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Strategies for Teaching Environmental Education to Support Education for Sustainable Development (ESD) at the Secondary School Level

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Abstract

Environmental Education (EE) at the secondary school level is increasingly expected to do more than deliver ecological knowledge: it must help adolescents develop sustainability competencies, civic agency, and practical problem-solving capacities aligned with Education for Sustainable Development (ESD). UNESCO's ESD for 2030 roadmap emphasizes transformative learning that equips learners to address interconnected sustainability challenges. Yet many secondary EE programs remain fragmented, overly content-heavy, and weakly connected to authentic local problems, decision-making trade-offs, and measurable competencies. This article synthesizes peer-reviewed research and authoritative ESD guidance (≤ 2024) to propose an evidence-informed strategy set for teaching EE in secondary schools. Using a framework-synthesis method, we integrate ESD competency frameworks, evidence on effective EE and climate change education interventions, and whole-school approaches. Results are organized into a Strategy Stack of eight components: competency-aligned outcomes; place-based inquiry/outdoor learning; socioscientific issues (SSI) pedagogy; project- and design-based learning; citizen science; service learning; digital systems learning; and whole-school governance. We translate evidence into practical lesson architectures, assessment rubrics, and an implementation roadmap for secondary schools, highlighting equity safeguards and feasibility constraints.

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Keywords: Environmental Education; Education for Sustainable Development; Secondary School; Sustainability Competencies; Place-Based Learning; Socioscientific Issues; Project-Based Learning; Citizen Science; Whole-School Approach; Assessment

1. Introduction

Secondary school is a pivotal stage for environmental education (EE). Adolescents are cognitively ready for systems thinking, ethical reasoning, and multi-stakeholder analysis, while also forming identities, values, and civic orientations that shape lifelong behaviors.

Education for Sustainable Development (ESD) provides a normative and pedagogical direction for this challenge. UNESCO's Education for Sustainable Development: A Roadmap (ESD for 2030) frames ESD as education that empowers learners to take informed decisions and responsible actions for environmental integrity, economic viability, and a just society.

Meta-analytic evidence suggests that EE can improve environmental knowledge, attitudes, intentions, and (often self-reported) pro-environmental behavior, but with substantial heterogeneity—meaning that program design and pedagogy matter greatly. This manuscript presents an evidence-informed strategy set for teaching EE to support ESD at the secondary level.

2. Literature Review

2.1. From Environmental Education to ESD in secondary schooling

ESD extends environmental education by emphasizing justice, governance, interlinkages, and learner agency. UNESCO's ESD for 2030 roadmap reinforces a move from teaching about sustainability to learning for sustainability through transformative pedagogy.

2.2. Sustainability competencies as intended learning outcomes

Competency frameworks translate ESD goals into assessable learning outcomes. A widely used reference framework defines systems thinking, anticipatory, normative, strategic, and interpersonal competencies as key sustainability competencies for program design.

2.3. Evidence on effective EE and climate change education

Evidence syntheses indicate positive EE effects on knowledge and attitudes and variable effects on behavior, with wide heterogeneity across contexts. Climate change education research similarly emphasizes active, experiential, and efficacy-building approaches rather than information-only instruction.

2.4. Whole-school approaches and eco-school models

Whole-school approaches embed ESD across curriculum, school culture, governance, and partnerships. Research on eco-schools suggests that outcomes depend on the quality of didactics and school practices, not labels alone.

2.5. Outdoor learning, place-based learning, and Socio-scientific issues

Outdoor learning and place-based inquiry can strengthen engagement and understanding when field experiences are prepared and followed up. SSI pedagogy helps learners practice deliberation, argumentation, and ethical reasoning around contested environmental problems.

3. Method

This article uses a framework synthesis approach, integrating authoritative ESD guidance (UNESCO), major evidence syntheses (meta-analyses and systematic reviews), and selected empirical studies relevant to secondary EE implementation, limited to sources published no later than 2024.

Evidence is organized into four design layers: (1) outcomes (competencies and SDG learning objectives), (2) pedagogy (instructional strategies), (3) assessment (evidence of competence and action), and (4) whole-school enabling conditions.

