation	Public University	28	65.1
	Private University	15	34.9
Region (Island)	Java	16	37.2
	Sumatra	8	18.6
	Kalimantan	5	11.6
	Sulawesi	5	11.6

	Nusa Tenggara	4	9.3
	Papua	3	7
	Maluku	2	4.7

Types of learning strategies integrable with LBL

The analysis revealed that nearly all respondents expressed positive perceptions of life-oriented instructional approaches. A majority strongly agreed (69.8%) and agreed (30.2%) that Problem-Based Learning (PBL) is well-suited for implementation within the LBL framework. Similarly, most respondents affirmed that Project-Based Learning enables students to learn from real-life experiences, with 58.1% strongly agreeing and 41.9% agreeing. In addition, 60.5% strongly agreed and 32.6% agreed that Inquiry-Based Learning fosters students' ability to derive meaning from life through scientific investigation, although 7% remained neutral. A similar pattern was observed for Contextual Teaching and Learning (CTL), with 60.5% strongly agreeing, 32.6% agreeing, and 7% neutral regarding its role in supporting life-based values (**Table 2**).

Experiential Learning received the highest level of support, with 76.7% strongly agreeing and 14% agreeing, though 9.3% reported a neutral stance. By contrast, Discovery Learning elicited more varied responses: 46.5% strongly agreed, 48.8% agreed, and 4.7% remained neutral. Overall, these results indicate that all examined instructional strategies were perceived as compatible with the LBL framework. The high levels of agreement suggest strong acceptance among respondents, although a small proportion expressed neutral views toward certain approaches.

Table 2. Lecturers' Agreement on Learning Strategies Integrable with LBL (N = 43)

Statement Items	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
Problem-Based Learning (PBL) is suitable to be applied in life-based learning (LBL).	69.8	30.2	0	0	0
Project-Based Learning allows students to learn from real-life experiences in the context of LBL.	58.1	41.9	0	0	0
Inquiry-Based Learning encourages students to explore the meaning of life through scientific inquiry.	60.5	32.6	7	0	0
Contextual Teaching and Learning (CTL) supports the application of life values in learning.	60.5	32.6	7	0	0
Experiential Learning allows students to learn directly from life-relevant experiences.	76.7	14	9.3	0	0
Discovery Learning helps students understand lessons through engagement in real social activities.	46.5	48.8	4.7	0	0

Integrated learning stages in LBL

As shown in **Table 3**, lecturers' levels of agreement with the stages of Life-Based Learning (LBL) were consistently very high. In the Real-Life Orientation stage, all respondents agreed, with 48.8% selecting "strongly agree" and 51.2% selecting "agree." This indicates that linking subject matter with authentic experiences is perceived as highly effective in helping students understand plant physiology concepts.

At the Exploration stage, most respondents strongly agreed (65.1%) or agreed (32.6%), with only 2.3% remaining neutral. These findings suggest that direct observation activities are viewed as valuable for strengthening students' ability to connect scientific concepts with real-world phenomena. The Scientific Reflection stage also received full support, with 53.5% strongly agreeing and 46.5% agreeing. The absence of neutral or negative responses underscores the importance of reflection in helping students assess and deepen their understanding of the material. Finally, at the Application stage, the majority strongly agreed (72.1%) and agreed (25.6%), although 2.3% remained neutral. This result confirms that applying concepts to real-life contexts is regarded as highly meaningful in the learning process. Overall, the data demonstrate that all stages of LBL received strong support from the respondents, with "strongly agree" dominating across the stages. This highlights the relevance and strong potential of LBL in bridging academic concepts with students' lived experiences.

