

From Species Observation to Practical Ecological Competence: Advancing iNaturalist-Enabled Fieldwork for Transformative Outcomes in Landscape Architecture Education

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ABSTRACT

This study redefines the role of iNaturalist in landscape architecture education by transforming it from a simple exercise in technology acceptance into a carefully planned intervention that is clearly linked to the course's learning outcomes. The innovation directly supports Course Learning Outcome 1 (CLO1): "Explain the ecological knowledge of the scientific principles, concepts, and processes in landscape ecology," and is in line with the Malaysian Qualifications Framework (MQF) 2.0 Program Learning Outcome 3 (PLO3) (Practical Skills) at the psychomotor P5 level (Complex Overt Response). Through the iNaturalist platform, the intervention fluently integrates field observation, mobile device-based biodiversity recording, species identification, geolocation, verification, and interpretation. The data were gathered from students taking the Ecosystem and Landscape Ecology course at the UiTM Perak Branch in Malaysia, as well as from the biodiversity records produced through the iNaturalist project. Eighty-three students participated in field observations at Taman Rekreasi MADANI Sungai Pinji in Ipoh, Perak, Malaysia, and recorded 268 species. The evidence shows that the students were actively engaged and came to appreciate the value of iNaturalist for observation, biodiversity identification, and a better understanding of ecology. While this study goes beyond measuring satisfaction to provide analytical evidence of CLO1 achievement, it also presents a constructivist alignment model that connects ecological knowledge to actual field performance and real biodiversity data. The findings show that iNaturalist functions as a practical link between the ecological principles taught in the classroom and the psychomotor skills needed to observe, document, verify, and interpret ecological features in real landscapes. The results deliver clear and unambiguous evidence of better learning outcomes: out of 83 score entries, the group obtained an average of 9.52 out of 10 (standard deviation = 1.09), with scores varying from 3.63 to 10.00, and 98.80% of the students (82 out of 83) scoring above the 5.00 out of 10 thresholds. As a result, the study creates a solid framework for educational innovation in landscape architecture programmes seeking to improve their students' practical ecological skills through accessible digital citizen science tools.

Keywords: iNaturalist, landscape architecture education, course learning outcome, field-based learning, MQF 2.0 Program Learning Outcome

INTRODUCTION

Landscape architecture education requires students to bridge ecological theory and hands-on observation of living systems (Mehlhorn & Davidson, 2026; Townley et al., 2024; Warners et al., 2026). True professional

competence in identifying and recording species, habitats, ecological interactions, and environmental processes is cultivated when learners interact directly with these phenomena in authentic environments (Cancino et al., 2025; Rode & Torkar, 2023; Tolhurst et al., 2023). Field-based learning is thus fundamental to ecology-focused landscape architecture curricula, exposing students to the variability, complexity, and spatial relationships that are tough to replicate in classroom environments (Arts et al., 2025; Liu & Chen, 2023; Richter et al., 2020). Because landscape design is anchored in the perception and interpretation of site-specific characteristics, direct site experience must precede form-making instruction and serve as the foundation for design learning (Liu & Chen, 2023). Nonetheless, a persistent capacity gap exists—particularly at the local level—in effective ecological site monitoring. Integrating research-driven experiential learning using structured student fieldwork can address this gap while improving graduates' competitiveness in the professional landscape architecture market (Tolhurst et al., 2023).

The main problem is not exclusively about giving students more exposure to the field, but about ensuring that field activities are deliberately coordinated with specific learning outcomes (Beltran et al., 2024; Tolhurst et al., 2023). There remains a lack of formal training in teaching field-based ecology, and if the course design is inadequate or the implementation is poor, this may result in unsatisfactory student experiences and learning outcomes (Beltran et al., 2024). The Malaysian Qualifications Framework (MQF) has undergone several changes, including MQF 1.0, MQF 2.0 (2017) and the MQF 2.0 Addendum (2024), so that programme directors have to systematically link Programme Learning Outcomes (PLOs), Course Learning Outcomes (CLOs), and the way the curriculum is delivered (Gunawan & Kartiwi, 2026). Under the MQF 2024, practical skills are included in the functional work-skills cluster, covering the selection and application of tools, technologies, methods and procedures, as well as scientific, design and research skills. This framework provides a rationale for considering digitally supported field observation as a fundamental and essential form of practical learning rather than a minor technological addition (Henri & Hubbard, 2025).

