e-ISSN 2963-2870
Vol 6 2025

BRIDGING LABORATORY ACCESS GAPS THROUGH ONLINE PRACTICUM GUIDES IN OPEN AND DISTANCE HIGHER EDUCATION

Hikmah Zikriyani[1*], Ahmad Syaikhu[2], Mayang Anglingsari Putri[3]

[1,3]*Faculty of Science and Technology Universitas Terbuka (INDONESIA)*
[2]*Faculty of Teacher Training and Education Universitas Terbuka (INDONESIA)*

[*]hikmah.zikriyani@ecampus.ut.ac.id

Abstract

Access to laboratory-based learning remains a persistent challenge in open and distance education, particularly for science disciplines requiring fieldwork. This study presents the development of an online practicum guide for the Ecology course at Universitas Terbuka, designed to address disparities in practicum access among geographically dispersed learners. Drawing on international benchmarking, expert validation, and contextual adaptation, the guide integrates modular field-based activities that can be conducted independently using locally available materials. Supported by video tutorials, QR-linked resources, and structured mentoring, the guide enables students to conduct ecological observations in freshwater, terrestrial, and urban environments. The initiative not only enhances practical competence and ecological literacy but also reveals opportunities for institutional collaboration and educational entrepreneurship through the distribution of practicum kits. Aligned with open education principles, the guide offers a scalable model for delivering meaningful practicum experiences in remote learning contexts and demonstrates the potential for innovation in science education within ODL systems.

Keywords: Distance Learning, Ecology Education, Instructional Innovation, Online Practicum, Open Educational Practices, Universitas Terbuka.

1 INTRODUCTION

In science education, laboratory-based learning plays significant role in science education, develop scientific notations and create models to test hypotheses (Riaz et al., 2023). Within the framework of distance science education at Universitas Terbuka (UT), the development of laboratory skills remains essential for promoting student engagement, enhancing conceptual understanding, and cultivating critical thinking abilities (Shana & Abulibdeh, 2020). Tshojay & Giri (2021) support the statement by stated practicum/practice is a form of teaching and learning activity intended to strengthen mastery of applicable material. Through practicum/practice, a person can comprehensively learn three competencies: cognitive, affective, and psychomotor (Yunus & Yuliana, 2020). However, within the framework of open and distance higher education, ensuring equitable access to laboratory experiences remains a considerable challenge. Unlike traditional university settings, distance education learners are

e-ISSN 2963-2870
Vol 6 2025

often scattered across regions with limited or no access to laboratory facilities. This structural limitation has been particularly evident in the biology undergraduate program at UT, where students enrolled in courses such as Ecology struggle to complete the practicum component.

The issue is particularly evident in the Biology undergraduate program at UT, where students enrolled in courses such as Ecology face persistent difficulties in fulfilling practicum requirements due to both geographic and logistical barriers. A 2022 student-led survey revealed that 49% of participants lived more than 40 kilometers from the nearest practicum site, while 19% resided between 20–40 kilometers away. Only 19% of respondents reported living in close proximity to practicum locations. This distribution highlights a widespread issue: the majority of students are located far from institutional partners providing practicum opportunities. In addition to distance-related barriers, students also reported concerns regarding the condition of practicum facilities. Of the 228 respondents, 22% reported dissatisfaction with the cleanliness and maintenance of partner institution facilities, while 16% indicated that the available laboratory infrastructure was minimal or inadequate (unpublished report, 2024). These findings are consistent with the broader literature, which emphasizes that in blended-learning environments, satisfaction with face-to-face tutorials constitutes a critical component of the teaching–learning process, particularly for students new to distance education (Budiman et al., 2017). Prior studies have sought to identify factors influencing such satisfaction and consistently show that, although learners value the benefits of direct, in-person engagement, geographical distance remains a substantial impediment in practicum-based courses. These findings underscore the urgent need for alternative practicum delivery models that are both accessible and pedagogically sound.

While previous research has explored the use of virtual labs and simulations as substitutes for physical laboratories in distance learning contexts (de Vries & May, 2019; Dyrberg et al., 2017; Mercado & Picardal, 2023). These approaches offer partial solutions, often emphasizing experimental sciences and relying on digital infrastructure or specialized equipment that may not be universally accessible to students in remote areas. Moreover, few studies have addressed the unique challenges of field-based disciplines like ecology, which require direct interaction with natural environments.

The present study seeks to address this gap by designing a structured, yet flexible, online practicum guide specifically for the Ecology course in the Biology study program at UT. Unlike prior approaches, this guide integrates practical fieldwork that students can conduct

e-ISSN 2963-2870
Vol 6 2025

independently in their local surroundings, guided by modular instructions, safety protocols, conceptual frameworks, and video demonstrations. The novelty of this work lies in emphasizing place-based ecological inquiry adapted for distance learners, employing low-barrier technologies, and aligning with national educational goals for inclusive and flexible learning. Through collaborative development with subject experts, benchmarking international practices, and incorporating user feedback, this guide not only enhances learning access but also offers a replicable model for other science programs facing similar challenges. There will be design process, implementation strategies, and implications for broader adoption in distance higher education.