Table 3. Lecturers' Agreement on Integrated Learning Stages in LBL (N = 43)

Stages	Statement Items	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
Real-Life Orientation	Initial orientation activities that relate the material to real experiences make it easier for students to understand the concepts of plant physiology	48.8	51.2	0	0	0
Exploration	Direct observation activities help students understand the relationship between concepts and real phenomena	65.1	32.6	2.3	0	0
Scientific Reflection	Reflection activities help students realize their understanding of the plant physiology material that has been studied	53.5	46.5	0	0	0
Application	Activities that involve the application of concepts into life make learning feel meaningful	72.1	25.6	2.3	0	0

Teaching experiences in plant physiology related to LBL

As presented in Table 4, lecturers' teaching experiences related to Life-Based Learning (LBL) generally received high levels of agreement. For the statement "I begin Plant Physiology instruction by linking content to real-life issues," most respondents strongly agreed (53.5%) or agreed (37.2%), while 9.3% remained neutral. This indicates that contextual approaches at the beginning of instruction are considered important, although a small proportion of lecturers reported not applying them consistently.

For the statement "I encourage students to directly observe plant physiology phenomena," responses were balanced, with 46.5% strongly agreeing and 46.5% agreeing, while 7% were neutral. This suggests that direct observation is widely regarded as a relevant strategy for bridging theory with real-world phenomena.

Regarding the statement "I provide students with time to reflect on their learning in Plant Physiology," a majority agreed (55.8%) and 39.5% strongly agreed, while only 4.7% were neutral. This highlights the importance of reflection in consolidating students' understanding.

Finally, the statement "I assign project-based tasks that encourage students to apply plant physiology concepts" was strongly supported, with 55.8% strongly agreeing and 37.2% agreeing, although 7% remained neutral. These results emphasize that project-based learning is considered effective in encouraging students to apply concepts to real-life contexts.

Overall, the findings suggest that lecturers' teaching practices are already well integrated with LBL principles, although a small proportion of respondents expressed neutrality in areas such as linking lessons to real-life issues, facilitating direct observation, and assigning life-based projects.

Table 4. Lecturers' Teaching Experiences Related to LBL (N = 43)

Statement Items	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
I started learning plant physiology by relating the material to real-life issues	53.5	37.2	9.3	0	0
I invite students to make direct observations of plant physiological phenomena	46.5	46.5	7	0	0
I give students time to reflect on the plant physiology learning that is carried out	39.5	55.8	4.7	0	0

I give project-based assignments that encourage students to apply the concepts of plant physiology	55.8	37.2	7	0	0

Qualitative Level: Interview
The interview participants consisted of seven biology lecturers representing seven major islands in Indonesia: Sumatra, Kalimantan, Sulawesi, Maluku, Java, Nusa Tenggara, and Papua (**Table 5).** Of these participants, four were female and three were male. Most hold doctoral qualifications. Based on the earlier survey results, all interviewees expressed strong agreement that Life-Based Learning (LBL) plays an important role in teaching Plant Physiology, particularly in bridging abstract concepts with students' real-life experiences. Table 6 presents the characteristics of the interview participants.

Table 5. Characteristics of Interview Participants (N = 8)

Participants	Name	Gender	Academic Qualification	Affiliation	Island
P1	AN	Female	Doctoral Degree	Public University	Jawa
P2	BS	Male	Master's Degree	Private University	Sumatra
P3	CL	Female	Doctoral Degree	Public University	Kalimantan
P4	DM	Male	Doctoral Degree	Public University	Sulawesi
P5	ER	Female	Master's Degree	Private University	Maluku
P6	FN	Female	Doctoral Degree	Public University	Nusa Tenggara
P7	GP	Male	Doctoral Degree	Public University	Papua
P8	HQ	Female	Doctoral Degree	Public University	Jawa

Based on the content analysis, three overarching themes emerged that describe Indonesian biology lecturers' perceptions of implementing Life-Based Learning (LBL): (1) instructional strategies that can be integrated with LBL, (2) learning stages aligned with LBL principles, and (3) teaching experiences in Plant Physiology related to LBL (Table 7). These three themes, together with illustrative quotations from the lecturers' interviews, are elaborated in the subsequent sections (**Table 6**).

