SEEING, FEELING, MEASURING ECOSYSTEM SERVICES: TRANSFORMATIVE LEARNING FOR THE NEXT GENERATION OF BIOECONOMY PROFESSIONALS

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ABSTRACT

As higher education institutions increasingly face the challenges of transitioning to a sustainable bioeconomy, the development of pedagogical models that integrate ecological literacy, emotional engagement, and empirical reasoning becomes essential. Bioeconomy education must move beyond narrow sectoral training to embrace systems thinking, interdisciplinary collaboration, and experiential learning (Paris et al., 2023; Cardozo Ruíz Díaz et al., 2024). For students of landscape architecture and environmental sciences, who are future stewards of sustainable land use, this transformation requires educational approaches that engage both sensory perception and scientific understanding (Horova, 2025; Santos et al., 2025).

The concept of ecosystem services (ES), although well established in scientific discourse (Costanza et al., 1997), has yet to permeate mainstream societal awareness and everyday practice. Broader recognition and integration of ES into urban planning may depend on whether designers and environmental managers have a deep understanding of specific ecosystems and the benefits they provide (Palacios-Agundez et al., 2022). These professionals play a key role in communicating and implementing nature-based solutions, holding considerable potential to influence public perception and environmental behaviors (Helfand et al., 2006).

One of the major obstacles to advancing sustainable urban green infrastructure lies in the limited knowledge of ecosystem services among both practitioners and citizens. In contemporary participatory planning, ES can serve as an effective tool for assessing the multifunctionality of green spaces and facilitating inclusive, sustainable design processes (Terêncio et al., 2021). Researchers and educators therefore play a crucial role in training these professionals and, indirectly, in enhancing public ecological awareness.

Our study aimed to investigate how different stakeholder groups perceive typical urban ecosystems. While perception-based assessments of green spaces among citizens have been conducted

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(Xinyuan et al., 2024), few studies have compared these perceptions to quantified ecological values. We sought to identify which ecosystem characteristics are positively or negatively correlated between perceived (subjective) and measured (objective) ecosystem services in urban environments.

To this end, we formulated three research questions: (1) How do residents perceive ecosystem services in cities based on survey data, and how do these perceptions compare to ecological measurements? (2) How do students of landscape architecture and environmental sciences perceive ES, and how do these perceptions align with measured values? (3) Which ecosystem features should be emphasized in ES education to enhance both perceived and actual ecological performance?

We conducted a large-scale pedagogical experiment involving 489 first-year students enrolled in an introductory course on ecosystem services. The educational intervention combined field-based perceptual learning with empirical ecological assessment across ten different urban green space types in Warsaw, including managed parks, riparian forests, secondary woodlands, meadows, lawns, and informal wastelands. At each site, participants completed standardized Likert-scale questionnaires assessing a range of perceived ecosystem services (e.g. air purification, thermal regulation, water retention) alongside subjective impressions such as aesthetic quality and emotional inspiration. These responses were then compared with ecological data collected by instructors using field-based indicators, such as vegetation structure, canopy cover, and functional traits relevant to ecosystem regulation (e.g. particulate matter capture, evapotranspiration potential).

The findings revealed notable discrepancies between perceived and measured ecosystem services, particularly with respect to regulating functions, which were frequently undervalued by students. Recreational and thermal services were more accurately identified, suggesting that visible and directly experienced features are more readily acknowledged. Rather than interpreting these mismatches as deficits, we regard them as fertile ground for transformative learning (Mezirow, 1997). By confronting intuitive perceptions with ecological evidence, students are guided toward a deeper awareness of often-invisible ecosystem processes and a more robust ecological literacy.

Complementing the student-focused experiment, additional data were gathered through parallel surveys administered to urban residents and professional landscape designers. The results reinforce the importance of biodiversity in shaping positive evaluations of green space quality among both user groups. Naturalistic areas with dense vegetation, such as wetlands and woodland groves, were highly rated for their ecological value and experiential richness. The findings also underscored a preference for hybrid landscapes—spaces where wild and designed elements are integrated—though the emphasis differed by group: designers prioritized functional infrastructure, while residents

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favored naturalness. Informal green spaces (e.g. urban wastelands), despite their unregulated character, were valued by both residents and professionals for their potential to offer intimate recreation and biodiversity support. However, awareness of ecosystem services remained generally low among residents and only modestly higher among professionals, highlighting the need to strengthen educational interventions that target both groups.

Our study concludes that better alignment between perceived and actual ecosystem services can be achieved through design strategies that explicitly incorporate both ecological function and social resonance. For educators, these findings provide actionable insights into the features and metrics that matter most to students, supporting curriculum reform that advances ecological literacy and empowers the next generation of bioeconomy professionals.

Keywords: Ecological literacy, Field-based learning, Curriculum innovation, Student perception, Sustainability education

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