2 METHODOLOGY

This study employed a developmental qualitative approach, grounded in a problem-solving cycle centered on improving practicum access within a distance learning context. The initiative was started in the Biology Undergraduate Program at Universitas Terbuka, a fully online higher education institution in Indonesia. The methodology was designed to systematically address the challenge of unequal access to ecological field practicums, particularly for students residing in geographically remote areas with limited access to the university's partnered laboratory facilities. To overcome this, the approach incorporated the use of each student's local environmental surroundings as a contextual learning resource, enabling them to conduct field-based ecological observations and data collection within their own communities.

The development of the online practicum guide followed six major phases:

2.1 Initial Discussion and Needs Assessment

The process began with structured consultations involving course coordinators, subject matter experts, and Institute for Research and Community Service of UT. These discussions aimed to map existing practicum difficulties and identify core practical competencies required by the Ecology course. articular attention was given to ensuring that the practicum goals were consistent with both the course's general competencies and the existing curriculum framework.

2.2 Benchmarking and Literature Exploration

A benchmarking exercise was conducted through desk research, exploring international models of online science laboratories and practicum simulations. Institutions with recognized distance learning programs, such as La Trobe University and Penn State World Campus were examined to gather best practices and pedagogical strategies adaptable to the Indonesian context.

Literature related to remote science education, instructional design for practical skills, and digital ecology labs informed the content development.

2.3 Guide Drafting and Content Design

Drawing from both institutional consultation and benchmarking data, a preliminary draft of the online practicum guide was produced. The draft included structured instructions for field observation, sample data collection protocols, analysis templates, and links to supplementary video demonstrations. Each module was designed to be flexible, allowing students to conduct practicum tasks independently using accessible materials from their local environments.

2.4 Expert Review and Validation

To ensure academic rigor and pedagogical relevance, the draft guide was reviewed by three ecology lecturers from different Indonesian universities. Feedback was collected via structured questionnaires and follow-up interviews. Suggested improvements were incorporated, especially concerning clarity of instructions, feasibility of independent tasks, and alignment with the course’s learning outcomes.

2.5 Revision and Finalization

Based on the validation results, the guide underwent a series of content refinements. Additional contextual was added to better suit diverse ecological conditions across student domiciles, particularly in rural and maritime areas. Language adjustments were also made to ensure clarity and instructional coherence.

2.6 Approval and Institutional Integration

The finalized guide was formally submitted to the head of biology study program and course coordinators for internal endorsement. It was approved as a complementary resource to support the Ecology practicum course and proposed to be included in the learning management system (LMS) and course material package.

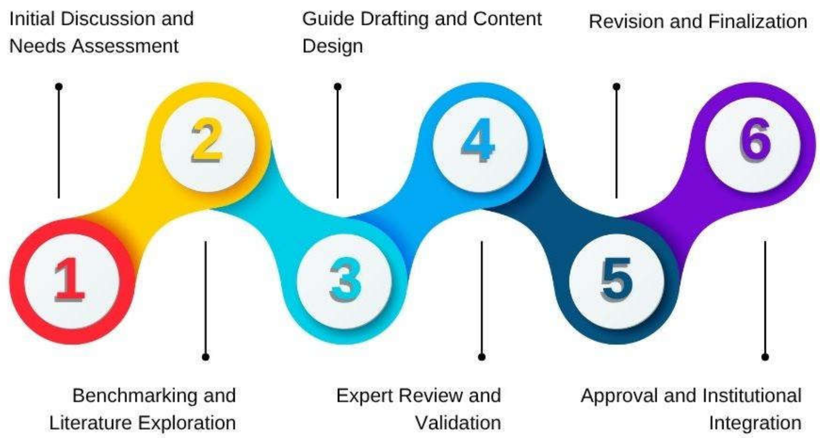


Figure 1. Six major phases of the development of the online practicum guide

Throughout the process, the development emphasized collaborative input, contextual adaptability, and student-centered design. The methodology also reflects 3 out of six Universitas Terbuka's institutional values (KIIARA) of quality, accessibility, and innovation in higher education.

3 FINDINGS AND DISCUSSION

The development of the online practicum guide at Universitas Terbuka began in 2020, with several forms: online practicum/practice and asynchronous online mentoring; on-site practicum/practice and mentoring carried out online asynchronously through e-learning (Moodle); on-site practicum/practice and mentoring carried out synchronously online through webinars (Yunus & Yuliana, 2020). During the pandemic, biology courses were often conducted in hybrid formats, relying heavily on remote supervision. The needs and lifestyle of digital natives are shaping a social model that demands proficiency in technology utilization and significant contributions across various domains of life (Budiman & Syafrony, 2023). These experiences laid the groundwork for the current practicum guide, which consolidates lessons from earlier models into a single, structured framework. The finalized guide yields both tangible course-level learning outcomes and institutional readiness for broader implementation. It also offers a viable solution for students unable to access physical laboratories, especially those in remote regions, a demographic heavily represented in UT's distance education system.