Table 6. Themes, Sub-Themes, Categories, and Codes from Qualitative Analysis

Themes	Sub-themes	Categories	Codes
Instructional Strategies Integrable with LBL	Active learning strategies	Problem-Based Learning	Facilitate real-world problem-solving
		Project-Based Learning	Connecting concepts with contextual projects
		Inquiry-Based Learning	Encourage scientific inquiry
		Contextual Teaching and Learning	Emphasizing the relevance of life
		Experiential Learning	Learning through hands-on experience
		Discovery Learning	Encourage student discovery
Learning Stages integrated with LBL	Real-Life Orientation	Contextual orientation	Connects material to real-life issues, aiding in the understanding of abstract concepts
	Exploration	Direct observation	Field practicum, observation of plant phenomena, contextual experiments
	Scientific Reflection	Scientific reflection	Class discussions, journaling/reflections, experiential presentations

	Application	Concept application	Real problem-based projects, implementation of concepts to local issues
Teaching Experiences in Plant Physiology Related to LBL	Student response	Enthusiasm & engagement	Students are more interested when the concept is associated with real phenomena, increasing active discussion
	Lecturer challenges	Pedagogical & contextual barriers	Difficult concepts to contextualise, limited facilities & time

Theme 1: instructional strategies integrable with LBL

Sub-theme 1 : active learning strategies

A key dimension emphasized by the participants was the integration of diverse active learning strategies within the Life-Based Learning (LBL) framework. Six approaches were repeatedly mentioned as particularly compatible with LBL: Problem-Based Learning (PBL), Project-Based Learning (PjBL), Inquiry-Based Learning (IBL), Contextual Teaching and Learning (CTL), Experiential Learning, and Discovery Learning. Each of these was perceived to provide authentic opportunities for connecting abstract plant physiology concepts with students' everyday realities.

Problem-Based Learning (PBL) was viewed as especially relevant, as it introduces students to real-world problems such as drought, deforestation, or urban farming. This approach helps students to move beyond theoretical understanding and connect concepts directly to everyday challenges. As one lecturer noted:

"*When we begin with real problems, such as drought and its impact on crops, students more easily grasp the concept of transpiration. They realize learning is not just theory but something linked to their daily lives*" P1.

Project-Based Learning (PjBL) was described as highly aligned with LBL, since it situates students in real projects rooted in their life context. In Plant Physiology, this includes designing hydroponic systems, cultivating local vegetables, or auditing crop health on campus farms. One lecturer illustrated:

"*When students build a mini hydroponic installation and monitor growth rates, they understand why nutrient ratios and light intensity matter. Concepts that seemed abstract become technical decisions they must make*" P2.

Inquiry-Based Learning (IBL) was highlighted as fostering scientific investigation and life relevance. It allows students to construct knowledge by questioning, experimenting, and drawing conclusions from authentic phenomena. For example, measuring transpiration rates under different conditions helps them connect physiology with issues like climate change. As expressed by one participant:

"*When students compare transpiration rates in shaded and open areas, they become more engaged and start linking concepts with environmental problems they encounter daily*." P3.

Contextual Teaching and Learning (CTL) was seen as effective in making abstract concepts more accessible by situating them in familiar contexts. Linking photosynthesis to food security or climate change was reported to raise students' awareness of the societal significance of science. One lecturer explained:

"*I usually connect photosynthesis to local food security issues. Students then realize what they are learning has relevance to the needs of their community*" P4.

Experiential Learning was described as the strongest support for LBL, as it immerses students in direct, real-life experiences. Fieldwork, farm visits, or practical experiments in water transport and photosynthesis enabled students to experience phenomena first-hand, strengthening both emotional connection and conceptual understanding. As one lecturer stated:

"*When students go into the field and observe cultivation practices, concepts like plant nutrition become easier to grasp. They learn from experience, not just from books*" P5.

