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Special Issue

Integrating wetland ecology into ecological education for curriculum reform

Pei-Luen LU*

*Department of Life Sciences, National Taitung University, Taitung City, Taiwan (R.O.C). *Corresponding author's email: peiluen@nttu.edu.tw; Tel: +886-089517960; Fax: +886-089-517448*

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ABSTRACT: The COVID-19 pandemic, beginning in 2020, underscored the critical need for a healthy ecological environment, prompting shifts in educational priorities toward sustainability. While digital and online learning have become indispensable tools, it is equally important that curriculum design fosters real-world applications of ecological knowledge. From 2020 to 2023, an ecology course conducted in proximity to National Taitung University focused on the Beinan Estuary National Important Wetland (TW31), offering students direct engagement with nature. This outdoor-oriented course introduced natural resource learning through hands-on activities, with students documenting their experiences in group reports and integrating this knowledge into their assessments. Going beyond the classroom, the course sought to strengthen students' connection to the land by merging theoretical learning with practical, experiential education. Key exploration activities included a range of ecological topics such as wetland ecology, plant and animal ecology, art ecology, landscape ecology, community ecology, and broader ecosystem dynamics, providing students with a comprehensive understanding of ecological processes.

KEY WORDS: Beinan Estuary National Important Wetland, curriculum design, ecology education, wetland Ecology.

INTRODUCTION

One of the founders of modern educational theory, American scholar Dewey (1938), emphasized that education should combine study with life experiences in natural contexts. This approach fosters reflective thinking, practical engagement, and a sense of social responsibility in students. Building on this principle, contemporary ecological education faces unique challenges that demand innovative approaches. High school (vocational) education has traditionally been oriented towards further education, with students viewing universities as pathways to advancement. For example, in recent years, the government has begun to emphasize mother tongue and ethnic education. However, the evaluation of the success of such education still revolves around the narrow gates of further education and employment. Questions such as "What is the philosophy of university education?", "What are the medium to long-term plans in life? How can they be achieved?", "What are the functions of education?", and "How can university graduates become interdisciplinary, specialized, and liberal future talents?" have long been directed by utilitarianism.

With the increasing importance of teachers in shaping the future of education in Taiwan, exacerbated by the continuing decline in student numbers over the years and the increasingly severe impact of inflation, compounded by the experience of three years of online teaching due to the COVID-19 pandemic, learning effectiveness has decreased. In the cultivation of professional courses, the essence of "university education" is often overlooked. Chairman and CEO of the All-Around Education Foundation, Guan-Wei Lu, also pointed out the increasingly important role teachers play in Taiwan's future education, guiding students in the right direction. Education must change, and he proposed three major goals for solutions: personalized learning, non-cognitive abilities, and project-based learning (Huang, 2015; Li, 2021; Zhou, 2022).

Due to the impact of declining birth rates and the influence of the digital Millennial generation, according to psychosocial theory, the age of university students (18-22 years old) falls between late adolescence and early adulthood. According to theoretical classifications, this period belongs to the stage of self-integration and the crisis of self-integration. Currently, most people are capable of higher-level thinking, but they are also more susceptible to confusion in values (Erikson, 1968) and a lack of sense of life meaning (Ho, 1985). University students in our country are prone to the following problems: (1) Lack of teamwork skills, (2) Lack of motivation and curiosity in learning, (3) Lack of understanding of environmental sustainability, (4) Weak resilience, and (5) Lack of empathy. (6) The rise of utilitarianism also lacks foresight. Moreover, many universities face insufficient funding for the establishment and updating of teaching equipment. These challenges and problems urgently need to be addressed to improve the effectiveness of students nationwide and enhance their professional abilities.

The researchers themselves are practitioners in the field of education, observing and experiencing some problems and phenomena in teaching settings. They hope to improve these issues, enhance teaching quality, and increase student learning outcomes (Tsai, 2000, 2020). Therefore, this study adopts an action research approach for the following main reasons: 1. Teachers are also researchers, and knowledge must be continuously

absorbed, revised, and constructed through accumulated experiences. In the face of the ever-changing educational environment, there are no standard answers to problems, but rather solutions tailored to specific times, places, and individuals (Tsai, 2000, 2020). Since teachers are professionals in the educational field, they should play the role of researchers in curriculum design and teaching practice. By directly improving or refining their professional practices through research, teachers can internalize and transform theory into teaching techniques that can be flexibly applied in their teaching practices. This not only enhances the individual teaching abilities of teachers but also bridges the gap between theory and practice through the integration of action and research. Throughout the process of action and practice, through the collection, organization, and analysis of diverse data, teachers deeply study their actions, continuously reflect, criticize, question, and argue, generating their own knowledge. Therefore, the characteristics of action research meet the needs of teachers in teaching settings (Tsai, 2000, 2020). 2. Ecological education needs to be adjusted based on students' responses and is suitable for implementation through action research. It focuses on local connections, talent cultivation, international links, and various issues, expecting universities to play important roles and promoters in societal engagement. Encouraging the utilization of professional knowledge and creativity to bridge the gap between theory and practice; promoting local identity and development to move towards the vision of international integration, namely, universities play a pivotal role in sustainable development goals.