In the Ecosystem and Landscape Ecology course examined in this study, learning outcome CLO1 requires students to apply scientific principles, concepts, and processes pertinent to landscape ecology to explain ecological knowledge. The present paper argues that achieving this CLO is greatly enhanced when students conduct ecological observations employing a structured fieldwork protocol (Nicotra et al., 2022; Yeshimbetova et al., 2026). In this method, students go beyond simple observation: they choose relevant phenomena, use digital tools, take photographic evidence, record geospatial data, check identification suggestions, verify their observations, and link up species occurrences with the particular ecological conditions of the site (Cochrane et al., 2022; Rubiales et al., 2024; Rianti, 2026). These observable and systematic actions reinforce the important link between conceptual ecological knowledge and psychomotor skill (Mukherjee & Kittur, 2025; Henri & Hubbard, 2025).

iNaturalist is well-suited to this aim, as it brings together image-based identification, geolocation, community-supported verification, and a large database of biodiversity observations (Cancino et al., 2025; Rode & Torkar, 2023). Educational research has previously found benefits in the areas of biodiversity learning, outdoor education, bioliteracy and data literacy (Chozas et al., 2023; Rubiales et al., 2024; Rode & Torkar, 2023), and systematic review evidence shows that iNaturalist is being used more and more in BioBlitz and outdoor learning (Rode & Torkar, 2023). More recent studies also show that the platform is still being used in undergraduate and teacher education (Cancino et al., 2025; Rode et al., 2026; Salas & Barco, 2025). The innovation is presented as a learning intervention aligned with CLO requirements, the main evidence of both its educational and practical value being student educational performance and the biodiversity dataset (Yassin, 2026).

This method is presented as a pedagogical measure aligned with the CLOs, using students' educational performance and the biodiversity dataset produced as the primary indicators of the approach's educational and practical value. By doing so, it makes a more direct and measurable contribution to outcome-based education in landscape architecture. The study, therefore, sets out to answer three key questions: (1) In what way can field observations enabled by iNaturalist be constructively aligned with CLO1, MQF 2.0 PLO3 Practical Skills, and psychomotor P5? (2) What evidence from students' performance in relation to CLO1 shows that the learning outcomes achieved through this innovation have been met? (3) In what ways does the biodiversity dataset generated with iNaturalist confirm the veracity and ecological richness of the learning activity?

CONCEPTUAL AND LITERATURE FOUNDATION

From Ecological Knowledge toward Observable Competence

Outcome-based education involves linking teaching activities and assessments to the knowledge and skills that learners are expected to acquire (Sarun & Sopheap, 2026; Shaikh et al., 2024; Yassin, 2026). In a constructively aligned curriculum, the course's purpose, the learning outcomes, the teaching methods and the assessment methods together with their criteria are aligned in such a way that the intended learning takes place, and students who are studying declarative knowledge are required to apply that knowledge within practical and demonstration assessments (Sit & Zeller, 2024; Yassin, 2026). The student learning outcomes are evaluated in relation to the MQF domain, thus connecting the programme's overall aims with the CLO (Noor et al., 2023). All higher learning institutions in Malaysia are required to follow the Malaysian Qualifications Agency, and the MQF has three levels of outcomes: Programme Educational Outcomes (PEO), which act as an overarching framework for the PLOs and the CLOs, the PLOs being realised through Outcome-Based Education (OBE) during the course of study (Ismail & Othman, 2023). Under MQF 2.0, published in 2024, practical work skills include the use of tools, technologies, methods and procedures, and can also involve scientific skills and research practices (Gunawan & Kartiwi, 2026).