3.1 Guide Development and Institutional Integration

By benchmarking online science laboratories and practicum simulations from institutions with established distance learning programs, such as La Trobe University, Abbey (2020) identified three feasible models for designing an online practicum: the mail-order lab, the home lab, and the online lab. Based on these models, the Ecology practicum was collaboratively developed with subject matter experts to align with curriculum expectations. The modules was subsequently validated by ecology lecturers. The final version was implemented through the university's LMS, featuring accessible instructions, downloadable templates, and video tutorials. Students were required to submit written reports along with short video documentation of their practicum activities.

The guide was organized into three modules corresponding to key topics in the practicum ecology module's book STBI4143, such as water ecosystem, land ecosystem, and ecology of population. Each module includes step-by-step procedures, locally adaptable observation checklists, and spaces for data entry. A series of instructional videos, demonstrating the use of simple field tools and techniques, were also embedded via quick-response code (QR codes) and hyperlinks to facilitate self-directed learning.

Although the practicum guide enables independent fieldwork, students are also supported with a structured mentoring process. This includes three mentoring sessions conducted by instructors: (1) before the practicum to explain procedures and expectations, (2) after the field experiment to guide data analysis, and (3) during the final reporting stage. These sessions ensure academic integrity, provide clarification, and help students interpret ecological findings accurately. The mentoring is facilitated online (both synchronously and asynchronously) depending on student accessibility. The arrangement reflects ongoing collaboration between the Biology study program, the central academic units of Universitas Terbuka, and regional UT offices called as UT *daerah*, which continue to play a vital role in coordinating practicum activities across Indonesia.

3.2 Development Relevance and Pedagogical Value

The collaborative and iterative development process ensured that the guide aligned with general and specific course competencies for ecology and addressed structural inequities in practicum access. This reflects previous research highlighting the importance of contextualizing practical science for distance learners. The use of Learning Management System (LMS) integration and flexible access materials is essential in asynchronous education models.

Table 1. Mapping of Online Practicum Modules to general and specific course competencies from STBI4143

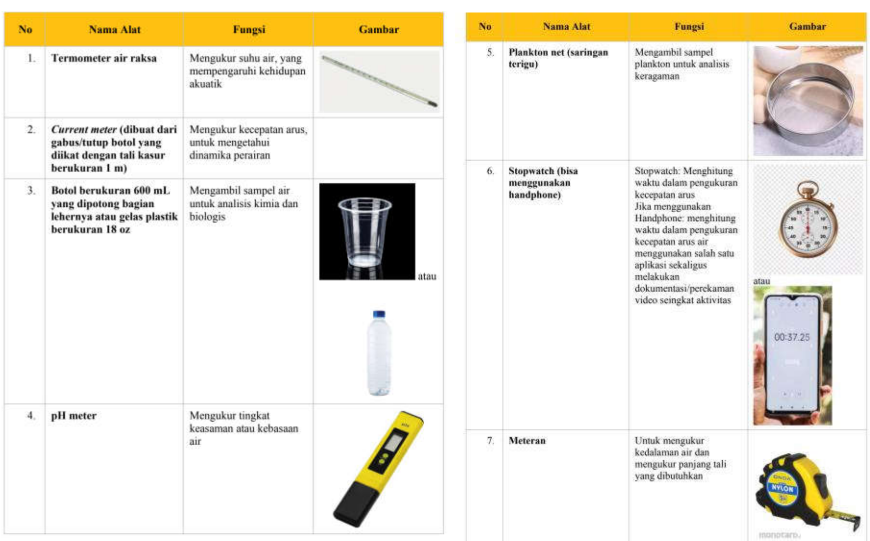
Module	Related general and specific course competencies from STBI4143	Learning activities in the online practicum guidelines
Module 1: Freshwater Ecosystem	Explain the principles and concepts of ecology and apply them in the management of aquatic environments 1. Identify and describe measuring instruments and sampling tools used in aquatic ecosystem practicum, 2. explain the functions of measuring instruments and sampling tools used in aquatic ecosystem practicum, 3. explain how to use measuring instruments and sampling tools in aquatic ecosystem ecology, 4. determine the location or station for environmental measurements, 5. measure the chemical parameters of freshwater ecosystems, 6. identify and calculate plankton diversity in freshwater ecosystems.	1. Measuring water parameters (temperature, pH, current, depth) 2. Identifying macro zoobenthos in rivers, lakes, or ponds
Module 2: Terrestrial Ecosystems	Apply knowledge and techniques in terrestrial ecosystems to environmental management 1. Determine research plots using the quadrat sampling method, 2. measure parameters in vegetation analysis of garden ecosystems, 3. measure limiting factors in garden ecosystems, 4. measure parameters in vegetation analysis of grassland ecosystems, 5. measure limiting factors in grassland ecosystems.	1. Quadrat-based sampling of plant communities 2. Calculating frequency, dominance, and Shannon-Wiener diversity index
Module 3: Animal’s behaviour	Observe biodiversity and understand population-level dynamics 1. Observe and analyse defensive behaviours in organisms 2. Explore survival strategies in response to physical environmental conditions	1. Conducting pitfall trapping of soil insects 2. Comparing captures across habitats and times 3. Analysing factors influencing population variation