This study for the first time integrates ecological curriculum with nearby practical sites of National Taitung University, hoping for mutual growth through their positive interaction and connection towards sustainable development goals. Therefore, action research, with its characteristic of iterative cycles, allows curriculum design and teaching practices to be revised, implemented, and re-revised, enabling teachers and students to grow together through shared learning experiences, especially with the practical support of the local community and abundant ecological resources. Hence, the design and implementation of ecological education with practical courses are suitable for action research. 3. Action research helps enhance teachers' professional capabilities. Throughout the process of action research, teachers' roles transform from being passive, waiting for curriculum execution, to knowledge distributors and facilitators, further evolving into knowledge creators and producers (Huang and Tsai, 2009). Teachers' awareness and actions towards role transformation enable them to see themselves in the teaching field and demonstrate their potential in their respective positions, enhancing their problem-solving abilities and making them genuine participants and constructors of teaching professionalism, thus improving teachers' professional capabilities and teaching quality. Therefore, researchers in this study have multiple roles as curriculum designers, teaching practitioners, and collectors and interpreters of data (Huang and Tsai, 2009).

In the "Garden Path Essays" by the Qing dynasty scholar Qian (2024), it is stated: "Reading ten thousand books is not as beneficial as traveling ten thousand miles; both are equally important." This principle reflects the modern concept that classroom knowledge and practical experience (outdoor education) are equally vital. Deway (1938) emphasizes the cultivation of personal abilities in university students, with a focus on community-centered education and a recognition of social responsibility in communal living. He emphasizes the importance of experiential learning: "Life experiences serve as the material for reflective thinking" and "Return to one's own life experiences to gain understanding." Therefore, Dewey's experiential learning approach places students at the center, akin to modern educational methods that use group work to foster a spirit of community and collaboration. This approach aims to (1) make students active participants rather than passive observers in the learning process, (2) assist students through guided instruction, (3) stimulate students' intrinsic motivation and willingness to engage actively in learning, (4) encourage students to reflect continuously, learn from reflection, and (5) provide students with authentic, natural experiences to facilitate meaningful learning. Ultimately, this approach aims to instill in students a lifelong attitude towards self-directed learning.

Experiential learning is a process of direct cognition, enthusiastic acceptance, respect, and application of knowledge and abilities taught at the present moment, which aligns with the teaching philosophy of ecology courses (Wang, 2007). It is particularly suitable for dealing with significant aspects of life, as it touches upon people's deep-seated beliefs and attitudes under the premise of respect, deeply rooted emotional values, or human interaction and trust issues (Wu and Lin, 2005). Research on experiential learning in Taiwan can be divided into four areas: special group therapy, behavioral and psychological aspects, education and leisure, each analyzed based on research subjects, themes, and designs (Hsiao, 2014). 1. Research Subjects: Experiential education can be applied to both special and general groups. Special groups typically focus on delinquent adolescents, while general groups often include primary, junior high, and senior high school students. However, there is relatively limited research on adults beyond the university level. Currently, there are over a hundred theses related to "experiential learning" in Taiwan's master's and doctoral theses database, with over sixty focusing on primary education (including teachers and students) and over thirty on secondary education. Therefore, research in Taiwan predominantly targets

primary and secondary education, with only a few studies involving university students, while research abroad tends to focus on adults. 2. Research Themes: There is a diversity of research themes, ranging from exploring self-concept, life efficacy, and self-esteem to recent investigations into intrinsic motivation, levels of engagement, problem-solving abilities, team building, effectiveness of character education implementation, and sense of life meaning. It is evident that experiential learning is increasingly applied in educational settings or activities, mainly for self-efficacy, curriculum development and material writing, character education, community integration, learning attitudes, or teaching effectiveness, conducted through empirical research, primarily focusing on practical aspects.3. Research Designs: Most studies adopt empirical research methods, primarily focusing on practical aspects. These methods include action research, quasi-experimental research, and case studies. Besides quantitative data, qualitative data such as student work, learning journals, and teacher reflections are often utilized. Overall, this study will adopt action research and integrate experiential learning into the design and implementation of ecology courses with practical components for undergraduate students to investigate their learning outcomes.

Ecology, a discipline studying the relationship between organisms and their environment, has a history of approximately 150 years, emerging about 30 years after the birth of evolutionary biology (Kingsland, 1991). The term "ecology" originates from the German biologist Ernst Haeckel, who proposed it in 1869. "Eco" is derived from the Greek word for home or habitat, while "logy" comes from the Greek word for study or science (Kingsland, 1991). Ecologists employ scientific methods and emphasize hypotheses within the scientific framework (Kingsland, 1991). In 1859, Charles Darwin, one of the founding fathers of evolutionary biology, published his renowned work "On the Origin of Species," causing a significant stir in the academic and social circles of Europe (Smith and Smith, 2015). Darwin's main theory became the primary interpretation of the mechanisms of evolution and formed the basis of modern evolutionary thought (Smith and Smith, 2015). It provided a consistent and rational explanation for biodiversity in biology (Smith and Smith, 2015). Upon reading the third chapter of "On the Origin of Species," titled "Struggle for Survival," Ernst Haeckel believed that Darwin's ideas warranted exploration in a new field. He named this new domain "ecology." (McIntosh, 1985).