The field observation task is thus seen in the present study as a practical application of ecological knowledge (Henri & Hubbard, 2025; Nicotra et al., 2022; Yeshimbetova et al., 2026). The concept of competence refers to the capacity to integrate skills, knowledge, attitudes, and connections between hands-on learning and the wider world to promote progressively inclusive and authentic learning experiences (Henri & Hubbard, 2025). Similarly, the assessment field practice uses field agendas, observational records, specimen documentation, and reports as evidence of conceptual comprehension and practical competence (Yeshimbetova et al., 2026).

The concept of the psychomotor P5 level is used here to refer to Complex Overt Response: the skilled execution of complex and coordinated actions (Mukherjee & Kittur, 2025; Mahmudi et al., 2022). At this level, the learner carries out action patterns of greater complexity, lying between Mechanism and Adaptation (Mukherjee & Kittur, 2025), performing skills composed of many stages smoothly, accurately, and efficiently, which involves skilled motor actions based on complex movement patterns (Mahmudi et al., 2022). In Malaysia, the outcome-based education guidelines for higher education generally associate P5 with a complex overt response (Noor et al., 2023). The relevant implication is that students should demonstrate coordinated performance rather than merely recognise a species or recall an ecological definition (Bourassa et al., 2024; Chweu, 2025). The assessment literature agrees on this: even though higher education institutions thoroughly evaluate students' knowledge, the assessment of psychomotor skills is usually implicit, unsystematic and inadequate; in one survey, 54% of lecturers did not assess psychomotor skills at all (Chweu, 2025). There is also little agreement on the most effective methods for teaching or assessing psychomotor skills, so the design of the assessment instrument has pedagogical importance (Bourassa et al., 2024).

In the context of landscape ecology, this can be put into practice by carrying out a series of field activities: locating the area, observing it, taking photographs, making notes, identifying features, checking the findings, organising the data and interpreting it (Cochrane et al., 2022; Rianti, 2026; Yeshimbetova et al., 2026). Records of observations, specimen documentation, and the reports produced serve as structured evidence of practical ability, but checklists, which reduce complex performance to simple yes-or-no judgments, do not capture its depth, coherence, or scientific rigour (Yeshimbetova et al., 2026). It is the coordination throughout the sequence that sets P5 performance apart: students who achieve strong psychomotor results show a significant degree of consistency between the formative practical assessment and the summative practical test (Zanal et al., 2025), and structured practical assessment tools such as checklists, rubrics and peer-supported evaluation are recommended for this aim (Agongo & Tindan, 2025).

CLO1 continues as a knowledge-type outcome because the verb used is 'explained'. Operational verbs indicate the degree of cognitive or practical difficulty that an outcome aims to achieve, and it is necessary for these same verbs to appear in both the teaching and learning activities as well as in the assessment tasks in order to ensure that the outcomes remain systematically aligned (Harahap et al., 2023; Yassin, 2026). The innovation does not alter the approved CLO; rather, it provides students with a genuine and practical means to collect evidence

demonstrating the ecological principles, concepts, and processes that underlie the explanation (Hamel & Lee, 2024; Polley et al., 2024; Sit & Zeller, 2024). Authentic assessment, in which instructors design realistic, cognitively demanding learning situations, is essential in environmental science education and is associated with positive cognitive, affective, and behavioural responses (Hamel & Lee, 2024). The study, therefore, separates the cognitive statement of the CLO from the practical learning process, thereby supporting and providing evidence for its achievement (Henri & Hubbard, 2025; Sit & Zeller, 2024; Yassin, 2026).