e-ISSN 2963-2870
Vol 6 2025

3.2.1 Module 1: Freshwater Ecosystem

This module introduces procedures for assessing both abiotic and biotic components of freshwater ecosystems. It guides students to conduct field observations in accessible aquatic environments (such as rivers, lakes, or ponds) using simple, improvised tools like plastic bottles, thermometers, and basic current-measuring devices. The module also outlines the required materials in advance (Figure 2a), allowing students to prepare independently. Observations include the measurement of water temperature, depth, flow velocity, and pH levels, followed by sampling of macro zoobenthos (particularly molluscs) using commonly available equipment such as sieves or household strainers.

Although the practicum has not yet been fully implemented with students, the module is designed to enable learners to document ecological observations and apply basic ecological calculations, such as species density using Krebs' formula. It introduces fundamental field techniques and aims to enhance student understanding of freshwater ecosystems, particularly by connecting ecological parameters to pollution indicators through biological monitoring of aquatic organisms. To support independent learning, the module includes QR codes that link to YouTube videos demonstrating key procedures—such as measuring water quality and conducting macro zoobenthos sampling, using simple, locally accessible tools (Figure 4). QR codes provide an efficient tool for learning, as their high data capacity and compatibility with smartphones allow students to access materials quickly, engage more actively, and share resources with ease. QR codes included in this guide are considered effective learning tools, providing access to high-quality, and relevant instructional videos (Bakri et al., 2020).



No	Nama Alat	Fungsi	Gambar
1.	**Termometer air raksa**	Mengukur suhu air, yang mempengaruhi kehidupan akuatik	
2.	***Current meter* (dibuat dari gabus/tutup botol yang diikat dengan tali kasur berukuran 1 m)**	Mengukur kecepatan arus, untuk mengetahui dinamika perairan	
3.	**Botol berukuran 600 mL yang dipotong bagian lehernya atau gelas plastik berukuran 18 oz**	Mengambil sampel air untuk analisis kimia dan biologis	atau
4.	**pH meter**	Mengukur tingkat keasaman atau kebasaan air	
5.	**Plankton net (saringan terigu)**	Mengambil sampel plankton untuk analisis keragaman	
6.	**Stopwatch (bisa menggunakan handphone)**	Stopwatch: Menghitung waktu dalam pengukuran kecepatan arus Jika menggunakan Handphone: menghitung waktu dalam pengukuran kecepatan arus air menggunakan salah satu aplikasi sekaligus melakukan dokumentasi/perekaman video seingkat aktivitas	atau
7.	**Meteran**	Untuk mengukur kedalaman air dan mengukur panjang tali yang dibutuhkan	

a.

A. **Suhu Air**

Hasil Pengamatan

No	Percobaan ke	Hasil pengukuran di titik 1 (^{0}C)	Hasil pengukuran di titik 2 (^{0}C)	Hasil pengukuran di titik 3 (^{0}C)
1	Percobaan ke 1			
2	Percobaan ke 2			
3	Percobaan ke 3			
4	Suhu Rata-rata			

b.

6.	**Identifikasi dan Penghitungan Kepadatan Spesies Makrozoobentos**	Prosedur pengambilan sampel Makrozoobentos 1. Gunakan plankton net/saringan yang ada di dalam kit praktikum ekologi untuk menyaring lumpur/pasir di dasar perairan pada titik lokasi yang telah ditentukan. 2. Kumpulkan makrozoobentos dalam wadah (botol bening yang telah diberikan Alkohol 70%) 3. Amati sampel di bawah mikroskop atau kaca pembesar (jika tidak ada mikroskop, bisa mencari hewan bercangkang dengan ukuran yang bisa dilihat dengan mata) 4. Hitung jumlah individu hewan bercangkang yang ditemukan pada setiap titik lokasi 5. Dokumentasikan spesies hewan bercangkang yang ditemukan untuk dimasukkan ke dalam laporan 6. Hitung kepadatan spesies Mollusca menggunakan rumus Krebs (1998), berdasarkan jumlah individu yang ditemukan di kuadrat dengan ukuran 0,5 x 0,5 meter. $d = \frac{x}{z\,(m^2)}$	https://www.youtube.com/watch?v=TVhGqb5WYY8

c.