Ecology is a branch of biology that encompasses a wide range of topics and is considered a fundamental subject in contemporary biological sciences (Smith and Smith, 2015). It covers animals, plants, and microorganisms, spanning from individual organisms, populations, communities, ecosystems, landscapes, biomes, to the entire biosphere (Smith and Smith, 2015). Fundamental concepts in ecology establish the theoretical basis for environmental conservation and help understand the impact of environmental changes on ecosystems. This knowledge enables us to comprehend how to protect the environment and the purposes of conservation (Smith and Smith, 2015).

Understanding the functioning of ecosystems, the relationships between organisms and their environment, and exploring interactions among organisms such as competition, mutualism, and symbiosis are essential aspects of ecology. Ecological models provide crucial foundations for various predictions (Smith and Smith, 2015). From the historical perspective of ecological evolution described by Egerton, the history of ecology largely overlaps with that of early biology until the rise of modern molecular biology, which marked a more distinct separation. However, even with this separation, the application of modern biotechnological tools in ecology has become a new mainstream (Egerton, 2012, 2015).

Ecology has been redefined by numerous scholars, but a concise and comprehensive definition comes from American ecologist Gene Likens in his book "The ecosystem approach" (Likens, 1992). Likens stated that ecology studies the processes influencing the distribution and abundance of organisms, interactions among organisms, and interactions between organisms and the transformation of matter and flow of energy. Following this enumerative definition, ecology encompasses at least three indispensable themes: population dynamics, community aggregation, and ecosystem functioning. Other topics, large and small, are either the content or derivatives of these three major themes. The term "ecosystem" first appeared in 1935, marking 88 years to date. However, the first research report to cite the concept of ecosystems was published in 1942 by Lindeman. Since the introduction of the term "ecosystem," ecologists have continuously explored its precise definition, theoretical basis, and practical applications. Two representative books discussing the evolution of the concept and content of ecosystems within this historical context are Hagen's "Ecosystem theory and application" (1992) and Golley's "Ecosystems of the world" (1993).

Taiwan's higher education development has also evolved with the development of ecology (Lu, 2023). Major universities in the life sciences field consider ecology as an important course. Over the past 30 years, with the rapid development of biotechnology, ecology has become an elective course in many departments focusing on biotechnology (Lu, 2023). However, in departments mainly focusing on life sciences, ecology remains a compulsory subject (Lu, 2023). In addition to exploring its principles, understanding the impact of ecology on other sciences is crucial in ecological education. Environmental science is one of the most important disciplines for addressing the survival challenges of the 21st century (Boersema and Reijnders,

2009). The relationship between ecology and environmental science is akin to that of mathematics to physics (Boersema and Reijnders, 2009). Without the principles and methods of ecology, humanity would be unable to understand environmental issues, let alone achieve sustainable development on our only planet (Boersema and Reijnders, 2009).

Therefore, ecology-related courses are offered in many schools, including as general education courses in non-life science departments (Yang, 2015). Due to its close relationship with environmental science, agriculture, forestry, fisheries, environmental education, human ecology, soil and water conservation, river and coastal engineering, and climate change, among many other disciplines, international attention to ecology has increased (Smith and Smith, 2015). With the large-scale policy of achieving net-zero carbon emissions by 2050, ecology continues to play an important role, but it manifests in diverse forms across different fields (Lu, 2023).

Focusing on the need for localized ecological education, there are generally two main challenges in the current ecology curriculum in Taiwan. Firstly, there is a lack of comprehensive textbooks that include local ecological scopes for higher education (Guo, 2010; Yang, 2015). Instead, the textbooks used in courses mainly come from foreign sources, with content largely citing examples from Europe and the Americas. While this approach effectively teaches ecological theories and fundamentals, it lacks direct local connections, which can fail to resonate with students on a deeper level (Guo, 2010; Yang, 2015).

In addition to learning examples from textbooks worldwide, it is crucial for educators in Taiwan to provide students with knowledge about local ecosystems and natural resources (Guo, 2010; Yang, 2015). It is recommended to utilize outdoor teaching and experiential learning opportunities to directly engage with real ecological environments (Key, 2003; Resasco, 2013). This approach helps students develop a global perspective and practical skills applicable to local contexts. Outdoor ecology teaching and field experiments can strengthen students' connection with the environment and foster positive environmental behaviors (Key, 2003; Resasco, 2013).

