

E-BOOK OF EXTENDED ABSTRACT

THE 14TH INTERNATIONAL INVENTION, INNOVATION & DESIGN COMPETITION 2025



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ECOLOGY IN THREE DIMENSIONS: A SUSTAINABLE LEARNING INNOVATION FOR ENVIRONMENTAL AND DESIGN EDUCATION

Nadiyanti Mat Nayan^{1*}, Azrul Bahaluddin², Helmi Hamzah³

^{1,2,3}Programme of Landscape Architecture, Faculty of Built Environment,
Universiti Teknologi MARA (UiTM) Perak Branch, 32610 Seri Iskandar,
Perak, Malaysia

*nadiy028@uitm.edu.my

ABSTRACT

Sustainability education requires more than theoretical instruction; it demands immersive, system-based approaches that illuminate the interconnectedness of ecological systems. This innovation presents an innovative pedagogical method in which students transform 2D ecological diagrams into 3D paper models, fostering hands-on, interdisciplinary learning. Piloted across diverse fields, including environmental studies, geography, architecture, and urban planning, this method engages students in ecological analysis and spatial reasoning through the tactile construction of models using recycled materials. The approach has demonstrated significant benefits, including enhanced ecological literacy, increased student engagement, and strengthened systems thinking. It also aligns with multiple United Nations Sustainable Development Goals (SDGs), particularly in the areas of education, climate action, and sustainable land use. By making abstract systems visible and tangible, this scalable, low-impact learning tool empowers learners to understand better and address complex sustainability challenges, offering strong potential for integration into curricula and broader educational frameworks.

Keyword: Ecology, Three Dimensions, Sustainable Learning, System-Based Learning, Paper Models

1. INTRODUCTION

Traditional sustainability education often emphasises theoretical knowledge, yet falls short in fostering the systems thinking required to address the complex, interconnected challenges of real-world ecological issues. This gap underscores the need for experiential, transdisciplinary learning approaches that engage both cognitive and affective domains (UNESCO, 2020). In response, this project introduces a hands-on method that transforms abstract ecological diagrams such as watersheds, land-use mosaics, and ecosystem flows into three-dimensional models using recycled materials. The aim is to enhance ecological literacy, spatial reasoning, and sustainability competencies through embodied learning. Specifically, the objectives are to: (i) engage students in visualising and physically constructing ecological systems; (ii) foster interdisciplinary collaboration and critical analysis of environmental processes; (iii) develop systems thinking and anticipatory learning; and (iv) promote resource-conscious practices with accessible, low-cost materials. Piloted across courses in environmental studies, geography, architecture, and sustainability education, the method demonstrated improved conceptual understanding, increased student engagement and creativity, strengthened spatial and ecological literacy, and enhanced systems thinking capabilities, aligning with recent findings on constructivist and modelling-based sustainability education (Brundiens et al., 2021; Ahamer & Kumpfmüller, 2023; Hwang et al., 2023). These outcomes support the integration of tangible, interdisciplinary tools in advancing SDG-aligned educational practices.

2. METHODOLOGY

The 3D modelling method was piloted in interdisciplinary classroom settings involving students from environmental studies, geography, architecture, urban planning, and sustainability education. Designed as an active, constructivist learning strategy, the process unfolded in three structured stages that guided students from interpreting diagrams to constructing physical models and reflecting on their work. This multi-phase approach emphasised analytical thinking, ecological literacy, collaboration, and the use of low-impact materials.

i) Diagram Selection

Students selected or were assigned ecological diagrams drawn from academic literature, field manuals, or online environmental data sources. These included land-use patterns, topographical cross-sections, ecological networks (such as patch–corridor–matrix models), and hydrological cycles. Diagrams were chosen for their real-world relevance and ability to represent spatial complexity, interdependencies, and system dynamics. This stage laid the foundation for deeper exploration of ecological structure and function.