Discovery Learning was also perceived as relevant, as it empowers students to construct knowledge independently through exploration and experimentation. For example, observing stomatal movement under different light conditions allowed students to derive conclusions and gain satisfaction from their own discoveries. One lecturer explained:

"*I let students try simple experiments, like testing how light affects stomatal movement. When they discover the results themselves, the satisfaction makes the concept stick in their memory*" P6.

Taken together, these findings indicate that active learning strategies provide an essential bridge between abstract plant physiology concepts and real-life applications, thereby reinforcing the transformative potential of LBL in higher education.

Theme 2: learning stages integrated with LBL

Sub-theme 1: real-life orientation

The first sub-theme emphasizes the role of real-life orientation as the foundation of Life-Based Learning (LBL). Lecturers consistently highlighted that beginning Plant Physiology instruction by linking content to authentic life experiences significantly enhances student engagement and comprehension. Real-life orientation was viewed as essential for activating students' prior knowledge and making abstract physiological processes more tangible and relevant.

Examples shared by lecturers included connecting topics such as transpiration to drought phenomena, photosynthesis to food security issues, and plant responses to climate change or urban farming practices. These contextualized entry points were considered effective in motivating students and providing meaningful anchors for deeper learning. As one lecturer explained:

"*When I start with examples of local farming problems, students immediately become interested and realize that the physiology they study directly relates to their community"* P7 Another participant emphasized: *"Relating concepts to real-life issues helps students feel that what they are learning is valuable, not just theory*." P2.

Sub-theme 2: exploration

Exploration through direct observation emerged as a stage strongly supported by the lecturers. Activities such as field practicums, laboratory studies, and visits to experimental gardens were regarded as crucial for connecting theoretical concepts with empirical phenomena. This stage provides students with opportunities to independently construct understanding through authentic observation and inquiry. As one participant described:

"*When students directly observe transpiration rates on leaves or measure chlorophyll content, they become more convinced that what they are studying truly exists, not just theory on slides*" P8.

Sub-theme 3: scientific reflection

Scientific reflection was considered essential as it provides students with the opportunity to contemplate, discuss, and integrate their learning experiences with plant physiology concepts. Through reflection, students are able to identify the extent of their conceptual development while simultaneously practicing critical thinking skills. Lecturers frequently emphasized the value of written reflection or group discussions as effective means of deepening understanding.

One lecturer explained: "*I always allocate time at the end of the practicum for reflection. Students write down what they discovered and how it relates to theory. From this, it becomes clear that they better understand concepts such as photosynthesis or respiration*" P4.

Sub-theme 4: application

The application stage was regarded as the culmination of life-based learning, as students are required to apply plant physiology concepts in real-world contexts. Applications included community-based projects, environmental campaigns, or simple innovations in crop cultivation. Lecturers viewed this stage as an avenue for students to test the relevance of their knowledge while simultaneously fostering social responsibility and ecological awareness. As one participant emphasized:

"*When students create a hydroponic project or a water conservation campaign, they not only understand physiological concepts but also learn how science can provide solutions to community problems*" P7

Theme 3: Teaching Experiences in Plant Physiology Related to LBL

Sub-theme 1: student response

Most lecturers reported that student responses to Plant Physiology instruction using the Life-Based Learning (LBL) approach were generally positive. Students became more enthusiastic, actively engaged in discussions, and demonstrated greater interest when topics were linked to real-world phenomena such as urban farming, climate change, or food security. These responses suggest that students perceived the learning process as more meaningful due to its direct relevance to their lives. As one lecturer explained:

"*When I connected the concept of photosynthesis to local food security issues, students became more eager to participate in discussions. They felt that what they were learning had a real impact, not just classroom theory*" P5.