Figure 2. The content of module 1 of the ecology online practicum

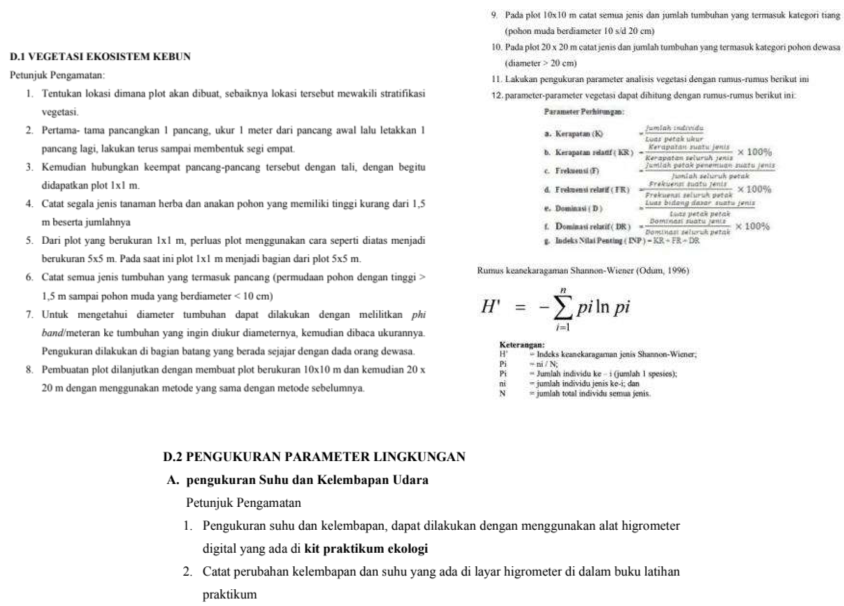
a. Example of materials needed to the practicum; b. the example of observation table for one practicum; c. the example of practicum procedure complete with qr code of video

3.2.2 Vegetation Analysis in Terrestrial Ecosystems

The module is designed to guide students in observing vegetation structure through plot-based sampling in gardens or nearby green spaces. The practicum activities involve creating nested quadrats (1×1 m to 20×20 m), classifying plants by strata, and analysing biodiversity using ecological indices such as frequency, dominance, and the diversity using formula given. (Sadia et al., 2024) stated community structure help to investigates the diversity patterns, vegetation structure, and environmental influences on terrestrial ecosystem biodiversity. The module encourages students to explore accessible landscapes, such as yards, parks, or field edges, to understand vegetation patterns and environmental influences (Figure 3). Sah et al. (2014) stated understanding how the biological communities in the terrestrial ecosystems function in the

e-ISSN 2963-2870
Vol 6 2025

presence of different structural components is the central point of plant-animal interactions both from ecological and evolutionary contexts. Although the guide has not yet been implemented, it is intended to foster ecological awareness and develop students' ability to analyse plant community structures in diverse terrestrial settings. With this analysation, the module given education about environment. Nisiforou & Charalambides (2012) stated environmental education is considered a pillar in developing responsible environmental attitudes and behaviour. This environmental education will enable students to identify problems and develop solutions.



D.1 VEGETASI EKOSISTEM KEBUN

Petunjuk Pengamatan:

1. Tentukan lokasi dimana plot akan dibuat, sebaiknya lokasi tersebut mewakili stratifikasi vegetasi.
2. Pertama- tama pancangkan 1 pancang, ukur 1 meter dari pancang awal lalu letakkan 1 pancang lagi, lakukan terus sampai membentuk segi empat.
3. Kemudian hubungkan keempat pancang-pancang tersebut dengan tali, dengan begitu didapatkan plot 1x1 m.
4. Catat segala jenis tanaman herba dan anakan pohon yang memiliki tinggi kurang dari 1,5 m beserta jumlahnya
5. Dari plot yang berukuran 1x1 m, perluas plot menggunakan cara seperti diatas menjadi berukuran 5x5 m. Pada saat ini plot 1x1 m menjadi bagian dari plot 5x5 m.
6. Catat semua jenis tumbuhan yang termasuk pancang (permudaan pohon dengan tinggi > 1,5 m sampai pohon muda yang berdiameter < 10 cm)
7. Untuk mengetahui diameter tumbuhan dapat dilakukan dengan melilitkan *phi band*/meteran ke tumbuhan yang ingin diukur diameternya, kemudian dibaca ukurannya. Pengukuran dilakukan di bagian batang yang berada sejajar dengan dada orang dewasa.
8. Pembuatan plot dilanjutkan dengan membuat plot berukuran 10x10 m dan kemudian 20 x 20 m dengan menggunakan metode yang sama dengan metode sebelumnya.
9. Pada plot 10x10 m catat semua jenis dan jumlah tumbuhan yang termasuk kategori tiang (pohon muda berdiameter 10 s/d 20 cm)
10. Pada plot 20 x 20 m catat jenis dan jumlah tumbuhan yang termasuk kategori pohon dewasa (diameter > 20 cm)
11. Lakukan pengukuran parameter analisis vegetasi dengan rumus-rumus berikut ini
12. parameter-parameter vegetasi dapat dihitung dengan rumus-rumus berikut ini:

Parameter Perhitungan:

a. **Kerapatan (K)** $= \frac{\text{Jumlah individu}}{\text{Luas petak ukur}}$

b. **Kerapatan relatif (KR)** $= \frac{\text{Kerapatan suatu jenis}}{\text{Kerapatan seluruh jenis}} \times 100\%$

c. **Frekuensi (F)** $= \frac{\text{Jumlah petak penemuan suatu jenis}}{\text{Jumlah seluruh petak}}$

d. **Frekuensi relatif (FR)** $= \frac{\text{Frekuensi suatu jenis}}{\text{Frekuensi seluruh petak}} \times 100\%$

e. **Dominasi (D)** $= \frac{\text{Luas bidang dasar suatu jenis}}{\text{Luas petak petak}}$

f. **Dominasi relatif (DR)** $= \frac{\text{Dominasi suatu jenis}}{\text{Dominasi seluruh petak}} \times 100\%$

g. **Indeks Nilai Penting (INP)** = KR + FR + DR

Rumus keanekaragaman Shannon-Wiener (Odum, 1996)

$$H' = -\sum_{i=1}^{n} pi \ln pi$$

Keterangan:

H' = Indeks keanekaragaman jenis Shannon-Wiener;
Pi = ni / N;
Pi = Jumlah individu ke – i (jumlah 1 spesies);
ni = jumlah individu jenis ke-i; dan
N = jumlah total individu semua jenis.

D.2 PENGUKURAN PARAMETER LINGKUNGAN

A. pengukuran Suhu dan Kelembapan Udara

Petunjuk Pengamatan

1. Pengukuran suhu dan kelembapan, dapat dilakukan dengan menggunakan alat higrometer digital yang ada di **kit praktikum ekologi**
2. Catat perubahan kelembapan dan suhu yang ada di layar higrometer di dalam buku latihan praktikum

Figure 3. The content of module 2 of the ecology online practicum

3.2.3 Animal's behaviour

The module focuses on introducing population ecology of insects through a simple pitfall trapping method. This practicum reimagines urban areas, not just as human-dominated spaces, but as valuable fragments of ecological landscapes that support biodiversity and vital functions. These environments offer accessible opportunities for students to engage in home-based ecological investigations, including observing insect populations and potentially identifying species that are either new to science or previously undocumented in the region. Insects offer abundant opportunity for introducing their indispensable roles as pollinators and recyclers, as well as the concept of biodiversity and its threats from habitat fragmentation and loss, invasive species, and disturbances such as drought, fire, and storms (Wheeler, 2008).

e-ISSN 2963-2870
Vol 6 2025

Students are expected to use household containers as insect traps, placed in different habitat conditions (shaded vs open, day vs night) over a short period. The practicum encourages analysis of insect behaviour in relation to environmental factors such as humidity and light exposure (Figure 4). While the practicum module STBI4143 emphasizes behavioural ecology, particularly defensive strategies and survival responses to physical environments, this online module guidelines extend that foundation by exploring population-level dynamics. The module guides students in identifying patterns of abundance, diversity, and microhabitat preference, thereby enriching their understanding of how organisms interact with their surroundings at both the individual and population scales. In doing so, it bridges individual behavioural observations with broader ecological analysis, offering a comprehensive perspective aligned with the goals of field-based population ecology. By framing these investigations within urban settings, the module emphasizes that built environments can also provide valuable opportunities for exploring biodiversity. Wheeler (2008) notes that close engagement with urban insect life not only enhances ecological literacy but also fosters a stronger personal connection to the natural world as an important goal in environmental education.

a. Persiapan *Pitfall Trap:*

1. Siapkan 4 botol selai (pitfall trap) dengan ketentuan:
   - 2 botol untuk hewan diurnal, dimana satu botol diletakkan di bawah naungan pohon, satu lagi di area terbuka/tanpa vegetasi (diletakkan di pagi hari dan diambil sore hari).
   - 2 botol untuk hewan nocturnal, dimana satu botol diletakkan di bawah naungan pohon, satu lagi di area terbuka/tanpa vegetasi (diletakkan sore hari dan diambil pagi hari).
2. Isi setiap botol dengan cairan gliserin atau air gula sebagai umpan, dan tambahkan alkohol 70% untuk membuat serangga pingsan atau mati saat terperangkap.

b. Proses Pengambilan Sampel

- Untuk hewan nokturnal: Letakkan botol sore hari (permukaan botol harus rata dengan tanah) dan ambil pada pagi hari berikutnya.
- Untuk hewan diurnal:Letakkan botol pada pagi hari dan ambil pada sore hari.
- Pastikan botol tertutup jika hujan agar cairan di dalam botol tidak tercampur air hujan

c. Pengambilan Data

- Ulangi langkah 3-5 selama 3 hari berturut-turut.
- Setiap hari, catat jumlah dan jenis serangga yang terperangkap di setiap botol.