iNaturalist As A Field-Learning Technology

iNaturalist has evolved from being just a programme for recording nature into a major citizen science infrastructure (Cancino et al., 2025; Rode & Torkar, 2023). Studies have shown that the platform can facilitate collaborative species identification, biodiversity monitoring, data literacy, and ecological learning (Cancino et al., 2025; Chozas et al., 2023; Rode & Torkar, 2023). According to the systematic review by Rode and Torkar, there is increasing use in education, particularly in outdoor activities and biodiversity learning (Rode & Torkar, 2023). Hitchcock, Sullivan, and O'Donnell revealed the potential of iNaturalist to foster bioliteracy, biodiscovery, and data literacy in undergraduate courses, while Herodotou and his colleagues proposed a blended-learning approach for biodiversity monitoring. More recent research supports the view of using iNaturalist as an educational link rather than simply as a means of quick identification: Rode, Torkar and Anđić (2026) describe educational applications with preservice teachers that involved both engagement with biodiversity and the production of observation data (Rode et al., 2026), and Cancino and his colleagues have documented projects in which 183 students from 23 undergraduate and graduate programmes recorded more than 6,400 observations and 1,190 species, nearly 70% of them staying active on the platform after the educational programme had ended (Cancino et al., 2025). These studies indicate that the platform can link learning, observation and real biodiversity records (Cancino et al., 2025; Rode et al., 2026).

At the same time, it would be wrong to regard iNaturalist data as automatically correct. Research has shown that identification errors, observer bias, uneven sampling, and spatial limitations are present in a single higher-education botany course. Students, on average, identified only half of the plants in each plot and made many misidentifications, regardless of which tool was used (Pernat et al., 2023). The educational value of these limitations should not be neglected. Students can be taught to see digital identification as a hypothesis that needs to be tested rather than as a definite answer (Hackel et al., 2026) and that the use of technology does not always lead to a deeper understanding of biodiversity topics, even if learning in nature is felt to be meaningful (Liukkonen et al., 2025). This step of critical verification is particularly important in the field of landscape ecology, since professional decisions regarding planting, habitat, and ecological management require evidence-based interpretation (Husby et al., 2025; Yeshimbetova et al., 2026).

Landscape Architecture and Authentic Fieldwork

Students studying landscape architecture should read sites as ecological systems and consider the design of spaces (Liu & Chen, 2023; Thompson & Chapman, 2025). Nowadays, teaching in the field is increasingly relying via digital tools to produce original spatial and environmental data sets (Bone et al., 2022; Cochrane et al., 2022), and it has been established that terrain-based investigation, the use of systematic field methods and the production of data sets by the students constitute learning outcomes (Cochrane et al., 2022; Irvine et al., 2022). Additional research in higher education has shown that field-based and outdoor learning still has value in linking conceptual knowledge to the solution of real-world problems (Labib & Abdelsattar, 2025; Townley et al., 2024; Warners et al., 2026). In cases where field trips have been combined with lectures through an experiential cycle, students have achieved significantly better results in terms of their learning outcomes, with more advanced students showing greater gains in knowledge (Labib & Abdelsattar, 2025), and project-based studio work has increased the chance that students will use pro-environmental design methods (Xi & Wang, 2022).

The contribution of this study is to apply that principle to the field of biodiversity observation (Coşkunserçe, 2024; Rode & Torkar, 2023). Rather than viewing species identification as a standalone biological activity, the approach treats species records as ecological evidence within a landscape (Cancino et al., 2025; Rubiales et al., 2024). Students can inquire into where a species is found, which habitat features are associated with it, how

vegetation structure affects observations, and how biodiversity data can be used to assist with landscape planning and design (Cancino et al., 2025; Tiago et al., 2024).