4. Results and Discussion

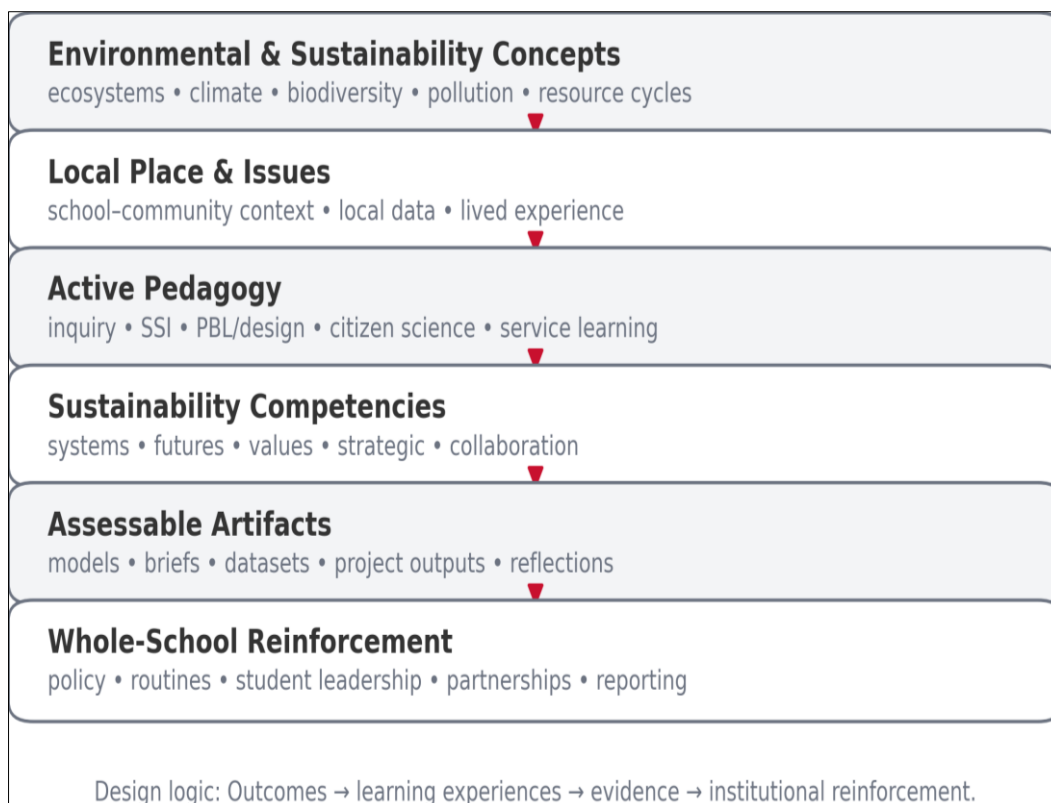


Fig 1: EE-for-ESD strategy chain in secondary schools (author-created infographic).

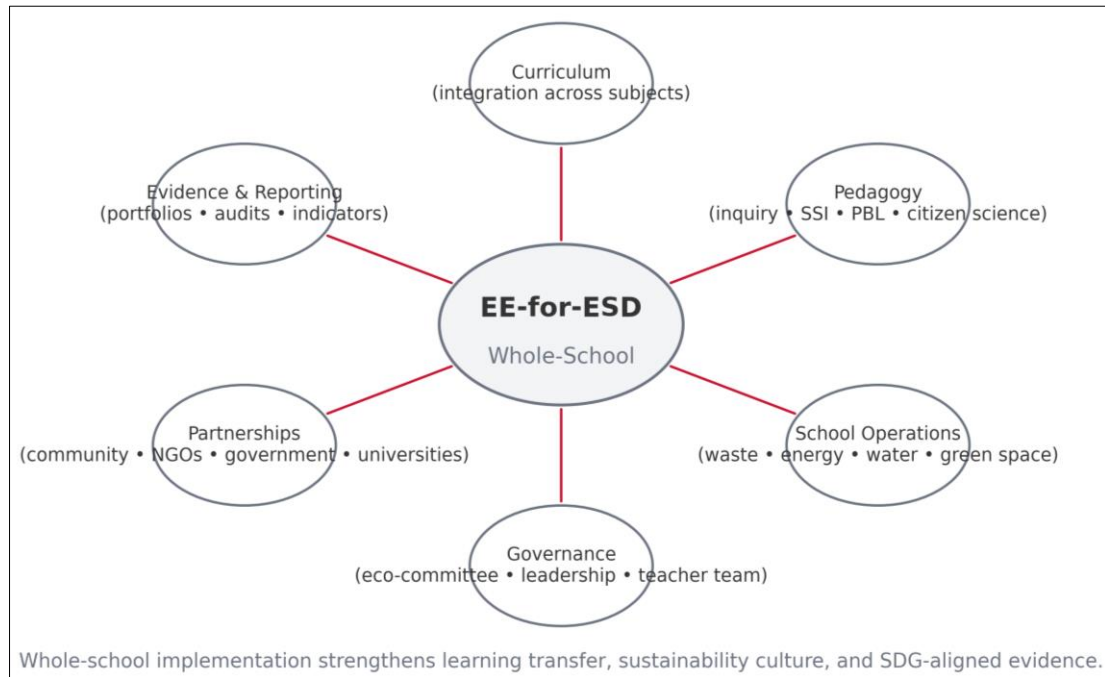


Fig 2: Whole-school model for EE-for-ESD in secondary schools (author-created infographic).