Sub-theme 2: lecturer challenges

Despite positive student responses, lecturers also reported several challenges in implementing Life-Based Learning (LBL). These included difficulties in contextualizing highly abstract concepts such as osmotic pressure, plant enzymes, and photoperiodism, as well as limited laboratory facilities and contextual learning resources. Time constraints in course delivery were also identified as a barrier to linking complex concepts with real-world phenomena. As one lecturer explained:

"*Explaining concepts like photoperiodism with real-life examples is difficult, especially when facilities are limited. Sometimes I need to find simpler ways so that students can still grasp the essence*" P2.

Discussion

Instructional Strategies Integrable with LBL

The findings indicate that biology lecturers perceive active learning strategies as highly suitable for integration with the Life-Based Learning (LBL) approach in Plant Physiology instruction. Approaches such as Problem-Based Learning (PBL) and Project-Based Learning (PjBL) were regarded as particularly effective in situating authentic problems and projects at the core of the learning process (Aslan, 2021; Bramwell-Lalor et al., 2020). These strategies enable students not only to comprehend abstract concepts such as transpiration or photosynthesis but also to connect them with real-world issues, including climate change, food security, and urban farming practices (Jha, 2021; Newton, 2020). By engaging with problems and projects, students are encouraged to adopt more reflective and solution-oriented perspectives toward environmental challenges (Lailis et al., 2023; Wosinski et al., 2018).

Inquiry-Based Learning (IBL) and Contextual Teaching and Learning (CTL) were also perceived by lecturers as strategies that strengthen the connection between Plant Physiology instruction and students' lived experiences (Jang & Tsai, 2013). IBL provides opportunities for students to conduct simple scientific inquiries, such as measuring transpiration rates under varying environmental conditions, thereby allowing them to discover connections between concepts and real-world phenomena on their own (Artigue & Blomhøj, 2013). Meanwhile, CTL was seen as effective in reducing the complexity of abstract concepts through contextual anchors that are socially and ecologically relevant (Bustami et al., 2018). For instance, one lecturer highlighted that linking photosynthesis to local food security issues increased students' awareness of the practical significance of the concepts being taught.

Experiential Learning was identified as the most dominant strategy because it allows students to gain direct experience through field practice, experiments, or community engagement (Daya et al., 2021; Dopico et al., 2021). This finding aligns with Kolb's experiential learning theory, which emphasizes the cyclical process of concrete experience, reflection, conceptualization, and application (Ivković, 2020). In addition, Discovery Learning was viewed as enriching the learning process by providing students with opportunities to construct knowledge independently (Großmann, 2019), thereby fostering a sense of learning satisfaction and strengthening long-term understanding.

Learning Stages Integrated with LBL

The findings indicate that all stages of the Life-Based Learning (LBL) framework were perceived as relevant and received strong support from biology lecturers. The real-life orientation stage was regarded as a crucial entry point because it connects Plant Physiology content with everyday phenomena familiar to students (Munthe et al., 2023). For example, discussions on transpiration were linked to issues of drought or seasonal changes experienced directly by students (McCright, 2013). This orientation is consistent with constructivist principles, where activating prior knowledge plays a central role in constructing new understanding (Yakar et al., 2020). By situating content within social and ecological realities, students felt more motivated and recognized the relevance of learning to their own lives.

In the exploration stage, lecturers emphasized the importance of engaging students in direct observation through laboratory experiments, field studies, or simple practicum activities (Ural, 2016). Exploration provides opportunities for students to encounter empirical evidence of abstract concepts such as photosynthesis or nutrient transport. This process enriches learning experiences while fostering scientific curiosity. These findings align with Kolb's experiential learning theory, in which reflective observation represents a crucial step following concrete experience (Cecep et al., 2024; Russell et al., 2013). Exploration was considered to strengthen conceptual understanding while cultivating students' scientific inquiry skills (Ardianto & Rubini, 2016).