Learning Innovation and Constructive Alignment

Building on recent work investigating mobile digital platforms in field pedagogy, Mat Nayan (2025) demonstrated that integrating iNaturalist into landscape architecture coursework significantly enhances student engagement and the accuracy of field observations by bridging observational practice and digital biodiversity recording. Extending these findings, this study operationalises the 'Observe–Document–Verify–Interpret' workflow to evaluate specific Course Learning Outcomes (CLOs) and psychomotor performance. This sequence was developed to link the four elements of ecological learning: scientific knowledge, practical action, digital data and landscape interpretation (Table 1). iNaturalist is not the learning outcome itself but rather the enabling technology that is incorporated into an aligned pedagogical sequence (Henri & Hubbard, 2025; Yassin, 2026). Educational innovation arises when students use technology to carry out a set of actions structured according to scientific methods and then turn the resulting evidence into explanations of ecological principles and processes (Cochrane et al., 2022; Yeshimbetova et al., 2026). An individually built mobile application for coastal ecology students that allows record annotation, image uploads, real-time information syncing, and offline data collection demonstrates the same design approach at the level of the tool (Cochrane et al., 2022).

Table 1. The Field Observation Workflow

Stage	Student action	Ecological knowledge	MQF/P5 alignment	Evidence
1. Observe	Locate and observe organisms and habitat conditions in situ.	Biodiversity, habitat, and ecological relationships.	Practical Skills; P5 preparation and coordinated observation.	Field observations and photographs
2. Document	Capture photographs and record location using iNaturalist.	Species occurrence and spatial context.	PLO3 Practical Skills; P5 use of tools and procedures.	Geotagged observations
3. Verify	Review AI suggestions and community identification; compare visible characteristics.	Scientific identification and evidence quality.	PLO3; P5 coordinated verification procedure.	Identification status/ supporting evidence
4. Interpret	Relate species to habitat and landscape conditions and explain ecological significance.	Ecological processes and landscape relationships.	CLO1 explanation supported by practical evidence.	CLO1 assessment/field report
5. Reflect	Evaluate limitations, uncertainty and relevance to landscape practice.	Scientific reasoning and responsible data use.	Practical and professional judgement.	Reflection/ assessment evidence

METHODOLOGY

Research Design

The study uses a practice-based educational innovation approach and draws on two main kinds of evidence: (1) student learning and performance results that are directly related to CLO1, and (2) biodiversity records obtained via the iNaturalist platform. While student perception responses are considered, they provide only limited contextual information about the implementation and are not used as the primary measure of CLO achievement.

Participants and Learning Context

The learning activity involved 83 diploma-level students in the Ecosystem and Landscape Ecology course at the Universiti Teknologi MARA (UiTM), Perak Branch, Malaysia. Field observations were conducted at Taman Rekreasi MADANI Sungai Pinji in Ipoh, Perak, thereby assuring a consistent ecological context and allowing all observations made by the students to be combined into a single project dataset.

Assessment Instrument and Rubric Structure

Student achievement for CLO1 and psychomotor P5 performance was evaluated using a structured, criterion-referenced rubric across four core dimensions, each scored on a 4-point scale (1 = Unsatisfactory, 2 = Developing, 3 = Proficient, 4 = Exemplary):

1. Field Participation & Coordinated Execution (P5 Psychomotor): Evaluation of fluid, systematic execution during site fieldwork, including proper handling of mobile devices, GPS calibration, and deliberate sampling strategy.
2. Plant & Biodiversity Inventory Completeness: Assessment of the depth, spatial distribution, and taxonomic variety of species recorded in situ.
3. Species Selection & Identification Accuracy: Evaluation of the critical selection of representative flora/fauna and the verification of machine-generated identification suggestions.
4. Image & Spatial Quality: Assessment of clarity, key photographic diagnostic features, and precise geolocation tagging required for scientific validation.