Secondly, the lack of experimental courses in ecology presents another challenge in ecological education in Taiwan. If ecology courses only rely on conventional classroom lectures with PowerPoint presentations and offer fewer than 3 credits, it may feel superficial and theoretical. However, due to the trend of reducing overall course hours across various disciplines in higher education, standalone experimental ecology courses have gradually disappeared from the curriculum structure of most universities in Taiwan (Yang, 2015).

Long-term outdoor exploration is essential for authentic ecological experiments. and cannot be effectively conducted within the confines of a classroom. Students need hands-on experience in forming hypotheses, designing experiments, collecting data, and analyzing results to bridge textbook knowledge with real-world observations or experiences. Such experiments require a longer duration to achieve meaningful outcomes (Yang, 2015). To address these challenges, it is recommended to supplement ecology education with relevant internship courses offered by departments or through credits from bachelor's thesis research courses to compensate for the lack of practical training in the curriculum (Lu, 2023).

The ecology with internship course is one of the fundamental subjects required for students majoring in life sciences. However, teaching ecological theory alone without connecting it to society can lead to students losing interest. Based on the problems identified in our teaching practices, this study plans to focus on ecology with internship as its research course. Using action research methodology, we aim to understand the learning effectiveness of outdoor experiential learning methods. The focus of this study will be on wetland outdoor education. We will begin by utilizing the nearby Taitung Forest Park (part of the national-level important wetland, the Beinan River estuary wetland) as the field site. Students will practice investigating various components of the ecological system and be guided to develop a sense of identity with the local area of Taitung. They will be encouraged to apply the knowledge from textbooks in practical situations, thereby demonstrating their core competencies in life sciences and achieving improved learning outcomes. Ultimately, the goal is to enhance student achievement and address the challenges encountered in teaching practices.

METHODOLOGY

A. Research Framework

This study adopts action research methodology to explore how experiential learning theory can be applied in ecology education when facing teaching challenges. Through designing experiential learning teaching programs that integrate ecological theory from textbooks with the ecological resources of Taitung, the study aims to investigate changes in students' understanding of ecological theory after implementing the experiential learning teaching programs. Additionally, it seeks to examine how students seek strategies to address and resolve problems encountered during the learning process and how they develop and extend the concept of sustainability throughout their learning journey. Simultaneously, the study aims to enhance professional growth for teachers and foster a deep connection with the local community.

Action research is a "practice-oriented" research method that encourages practitioners to adopt a questioning, exploratory, and critical attitude. It involves

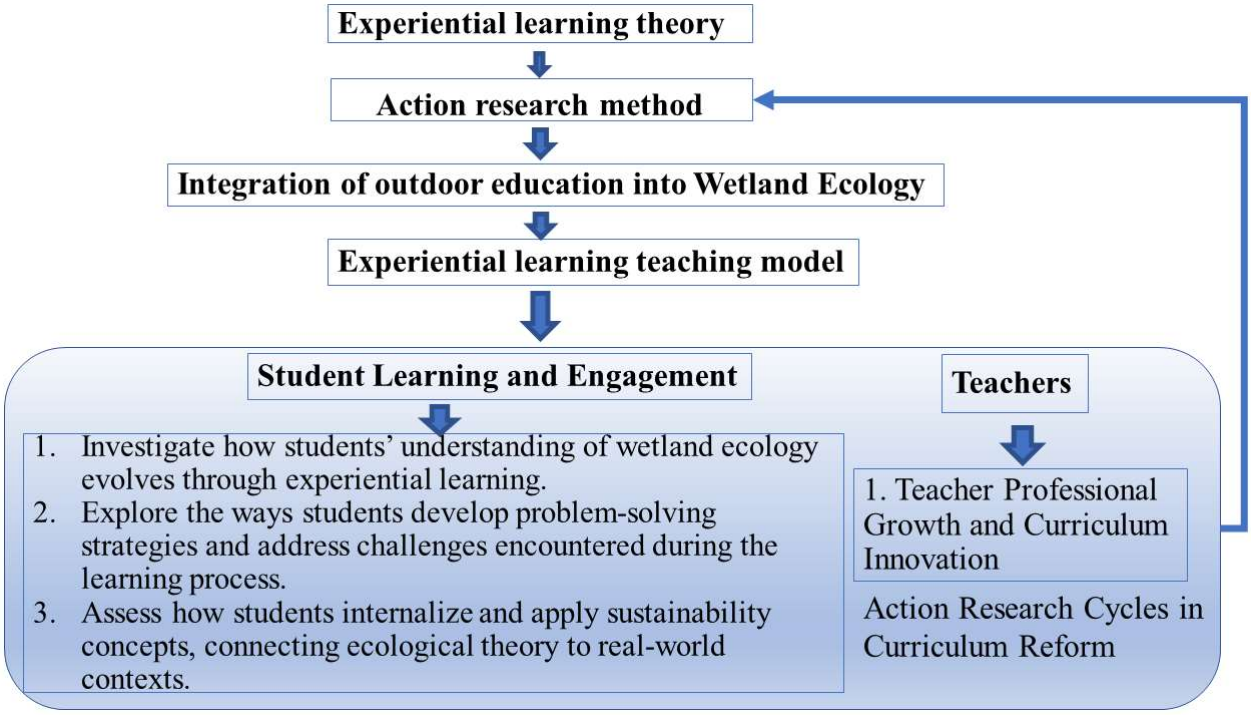

Fig. 1. Research Framework Diagram.

reflecting on practical actions to improve them, enhance understanding, and address practical situations effectively (Tsai, 2000). In other words, action research focuses on systematically investigating and taking action to address difficulties and problems encountered in teaching settings. Through a cyclical process of implementation, reflection, modification, and re-implementation, action research aims to improve the current situation, facilitate teacher professional growth, and enhance capacity building. The research framework of this study, based on the principles and practices of action research, is illustrated in Figure 1.