LAPORAN PRAKTIKUM

Mata Kuliah :

Masa Registrasi : ....

Unit Praktikum : Ekologi Populasi

Tujuan Praktikum :

a. Mengenal metode sampling hewan dengan teknik *pitfall trap*.
b. Menganalisis pertambahan atau penurunan populasi hewan berdasarkan pengamatan menggunakan pitfall trap.
c. Membandingkan jumlah hewan yang terperangkap di bawah vegetasi dan d terbuka selama 3 hari.
d. Mendiskusikan faktor-faktor yang menyebabkan perubahan populasi.

HASIL:

1. Identifikasi serangga yang tertangkap

Gambar 1. Beberapa jenis semut yang akan diperangkap

 e-ISSN 2963-2870
Vol 6 2025

2. Tabulasikan data jumlah dan jenis hewan yang terperangkap untuk masing-masing lokasi dan waktu (diurnal vs. nocturnal, di bawah vegetasi vs. area terbuka) dalam tabel berikut.

Tabel 1. Hasil Pengamatan Serangga Tanah

NO	JENIS HEWAN (NAMA LATIN)	JUMLAH RATA-RATA	
		DIURNAL	NOCTURNAL
1	...	...	...
2	...	...	...
3	...	...	...
4	...	...	...
5	dat	...	...
	TOTAL	...	...

3. Bandingkan hasil penangkapan serangga antara:
   a. Hewan diurnal dan nocturnal.
   b. Botol di bawah vegetasi dan botol di area terbuka.
   c. Jumlah serangga yang terperangkap selama hari pertama, kedua, dan ketiga.

Figure 4. The content of module 3 of the ecology online practicum

3.3 Bridging Gaps and Implications for Distance Learning

The guide addresses a critical gap in the literature, how to design field-based, rather than simulated, practicum alternatives for distance learners. Unlike many virtual labs that rely on digital simulations and bandwidth-heavy applications, this guide provides tangible ecological experiences. It promotes an exploratory approach to the environment, encouraging engagement with local ecological contexts and allowing for firsthand discovery and reflection (Nisiforou & Charalambides, 2012). Such engagement not only enhances ecological awareness but also cultivates a deeper appreciation for biodiversity and its role in sustaining life (Wheeler, 2008).

3.4 Emerging Opportunities from the Online Practicum Guide

The implementation of this guide demonstrated not only pedagogical value, but also revealed opportunities for institutional collaboration and educational entrepreneurship. Examining La Trobe University's distance laboratory approach, especially its mail-order model, where experiment kits are assembled on campus and delivered to students, shows both the advantages and the drawbacks of this system. La Trobe faced significant challenges, particularly high costs and logistical complexity (Abbey, 2020). In contrast, Universitas Terbuka has adopted a strategy that is better suited to its context and helps overcome these barriers. Collaborative efforts involving the *Pusat Layanan Bahan Ajar* (PUSLABA), which oversees learning material distribution, UT *daerah*, and third-party logistics providers have facilitated the delivery of practicum kits to students in geographically dispersed areas.

The need for accessible and low-cost laboratory kits has also led to initiatives for packaging and distributing essential tools (such as pH meters, thermometers, measuring ropes, and sample containers) through university-supported channels. In addition to improving access to practical learning, this model also opens opportunities to build a broader ecosystem of educational entrepreneurship. By centralizing the procurement and distribution of materials, institutions can reduce the burden on learners, especially those in remote or underserved areas. This opens a promising opportunity for PUSLABA and UT *daerah* to collaborate not only in educational delivery but also in providing affordable, equitable, and potentially revenue-generating solutions.

Furthermore, the guide's design and implementation align closely with the principles of the open education movement, which emphasizes the use of open practices, technologies, and collaborative networks to transform access to knowledge. As Ramirez-Montoya (2020) note, the most impactful innovations in open education are those that intentionally seek to reconfigure educational systems toward greater equity and participation. By linking pedagogical content with logistical solutions, the online practicum guide contributes meaningfully to this vision, enabling inclusive, practice-based learning while reinforcing the institutional capacity to scale and sustain quality science education in remote learning environments.

4 CONCLUSION

The development and implementation of an online practicum guide for the Ecology course at Universitas Terbuka has addressed the long-standing challenge of providing equitable laboratory access to distance learners. Through modular, field-based activities tailored to students' local environments, the guide promotes practical competency, ecological awareness, and scientific thinking in real-world contexts. The integration of this guide into UT's LMS, along with the support of asynchronous mentoring and accessible instructional materials, demonstrates that meaningful practicum learning is possible even without traditional laboratories. Additionally, the initiative opens new opportunities for institutional collaboration and educational entrepreneurship, such as the distribution of practicum kits through university channels. This approach may serve as a replicable model for other ODL institutions, particularly those in geographically diverse or underserved regions.