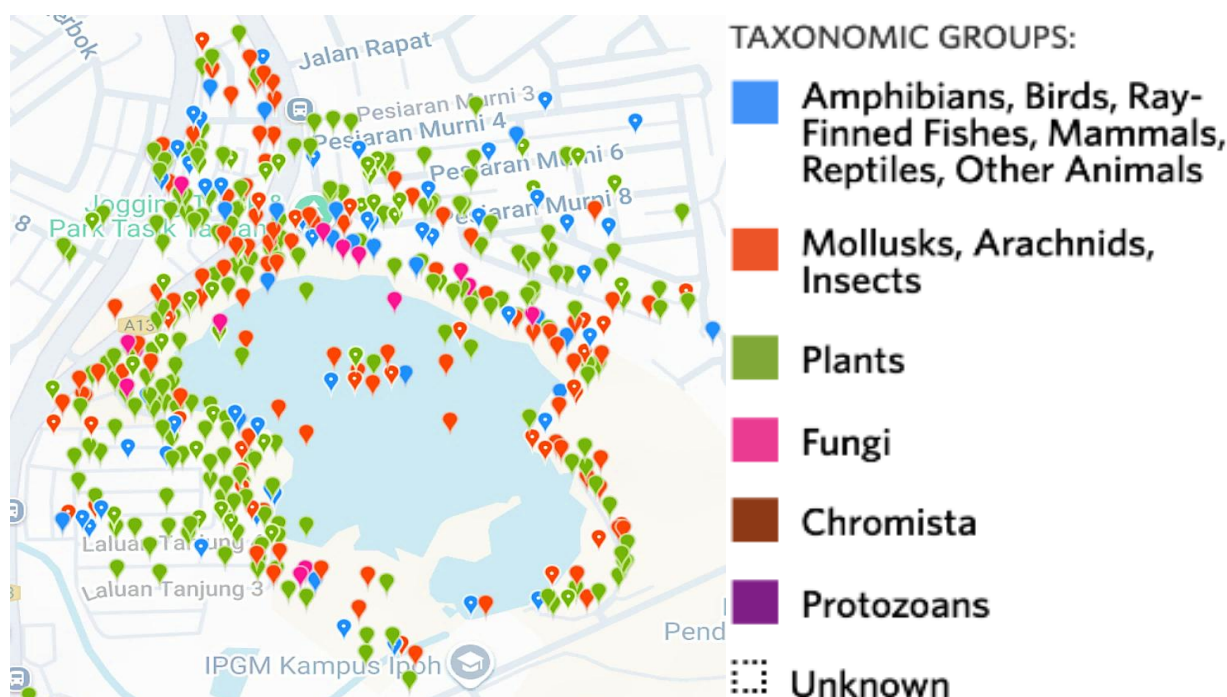
Inaturalist Field Activity

The students used their smartphones to record plants and animals, then uploaded their observations to iNaturalist, checked the identification suggestions, viewed information about the species, and recorded the geographic data. The instructors made it clear that the automatic identifications were only temporary and told the students to carefully check the suggestions against what they could see and, where possible, use identifications that had been supported by the community. After collecting the data, the students used their observations to analyse biodiversity and ecological relationships in the landscape. This exercise involved both psychomotor skills and the ability to provide higher-order conceptual explanations.

Inaturalist Biodiversity Evidence

The data collected as part of the iNaturalist project acted as an independent source of evidence confirming both the authenticity and the range of the field-learning activities. Together, the 83 students recorded 268 species, with plants most often recorded, followed by insects, birds, and finally fungi (see Figure 1). It should not be assumed that these results directly reflect the students' level of learning; rather, they provide evidence that the students had generated a comprehensive and diverse biodiversity dataset during the field activity aligned with the CLOs.

Figure 1. Mapping of 268 Species Recorded by 83 Students During the Site Visit



Source: iNaturalist, 2025

Data Quality and Observation Verification

To account for observer bias and identification errors inherent in digital citizen science platforms, observations uploaded to iNaturalist were categorised by verification status. Students were instructed to treat automated machine-learning suggestions as preliminary hypotheses. Observations underwent two-tier verification: community confirmation on iNaturalist (achieving *Research Grade* status when two or more independent identifiers concurred) and expert verification by course instructors. Reporting the ratio of verified versus uncertain identifications ensured transparency in scientific quality control within the learning exercise.