B. Research Objectives

This study is action research conducted by teachers in the teaching setting, aiming to investigate the integration of experiential learning into the mandatory undergraduate course of Ecology with practical components. The goal is to empower students to apply ecological knowledge gained in the classroom to real-world contexts, embracing the concept of learning by doing with ecological practices. The study emphasizes fostering students' emotional connections to Taitung's local ecology through active participation in ecological fieldwork. This approach aims to deepen their understanding of sustainability's value. By incorporating ongoing reflection and iterative adjustments into the teaching and learning process, educators strive to enhance the effectiveness of ecological education and its impact on student learning outcomes.

C. Research Scope

The research scope primarily revolves around the syllabus of the Ecology course with practical components, focusing on practical sessions conducted at the Peinan Estuary National Important Wetland within the Taitung Forest Park, which is a nationally recognized important wetland area.

D. Research Subjects and Field Sites

Research Subjects: The primary participants in the ecology course with practical components are second-year students majoring in Life Sciences at National Taitung University (80%). Some students from other departments also opt to take the course (10%), along with re-taking students or those who transferred from other majors (10%).

***Introduction to Research Field Sites*:** According to government data from the Forestry Bureau, the Taitung Forest Park is rich in biodiversity. It hosts 18 genera of planktonic algae and 13 genera of benthic and epiphytic algae, indicating clean water conditions. In terms of vascular plants, the park features 8 species of ferns and 181 species of seed plants from 54 families, with non-native species dominating the terrestrial vegetation. Terrestrial insects include 69 species from 26 families, predominantly common insects found in lowland or low-altitude areas. Aquatic insects comprise 16 species from 9 families, with dragonflies being particularly abundant. The park is also home to representative aquatic mollusks and fish species, including 8 species of aquatic mollusks

and 20 species of fish. Additionally, there are 5 species of amphibians and 7 species of reptiles, mainly common species. The avifauna consists of 60 species from 25 families, with a mix of terrestrial and aquatic birds, while mammals include 5 species from 3 families. The biodiversity of terrestrial animals varies across different plant zones, and there are significant differences in aquatic fauna among different lakes and marshes. Overall, terrestrial biodiversity is low and less distinctive. The wetlands of Beinan Estuary National Important Wetland are situated at the southern end of the Coastal Mountain Range, serving as the interface between the southern part of the Huatung Valley and the ocean. Together with the Xinwulu River upstream, both wetlands are nationally important and mutually complement each other as conservation treasures. Peinan Xikou Wetland, located on a floodplain, features diverse wetland landscapes, including river wetlands, swampy lakes, artificial lakes, rice paddies, ditches, and brackish lakes, all of which have conservation value. Due to its unique location and terrain, the vast riverbeds, farmland, and even the southern forest park serve as crucial habitats for migrating and resident birds, as well as breeding and nesting sites for conservation-grade birds. The diversity of bird species reflects the varied wetland landscapes, including estuarine waterbirds (e.g., terns, ospreys), swamp wetland birds (e.g., plovers, snipes), farmland birds (e.g., ring-necked pheasants), and forest-edge birds (e.g., shrikes, black-naped orioles, orioles). Therefore, the Beinan Estuary National Important Wetland is highly valuable for protection and sustainable management in terms of its natural geographical location, diverse terrain, and bird conservation. In summary, it is an ideal site for outdoor ecology education.

E. Research Methods and Tools

The research method employed in this study is action research. The focus is on the Ecology course with lab (outdoor education), a mandatory course for second-year students majoring in life sciences. Through teaching practice, diversified experiential learning strategies are implemented to encourage student autonomy. Outdoor teaching assignments guide students to develop an understanding of Taitung's local culture. Through thematic group exploration, students utilize experiential learning methods to deepen their ecological knowledge, in line with the theory of active learning. The goal is for students to internalize ecological knowledge and effectively share it through vivid and clear methods in their final presentations. The primary aim of this research is not prediction or inference but rather the development of suitable ecology courses, hence the adoption of action research.

The local ecological resources of Taitung serve as the field site for the practicum, where students practice investigating various components of ecosystems and the roles of environmental factors within them. This approach aims to foster students' sense of identity with Taitung and introduce the concept of ecological conservation. Through scientific observation and recording, students can present their ecological knowledge through written and oral reports, preserving, sharing, and promoting ecological knowledge and expertise. Students are also encouraged to produce documentary short films. The assessment methods employed are diverse, aiming to evaluate students' learning performance in ecology comprehensively.