ii) Ecological Analysis

Through instructor facilitation and peer discussion, students conducted visual and conceptual analyses of the diagrams they had selected. They identified key ecological components, spatial hierarchies, directional flows, and dynamic processes, including erosion, nutrient cycling, and water movement. Students were encouraged to interpret environmental patterns through the lens of landscape ecology and sustainability science. This step also integrated basic principles of geospatial literacy, systems thinking, and environmental ethics, preparing students for accurate representation of physical phenomena

iii) 3D Paper Modelling

Using recycled and biodegradable materials including paper, cardboard, scrap packaging, and non-toxic glue students constructed three-dimensional models that represented their ecological systems. This stage allowed them to externalise understanding through spatial reasoning and tactile engagement. Elements such as elevation changes, water pathways, habitat zones, and land-use mosaics were represented in physical form, facilitating the visualization of flows, gradients, thresholds, and resilience factors within the system. The hands-on modelling process fostered collaboration, iterative design thinking, and creative problem-solving.

Upon completion, the models were used in peer critiques, gallery-style presentations, and reflective writing exercises. These activities reinforced interdisciplinary dialogue and critical thinking while offering alternative modes of assessment. The accessibility and low environmental impact of the materials ensured that the process remained inclusive, scalable, and aligned with sustainable educational practices.

3. FINDINGS

Preliminary evaluations across multiple courses and student groups revealed that the 3D modelling method significantly enhanced students' conceptual understanding of ecological systems. The physical construction process supported the retention and synthesis of abstract content, consistent with embodied cognition theories. The activity also boosted engagement and creativity, particularly among non-technical students, by offering an accessible and differentiated learning experience that encouraged hands-on exploration and creative expression.

Additionally, the method fostered systems thinking, with students demonstrating a more evident ability to conceptualise ecological interconnections, found in constructivist, simulation-based learning (Ahamer & Kumpfmüller, 2023). The use of recycled materials aligned with responsible consumption principles, making the activity both sustainable and cost-effective. Students also showed improved ecological vocabulary and spatial reasoning, reinforcing ecological and spatial literacy outcomes supported by Hwang et al. (2023). Together, these findings affirm the value of tactile, interdisciplinary learning in advancing sustainability education.

This project directly supports multiple Sustainable Development Goals (SDGs) by integrating sustainability principles into hands-on, interdisciplinary learning. It advances SDG 4: Quality Education by promoting inclusive, equitable, and innovative pedagogy through experiential and participatory methods. Through its focus on ecological systems and spatial planning, it contributes to SDG 11: Sustainable Cities and Communities, encouraging awareness of sustainable land use and environmental design. By fostering understanding of ecological processes and resilience strategies, the project aligns with SDG 13: Climate Action, while its emphasis on biodiversity and ecosystem literacy supports SDG 15: Life on Land. Additionally, the use of recycled, low-impact materials models environmentally responsible practices, reinforcing SDG 12: Responsible Consumption and Production.

4. CONCLUSION

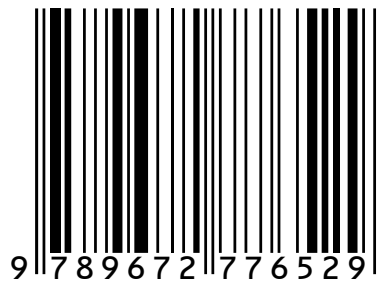
This project demonstrates that transforming ecological diagrams into tangible 3D paper models offers a powerful pedagogical strategy for sustainability education. By integrating experiential learning, interdisciplinary analysis, and low-impact materials, the method effectively bridges the gap between theory and practice. The findings indicate notable gains in conceptual understanding, systems thinking, spatial reasoning, and student engagement. Moreover, the hands-on modelling process cultivates ecological literacy while reinforcing key sustainability competencies, such as anticipatory thinking, collaborative problem-solving, and resource-conscious behaviour. Its accessibility and adaptability make it suitable across various disciplines and educational levels, supporting inclusive and equitable learning environments. Aligned with multiple Sustainable Development Goals, this approach not only enhances academic learning outcomes but also models sustainable practices within the learning process itself. As sustainability challenges become increasingly complex, innovative, embodied learning strategies are essential for equipping future leaders with the skills and mindsets necessary for transformative change.

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