4.1. Result 1 — The Strategy Stack

Synthesized evidence converges on eight strategies that are most effective when implemented as a coherent stack rather than isolated activities: (1) competency-aligned outcomes and rubrics; (2) place-based inquiry and outdoor learning; (3) SSI pedagogy for values and trade-offs; (4) project-based and design-based learning; (5) citizen science and data-rich learning; (6) service learning and partnerships; (7) digital and

media-supported systems learning; and (8) whole-school governance, routines, and student leadership. Active, contextualized, participatory learning designs are consistently associated with stronger outcomes than information-only approaches. For climate-related topics, efficacy building and opportunities for meaningful action are especially important to avoid helplessness and disengagement.

Table 1: Strategy typology for EE-for-ESD in secondary schools (what, why, and evidence).

Strategy	Core intent	Signature learning activities	Typical evidence/assessment	Evidence anchors (≤2024)
Competency-aligned outcomes	Make ESD measurable and coherent	Competency rubrics; performance tasks	Systems model; scenario brief; reflection	Wiek <i>et al.</i> (2011) ^[12] ; UNESCO SDG learning objectives (2017) ^[8] ; UNESCO ESD roadmap (2020)
Place-based inquiry + outdoor learning	Make learning authentic and contextual	Fieldwork; local audits; mapping	Field notebook; report; interpretation	Rickinson <i>et al.</i> (2004) ^[5]
SSI pedagogy	Teach trade-offs, ethics, and argumentation	Structured controversy; stakeholder debate	Argument map; policy memo	SSI systematic review (≤2024); Stern (2000) ^[6]
Project/design-based learning	Build action competence	Design sprints; implementation projects	Prototype + monitoring plan	UNESCO (2020)
Citizen science	Combine science practice + civic contribution	Monitoring; data analysis	Dataset + visualization	Ardoin <i>et al.</i> (2020) ^[11] ; green school citizen science study (2024)
Service learning	Connect learning with community needs	Community campaigns; partnerships	Impact log + reflection	Service/collaborative learning study (2024)
Digital systems learning	Extend analysis and communication	GIS basics; modeling tools; media	Digital model/map + critique	Aligned with UNESCO guidance (2017; 2020) ^[8, 9]
Whole-school approach	Sustain learning via school culture	Eco-policy; routines; leadership; student committees	School audit + governance evidence	UNESCO (2024) ^[10] ; whole-school ESD research; eco-school evaluation; Adiwiyata studies

Table 2: Assessment blueprint for sustainability competencies in secondary EE.

Competency	What it looks like (secondary)	Assessable products	Rubric indicators
Systems thinking	Feedbacks, causes, unintended effects	Causal loop diagram; system map	Accurate links; boundary justification; uncertainty
Futures/anticipatory	Scenario pathways, risk and resilience	Scenario brief; risk register	Plausibility; alternatives; sensitivity to assumptions
Normative/values	Ethical reasoning, equity lens	Stakeholder equity analysis; reflection	Beneficiaries/harms; ethical clarity; respectful reasoning
Strategic competence	Feasible interventions with monitoring	Project plan + indicators	Feasibility; resources; monitoring & evaluation
Collaboration	Teamwork and deliberation	Team contract; peer assessment	Role clarity; inclusive process; conflict handling

Table 3: Implementation roadmap (12 months) for secondary schools.

Phase	Time	Focus	Key actions	Evidence produced
Phase 1: Foundation	Months 1–3	Outcomes + baseline	Define competencies; baseline audit; teacher PD; select local issue	Baseline report; rubrics; school audit dashboard
Phase 2: Pilot units	Months 4–6	2–3 integrated units	Place-based inquiry; SSI module; small PBL	Unit portfolios; student models; reflections
Phase 3: Scale & partnerships	Months 7–9	School-wide reinforcement	Eco-committee; partnerships; citizen science monitoring	Datasets; partnership documentation; event evidence
Phase 4: Consolidate & report	Months 10–12	Evidence + improvement	Evaluate outcomes; refine routines; SDG/ESD reporting	Annual ESD report; improvement plan

5. Conclusion

Secondary environmental education can meaningfully support ESD when it is designed as a coherent system: competency-aligned outcomes, active and place-based pedagogy, authentic projects, and whole-school reinforcement. The Strategy Stack and implementation roadmap provide a practical pathway for schools to operationalize EE-for-ESD and document outcomes for SDG-aligned reporting.

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