Based on the research objectives, various teaching assessment methods and strategies are utilized. The main research tools include mid-term teaching assessments, end-of-semester comprehensive teaching assessments, course effectiveness questionnaires, experiential learning course satisfaction surveys, course feedback forms, and project reports. Mid-term teaching assessments serve as real-time adjustments to teaching methods, while end-of-semester comprehensive teaching assessments provide insights into students' opinions on teaching, serving as references for improving teaching and course planning. Course effectiveness questionnaires are used to evaluate the achievement of course goals and core competencies, guiding adjustments to teaching and course design.

(1) Mid-term Teaching Assessment Questionnaire: The questionnaire assesses aspects such as "Clarity in explaining course objectives, progress, assessment methods, and standards; utilization of different teaching methods to inspire learning motivation and interest; establishment of good interaction or communication channels with the teacher; creation of a positive learning atmosphere in the class." This mid-term formative teaching assessment serves as a reference for immediate adjustments to teaching.

(2) End-of-Semester Teaching Assessment Questionnaire: The questionnaire evaluates aspects such as "Ability of teaching materials or methods to inspire student learning; adjustment of teaching based on student learning responses; cultivation of core competencies; enhancement of absorption of course professional knowledge." This end-of-semester comprehensive teaching assessment aims to understand students' opinions on teaching, serving as a reference for improving teaching and course planning to enhance teaching quality.

(3) Experiential Learning Course Satisfaction Survey: The survey assesses aspects such as "Enhancement of self-awareness and interpersonal perception through experiential learning and reflection; ability to reflect on and examine relevant issues; effective transformation and internalization of knowledge to solve problems; application of learned knowledge and skills in daily life."

(4) Course Student Learning Effectiveness Assessment: Based on the student learning effectiveness assessment of National Taitung University, it examines

the achievement of course objectives and core competencies, serving as a reference for teaching and course design adjustments.

(5) Worksheets - Guest Speaker Lecture Feedback Form and Outdoor Practicum Feedback Form: Using semi-structured questions designed for reflection sheets based on the course's teaching objectives and core conceptual framework, the feedback obtained from students' reflections and feedback is analyzed to understand students' learning situations or encountered difficulties, serving as the basis for analyzing learning effectiveness.

(6) Course Feedback Form: To understand students' reflections on self-learning at the end of the semester, open-ended questions are used to gather suggestions for the course and impressions of the Taitung Forest Park practicum, enabling an understanding of students' learning outcomes and serving as a reference for course design and teaching practice improvement.

(7) Project Report Reflections: Open-ended questions are used for students to document their reflections in written report format, enabling an understanding of students' learning outcomes and serving as a reference for course design and teaching practice improvement.

In terms of implementation, apart from employing qualitative research methods such as learning process, observation, and interviews, this study also conducted questionnaire surveys after outdoor teaching sessions. In the academic year 2020, there were 48 students surveyed per session, with testing conducted in October 2020. Each questionnaire took approximately 30 minutes to complete. A total of 48 valid questionnaires were collected, achieving a 100% response rate. In the academic year 2021, there were 45 students surveyed per session, with testing conducted in November 2021. Each questionnaire took approximately 30 minutes to complete. A total of 45 valid questionnaires were collected, also achieving a 100% response rate. In the academic year 2022, testing took place in November 2022, with 59 students surveyed per session. Each questionnaire took approximately 30 minutes to complete. A total of 59 valid questionnaires were collected, achieving a 100% response rate. In the academic year 2023, testing took place in March 16, with 41 students surveyed per session. Each questionnaire took approximately 30 minutes to complete. A total of 41 valid questionnaires were collected, achieving a 100% response rate.

Research Ethics

This project has passed research ethics review, and research activities commenced only after obtaining ethical approval. When contacting potential interviewees, researchers will first identify themselves, explain the purpose of the study, and, after ensuring that they are fully informed of the potential impact of the research, ask if they are willing to participate. Interviewees may decide whether to consent to audio or video recording of the interviews, either in writing or orally. Participants have the right to withdraw from the study at any time, and they can request data destruction by contacting the researcher via email or phone. Interviewees' names will be anonymized, but information such as gender, occupation, and age may be presented in various ways in the research report if necessary. The research report will prioritize protecting the privacy and interests of the interviewees. All recordings will be managed by the researchers and securely stored on password-protected hard drives. Additionally, a formal notification of this research was sent to the Council of Indigenous Peoples by National Taitung University.

Table 1. Summary of Survey Questionnaire for Research Sample.