RESULTS

CLO1 Attainment

The students showed exceptional proficiency in the ecological knowledge assessment related to CLO1 ($n = 83$). Their average score was 9.52 on a scale of 10.00 (standard deviation = 1.09), with individual scores ranging from 3.63 to 10.00. It is worth noting that 98.80% of students (82 out of 83) exceeded the 50% continuous assessment threshold (5.00/10.00). The performance of all six subgroup cohorts remained high, with group means ranging from 8.72 to 9.89 out of 10.00. A thorough breakdown of performance by rubric criterion is provided in Table 2 (the criteria were assessed on a 4.00-point scale).

Table 2. Descriptive CLO1 Related Assessment Results Across Six Groups

Indicator	n	Mean / %	SD	Interpretation
Students assessed for CLO1	83	9.52/10	1.09	Direct course assessment
LO3 attainment	-	80%	-	Programme-level attainment
Students attaining the CLO1 threshold	83	98.80% (82/83)	-	Primary learning-outcome evidence
Participation	83	4.00	0.00	Rubric criterion, 4 marks
Inventory of plant species	83	4.00	1.33	Rubric criterion, 4 marks
Selection of plant species	83	3.74	0.58	Rubric criterion, 4 marks
Quality of images	83	3.80	0.58	Rubric criterion, 4 marks

Biodiversity Observations Generated through iNaturalist

The evidence from the project shows that the students, as a group, recorded 268 species during the field-learning exercise. 97.6% of the participants recorded plants, 51.2% recorded insects, 24.4% recorded birds, and 13.4% recorded fungi. The results show that the activity yielded a wide range of observations of various organisms, well beyond a narrow focus on identifying plants (see Table 3).

Table 3. Evidence of Data Collection Extracted from iNaturalist.

Evidence	Result	Educational meaning
Students involved	83	Common field-learning cohort
Species recorded	268	Substantive, authentic biodiversity dataset
Plant observers	97.6%	High exposure to vegetation identification
Insect observers	51.2%	Students noticed less conspicuous fauna
Bird observers	24.4%	Extends observation beyond vegetation
Fungi observers	13.4%	Introducing taxonomic diversity

DISCUSSION

The principal contribution of this innovation lies in its shift from application-centred to outcome-centred learning, anchoring all activities directly to CLO1, MQF PLO3, and psychomotor P5. CLO1 clearly defines the ecological knowledge students are expected to articulate, while MQF PLO3 emphasises practical skills, including the selection and application of tools, methods, and technologies. The psychomotor P5 descriptor highlights skilled, coordinated performance in actual contexts. The iNaturalist-enabled fieldwork operationalises this agreement by immersing students in authentic ecological data collection and interpretation (Henri &

Hubbard, 2025; Yeshimbetova et al., 2026). Notably, the literature demonstrates that explicit assessment of psychomotor skills in practical courses yields consistently strong student outcomes and strengthens the alignment between formative and summative assessments (Zanal et al., 2025; Chweu, 2025; Bourassa et al., 2024).

The fact that documentation has been provided for 268 species proves both the validity and the wide ecological range of the learning activity. Rather than relying on examples from textbooks that do not change, the students got hands-on experience with living organisms in a changing environment and produced observations that could be examined, critically questioned and verified (Cochrane et al., 2022; Pernat et al., 2023). This teaching method is supported by research showing that genuine, situation-specific fieldwork improves understanding of ecology and interpretive competence (Labib & Abdelsattar, 2025; Warners et al., 2026). Moving beyond simple species identification, the students acquire the ability to interpret ecological relationships and site-specific phenomena, skills essential for evidence-based assessment of the landscape (Husby et al., 2025; Tiago et al., 2024).

The study also responds to the practical requirements of landscape architecture. Landscape professionals increasingly work with digital information, site data and interdisciplinary environmental evidence (Bone et al., 2022; Cochrane et al., 2022; Irvine et al., 2022), so training students to collect and interpret biodiversity observations can help establish a stronger ecological foundation for later planting design, habitat-sensitive planning, green infrastructure and landscape management tasks (Cancino et al., 2025; Husby et al., 2025; Tiago et al., 2024).