ACKNOWLEDGEMENTS

The authors would like to express sincere gratitude to the Biology Study Program of Universitas Terbuka and the dedicated lecturers who provided validation and constructive feedback on the content of the online practicum guidelines. Special thanks are also extended to Dr. Yuni Tri Hewindati for her valuable insights and mentorship throughout the development of this work. Her guidance greatly enriched the quality and direction of the study.

REFERENCES

Bakri, F., Salsabila, S., & Muliyati, D. (2020). QR-Code Assisted Learning Book: Scientific-Based Physical Learning Solution. *Proceedings of the 7th Mathematics, Science, and Computer Science Education International Seminar, MSCEIS 2019*. https://doi.org/10.4108/eai.12-10-2019.2296464

Brian Abbey. (2020). Lab experiments moved online or mailed. *Https://Www.Latrobe.Edu.Au/News/Articles/2020/Opinion/Lab-Experiments-Moved-Online-or-Mailed*

Budiman, R., Riyanto, A., & Efendi, Y. (2017). *Student Satisfaction on Face-to-Face Tutorials in a Blended Learning Environment*. https://www.researchgate.net/publication/321526770

Budiman, R., & Syafrony, A. I. (2023). The digital literacy of first-year students and its function in an online method of delivery. Asian Association of Open Universities Journal, 18(2), 176–186. https://doi.org/10.1108/AAOUJ-01-2023-0017

de Vries, L. E., & May, M. (2019). Virtual laboratory simulation in the education of laboratory technicians–motivation and study intensity. *Biochemistry and Molecular Biology Education*, *47*(3), 257–262. https://doi.org/10.1002/bmb.21221

Dyrberg, N. R., Treusch, A. H., & Wiegand, C. (2017). Virtual laboratories in science education: students' motivation and experiences in two tertiary biology courses. *Journal of Biological Education*, *51*(4), 358–374. https://doi.org/10.1080/00219266.2016.1257498

Mercado, J. C., & Picardal, J. P. (2023). Virtual Laboratory Simulations in Biotechnology: A Systematic Review. *Science Education International*, *34*(1), 52–57. https://doi.org/10.33828/sei.v34.i1.6

Nisiforou, O., & Charalambides, A. G. (2012). Assessing Undergraduate University Students' Level of Knowledge, Attitudes and Behaviour Towards Biodiversity: A case study in Cyprus. *International Journal of Science Education*, *34*(7), 1027–1051. https://doi.org/10.1080/09500693.2011.637991

Onlinecourses, S., & Yamagata-Lynch, L. C. (n.d.). *Blending Online Asynchronous and Synchronous Learning*.

Ramirez-Montoya, M. S. (2020). Challenges for open education with educational innovation: A systematic literature review. In *Sustainability (Switzerland)* (Vol. 12, Issue 17). MDPI. https://doi.org/10.3390/su12177053

Riaz, S., Kousar, S., Saddique, R., & Rafiq, M. (2023). An Analysis of Laboratory Skills Among University Science Students. *IRASD Journal of Educational Research*, *4*(1), 10–17. https://doi.org/10.52131/jer.2023.v4i1.2199

Sadia, S., Waheed, M., Firdous, S., Arshad, F., Fonge, B. A., & Al-Andal, A. (2024). Ecological analysis of plant community structure and soil effects in subtropical forest ecosystem. *BMC Plant Biology*, *24*(1). https://doi.org/10.1186/s12870-024-06012-5

Sah, P., Singh, L. O., Clauset, A., & Bansal, S. (2014). *Exploring community structure in biological networks with random graphs*. http://www.biomedcentral.com/1471-2105/15/220

Shana, Z., & Abulibdeh, E. S. (2020). Science practical work and its impact on students'science achievement. *Journal of Technology and Science Education*, *10*(2), 199–215. https://doi.org/10.3926/JOTSE.888

Tshojay, P., & Giri, N. (2021). Contextualized approach in teaching Chemistry: The perspectives and practices of teachers and students. In *International Journal of Applied Chemical and Biological Sciences* (Vol. 2, Issue 4). www.visnav.in/ijacbs/

Wheeler, A. G. (2008). *College Campuses: Patches of Insect Diversity, Opportunities for Entomological Discovery, and Means for Enhancing Ecological Literacy*. https://academic.oup.com/ae/article-abstract/54/1/18/2474858

Yunus, M., & Yuliana, E. (2020). The Challenges of Open and Distance Learning in Managing Practicums/Practical Courses during the Covid-19 Pandemic: Universitas Terbuka Case Study The Challenges of Open and Distance Learning in Managing. In *ASEAN Journal of Open and Distance Learning ↲ Special Issue* (Vol. 12, Issue 2).