Samples	Female	Male	Total
2020	20	28	48
2021	20	25	45
2022	25	34	59
2023	10	31	41
Sum	75	118	193

RESULTS

1. The Assessment of Learning Outcomes

The results of this study show that both male and female students, as well as students from three different academic years, have a strong curiosity and interest in outdoor educational activities. The assessment tool used by the researcher is the "Experiential Learning Satisfaction Scale," developed based on Kolb's four-stage experiential learning cycle, using a five-point scale (Kolb, 1984). The quantified results of student assessments are as follows: The average ratings for the willingness to engage in learning through the learning methods employed in the Taitung Forest Park outdoor practicum were 4.60/5 for the academic year 2020, 4.80/5 for the academic year 2021, 4.61/5 for the academic year 2022, and 4.60/5 for the academic year 2023.

The sample data for this study is organized as shown in Table 1. Outdoor educational activities are indeed a manifestation of the saying "traveling a thousand miles is better than reading a thousand books." They involve personally bringing students into the classroom of nature, enhancing their sensitivity to all things and ecology through observation and recording. The aim is for students to validate what they have learned in textbooks in the field, with aspects not covered in textbooks serving as examples for future curriculum content.

The ecological themes corresponding to outdoor education are outlined before outdoor lab activity, covering a wide range of ecological content, and localizing ecology through outdoor educational activities. Due to differences in temporal and spatial structures, each year's outdoor education may vary to some extent, but the main learning objectives remain consistent. During exploratory activities, teams move in columns, which means learners cannot

Table 2. Outdoor education, teacher-guided content.

Guidance Approach	Commonly Used Topics and Content
Group Explanation	1. Ecology and Biological Indicators. 2. Daily Life and Cultural Ecology of the Local People in Taitung Forest Park. 3. Lake Ecology. 4. Ecological Characteristics and Research Status of the Beinan Estuary National Important Wetland.
Knowledge Test	1. Test students who have studied Plant Taxonomy on the names and classification characteristics of commonly found plants in the area, including dominant angiosperms, gymnosperms, ferns, mosses, algae, etc. 2. Link ecological terminology with observations in the field, focusing on relationships between species such as competition, parasitism, and symbiosis. 3. Explore how weather conditions influence ecological observations. 4. Test students who have studied Animal Taxonomy on the names and classification characteristics of commonly found animals in the area, including dominant amphibians, reptiles, common bird species, aquatic animals, dominant insect species, etc. 5. Examine the interaction and types of relationships between insects and flowering plants.

always stay close to the teacher or guide. Instead, they rely on their own curiosity to observe and discover surrounding objects when they have the opportunity. To prevent learners from missing important information and being unable to ask questions for clarification, teachers and guides choose suitable locations for active guidance during the exploration process, utilizing methods such as group explanations and knowledge quizzes, as summarized in Table 2.

DISCUSSION

Since the discovery of the DNA double helix, the advancement of biotechnology alongside the development of 21st-century information technology has greatly contributed to the refinement and flourishing of ecological research. Molecular ecology has emerged as a mainstream discipline, and remote observation has gradually taken shape (Lu, 2023). Relying on vast accumulations of digital data and internet databases, molecular ecology has, however, drifted away from real ecology, evolving into what can be termed as electronic ecology (Lu, 2023). Digital ecology lacks the sensory perception of smell, actual field environment and organism interactions, crisis response capabilities, and substantial understanding of real organisms—all of which are indispensable aspects of ecological training for ecologists (Tidball and Krasny, 2011).

Undeniably, the economic costs, energy, risk value, and time involved in outdoor teaching and learning far exceed those of classroom-based education, often causing hesitation among teachers. Therefore, schools should extend their support for teaching to encourage outdoor education and provide tangible support. After all, ecology disconnected from direct interaction with nature is akin to virtual reality (VR) or augmented reality (AR), where students cannot grasp the intricate environmental requirements for survival, making it difficult for them to develop a concrete understanding of ecological science. Consequently, outdoor learning not only benefits early childhood education and the 12-year national curriculum but also proves highly effective for university students and even members of society (Liu, 2017). For life science majors (biological sciences), this aspect of expertise is crucial, especially in the professional training of millennials Outdoor learning, particularly concerning topics related to natural ecology, sustainable development, and environmental conservation, holds significant importance (Rickinson *et al*., 2004).

Although Taitung Forest Park (Beinan Estuary National Important Wetland) consists of mostly flat terrain, during the 3-hour practicum sessions, some students with lower physical stamina or those unaccustomed to prolonged exposure to sunlight often show signs of fatigue before reaching halfway. Occasionally, unfavorable weather conditions make it challenging to locate certain species or observe their behavior. In such cases, mutual encouragement among classmates to complete outdoor assignments becomes a form of collective cooperation. This process not only fosters class cohesion but also yields additional benefits beyond the curriculum.

For those implementing the program, outdoor education has become an indispensable tradition, yet the pressure on leaders increases annually. Factors contributing to this include the lack of genuine encouragement from schools for wilderness ecology challenges in outdoor education, the aging of teachers, and changing student demographics (Liu, 2017). This reality partly explains the gradual decline of field-based teaching in ecology and natural history-related courses.