The stages of scientific reflection and application were also regarded as essential in LBL implementation. Reflection enables students to connect the outcomes of exploration with Plant Physiology concepts through critical discussion, reflective journals, or presentations (Lew & Schmidt, 2011). This not only deepens comprehension but also develops analytical thinking skills. Meanwhile, the application stage provides opportunities for students to implement concepts in authentic contexts, such as developing hydroponic projects, conducting environmental awareness campaigns, or designing simple innovations in local crop cultivation. By involving students in real-world actions, the application makes learning more meaningful and transformative. These findings reinforce the notion that LBL not only enhances cognitive understanding but also fosters practical skills and ecological awareness (Fachrunnisa et al., 2020; Nurjanah et al., 2020).

Teaching Experiences in Plant Physiology Related to LBL

The results revealed that students responded positively when Plant Physiology instruction was connected to real-life phenomena through the Life-Based Learning (LBL) approach. Students became more enthusiastic, actively engaged in discussions, and demonstrated improved understanding of abstract concepts when content was presented using contextual examples such as urban farming, deforestation, or food security issues (August et al., 2016; Warin et al., 2016). These findings highlight that orienting instruction toward real-life contexts enhances learning motivation and fosters students' environmental awareness (Cotner et al., 2017). The implementation of LBL was also reported to promote student motivation while strengthening their scientific communication skills (He et al., 2018).

Nevertheless, lecturers also encountered challenges in implementing LBL in Plant Physiology courses. Abstract concepts such as osmotic pressure, plant enzymes, and photoperiodism were perceived as difficult to contextualize without adequate facilities. Furthermore, limitations in laboratory infrastructure, a lack of contextual learning media, and time constraints within lecture schedules often hindered lecturers from providing fully life-based learning experiences (Ahmadi et al., 2013; Tengberg & Olin-Scheller, 2016). One of the major barriers to LBL implementation in higher education is the scarcity of supporting resources (Fachrunnisa et al., 2020).

These findings imply the need for stronger institutional support in the form of LBL-focused pedagogical training, the development of contextualized modules and teaching materials, and the provision of adequate learning facilities. Such support would allow lecturers greater flexibility in designing project-based activities, case studies, and field visits to enrich students' learning experiences (Suwono, 2019). This would further strengthen the role of lecturers as facilitators rather than mere transmitters of knowledge, guiding students toward meaningful understanding. Implementing LBL in Plant Physiology not only addresses cognitive challenges but also cultivates practical skills and reflective attitudes among students (Supriadi, 2022).

Conclusion

The findings of this study indicate that biology lecturers in Indonesia hold positive perceptions toward the implementation of Life-Based Learning (LBL) in Plant Physiology instruction. Active learning strategies such as Problem-Based Learning, Project-Based Learning, Inquiry-Based Learning, Contextual Teaching and Learning, Experiential Learning, and Discovery Learning were perceived as relevant in supporting the principles of LBL. Furthermore, the four stages of LBL—real-life orientation, exploration, scientific reflection, and application—were considered effective in enhancing students' understanding of plant physiology concepts while fostering critical thinking skills and ecological awareness. Student responses to LBL were also generally positive, although lecturers reported challenges in contextualizing abstract concepts, as well as limitations in facilities and instructional time.

This study has several limitations. First, the number of participants in both the survey and interview phases was relatively small, which may not fully represent the diversity of biology lecturers across Indonesia. Second, the instruments primarily focused on lecturers' perceptions and subjective experiences, without directly measuring the impact of LBL implementation on student learning outcomes. Third, due to time and resource constraints, the analysis focused more on descriptive accounts of perceptions rather than an in-depth evaluation of the practical effectiveness of LBL in classrooms.

Future studies are recommended to involve a larger and more representative sample of participants across different regions and higher education institutions. In addition, quasi-experimental research designs are needed to directly assess the impact of LBL on students' cognitive, affective, and psychomotor outcomes. The development of more comprehensive instruments, including classroom observations and analysis of student learning achievements, would further enrich the understanding of LBL effectiveness. Such efforts are expected to provide stronger empirical evidence on the contribution of LBL to creating meaningful, contextual, and sustainable Plant Physiology learning.

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