Educational Innovation Model

The model in question may be described as follows: ecological principle → field observation → digital documentation → verification → spatial/ecological interpretation → CLO evidence (Table 4). In this model, technology is given an assisting role, and the learning outcome is kept at the heart of the process. Furthermore, the activity can be mapped simultaneously along the cognitive, practical and psychomotor dimensions without altering the approved course outcome.

Table 4.0 Educational Innovation Model

Component	Learning focus	Evidence	Alignment
Ecological knowledge	Scientific principles, concepts and processes	Student explanation	CLO1
Practical field skill	Observe, photograph, locate, upload and organise	iNaturalist records	PLO3
Psychomotor performance	Coordinated use of device, camera, GPS and field procedure	Observed/assessed field performance	P5
Scientific verification	Check identification and recognise uncertainty	Validated observations/reasoning	CLO1 + PLO3
Landscape interpretation	Relate organisms to habitat and site conditions	Field report/assessment	CLO1

Limitations and Directions for Future Research

This study offers valuable empirical evidence regarding constructive alignment and the achievement of Course Learning Outcomes (CLOs); however, it is important to recognise several methodological limitations that may influence the findings. First, the evaluation is based on a single cohort (n = 83) from a single course at a single institution, which may limit the generalizability of the results to broader international curricula in landscape architecture. Hence, while the high scores reflect commendable overall performance, it is challenging to determine the specific contributions of the iNaturalist app versus those of general field exposure.

Hence, future research would benefit from addressing these limitations by adopting more rigorous comparative or longitudinal designs. By systematically comparing learning gains, skill retention, and identification accuracy between iNaturalist-enabled workflows and conventional fieldwork groups across multiple institutions, the evidence base for the scalability and transferability of this educational model can be significantly strengthened.

CONCLUSION

The study shows that iNaturalist should be seen as an effective supplement to, not a substitute for, ecological fieldwork in the teaching of landscape architecture (Cancino et al., 2025; Rode & Torkar, 2023). The key advantage of the present innovation is that field observation aligns with CLO1, MQF 2.0 PLO3 Practical Skills, and psychomotor P5 (Gunawan & Kartiwi, 2026; Henri & Hubbard, 2025). By following the Observe–Document–Verify–Interpret sequence, the students were able to engage thoroughly with ecological-related knowledge as active field practitioners, meeting biodiversity, producing digital records, critically reviewing their identifications, recording spatial data and expressing the ecological meaning (Nicotra et al., 2022; Yeshimbetova et al., 2026).

Since 83 students recorded 268 species, the data not only corroborate the method's effectiveness in providing genuine evidence of biodiversity but also correspond with the principles of outcome-based education (Yassin, 2026; Sit & Zeller, 2024). The Task 1 assessment continues to serve as the main evidence of learning achievement, while the iNaturalist records and student perceptions provide useful but secondary support. This approach corresponds with good practices in outcome-based education, as outlined by the MQF and recent research (Noor et al., 2023; Ismail & Othman, 2023). Future research needs to compare CLO attainment across cohorts, examine practical performance at the rubric level, and conduct longitudinal site monitoring to enable students to track ecological changes over time.

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Declaration Of Generative Ai and Ai-Assisted Technologies

The use of generative AI was limited to improving the language, proofreading, and making stylistic edits. Each suggestion generated was carefully assessed and finalised by the authors, who remain fully responsible for the research, the interpretation of the data, and the final version of the manuscript.

Ethics Statement

No personal or sensitive student information was gathered as part of this evaluation. The study used only anonymised, aggregated academic assessment scores and publicly available biodiversity observations, in full accordance with ethical requirements for research and the institutional guidelines of Universiti Teknologi MARA (UiTM).

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