Outdoor field teaching in ecology entails numerous uncertainties, compounded by safety considerations. If the burden of responsibility falls solely on teachers, many are deterred (Liu, 2017). Reflections and recommendations include: 1. The Ministry of Education and schools could provide better support systems and cultivate specialized teaching assistants or hire professional collaborators to work with teachers, which would increase teachers' willingness to develop such courses. 2. Ecological phenomena do not occur and conclude (or may never conclude) within short periods. Therefore, arranging indoor experiments within limited timeframes only simulates specific phenomena. In the future, incorporating micro-project experiments that place the experiment in real ecological settings and extend the timeline could enhance students' leadership, coordination, and communication skills through long-term collaborative efforts, thereby enriching university science education.

The issue in higher education lies not in the abundance of institutions but in the influence of multiple factors such as international status, policies, administrative regulations, funding, social values, flexibility, and systems. It is about whether the government can provide sufficient long-term funding assistance for schools to develop their characteristics and differences, encourage diverse development for both faculty and students, and promote the long-term development of each school. (Lin and Lee, 2021).

Starting from the academic year 2020, the ecological internship program has expanded to include joint lectures with industry experts at the Taipingxi Artificial Wetland in Taitung City and the flora and fauna interpretation course at the Zhiben Forest Road in Taitung County. In line with the spirit of learner autonomy, this program aims to cultivate individuals with a strong ecological awareness by combining classroom and outdoor teaching methods to explore local ecological resources (Hansen and Sandberg, 2020). The goal is to nurture future leaders who possess both academic potential and a solid foundation in ecology, whether they become young ecological scholars or excel in various fields.

Through personal experiences in implementing the curriculum, I have witnessed the transformation of young students after participating in outdoor education. Many students find it enjoyable, but more importantly, they transition from the world of cartoons and video games to the vibrant reality around them. This not only broadens their ecological perspectives but also shapes their attitudes towards life. I encourage more teachers to guide students into the real world, not only for the purpose of fulfilling the Ministry of Education's "University Social Responsibility (USR) Practice Program" but also for passing down experiences that cannot be conveyed solely in the classroom, particularly in disciplines related to life and humanity.

According to Lockwood *et al*. (2013) and Molles and Sher (2022), a proficient modern ecologist must develop a range of essential professional skills. First, having a strong passion for ecological work is crucial, as it drives the curiosity and persistence necessary for research. Additionally, ecologists should be capable of analyzing complex scientific and statistical data, which requires both understanding and explaining intricate concepts. Proficiency in data processing is equally important, as it involves recording, organizing, and analyzing data with appropriate methods and tools. Furthermore, effective written communication skills are vital for crafting reports and research papers, while strong oral communication skills enable the clear presentation of research findings. Successful ecologists must also possess strong planning and execution abilities, as they are responsible for organizing research projects, managing budgets, recruiting personnel, and devising contingency plans, all while maintaining excellent time management. A solid grasp of information technology is essential, given its integral role in modern research. Finally, ecologists should be able to work both independently and collaboratively within teams, and field research expertise remains a fundamental skill for collecting and interpreting ecological data.

Except for the first skill, the remaining eight can be taught and cultivated in university classrooms. In the stage of university ecological education, besides synchronizing with natural ecological knowledge and the world, connecting with local natural and cultural ecology, and teaching ecological wisdom can help students achieve the goals of autonomous learning and lifelong learning after graduation.

In "Toward a Mind Ecology" (Bateson, 2002), the cultivation of ecological wisdom is divided into three stages. Firstly, "zero learning" refers to the process of automatically making correct choices during learning. Secondly, learners develop the ability of self-correction, which is to cultivate "individual-centered intelligence" (Bowers 2001). Finally, learning must possess "ecological wisdom" (Bateson 2002). Bowers and Bateson's ecological wisdom share similarities: ecological concepts are grounded in local culture and world relations, and incorrect concepts can influence our thinking through recursive knowledge structures. Therefore, guiding students to establish correct ecological wisdom is crucial, and it deserves careful consideration and emphasis for effective transmission of ecological knowledge.

CONCLUSION

This project emphasizes reforming ecology education by integrating outdoor learning into wetland ecology. Using the ecology curriculum as a case study, it demonstrates that effective outdoor education can significantly enhance students' learning outcomes in science. However, the consistent and stable allocation of teaching funds remains critical to sustaining such initiatives.

In the 21st century, the balance between economic growth and environmental preservation has become increasingly important, particularly in light of the challenges posed by the COVID-19 pandemic and the energy transition driven by climate change. By incorporating practical outdoor education programs and experiential learning methods, students develop a deeper understanding of the vital role ecology plays in environmental sustainability.

Upon completing the ecology curriculum, students will be better equipped to propose innovative, mutually beneficial solutions to address natural environmental and socio-economic challenges when contributing to societal and national policies. This approach empowers individuals to critically engage with, utilize, and reflect on these pressing issues.

Our aim is not to turn everyone into ecologists or environmental educators, but rather to cultivate ecological literacy that can be seamlessly integrated into daily life. By achieving this, we hope to foster a society that is both informed and proactive in addressing environmental challenges.

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