Mapping Ecological Civilization Education from a Geographical Education Perspective: Knowledge Structure, Thematic Evolution, and Pedagogical Implications

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Abstract

Ecological civilization education (ECE) has expanded rapidly as an educational response to intertwined ecological, social, and developmental challenges, yet its conceptual boundaries and implementation pathways remain fragmented. This review combines a light bibliometric evidence synthesis with a thematic review of educational theory and practice. Four published quantitative mapping studies covering ECE, education for sustainable development, environmental education, and the broader ecological civilization literature were compared to identify growth patterns, dominant themes, and persistent blind spots. The synthesis shows a field moving from policy- and awareness-oriented discussion toward curriculum integration, experiential learning, school–community collaboration, sustainability competencies, digital augmentation, and outcome assessment. However, higher education and top-down policy discourse remain disproportionately visible, while longitudinal learning outcomes, teacher capacity, spatial accessibility, educational equity, and community-level implementation are underdeveloped. To organize future work, this review proposes the PLACE framework: Place-based experience, Learning integration, Action competence, Collaborative governance, and Evaluation, equity, and enabling technology. The framework positions ECE as a context-sensitive form of transformative sustainability education that links ecological knowledge with lived experience, collective action, and measurable learning.

Keywords

ecological civilization education; education for sustainable development; environmental education; bibliometric evidence synthesis; place-based learning; action competence; educational equity; PLACE framework

1. Introduction

Education has become a central arena in the transition toward sustainability. The international education agenda increasingly expects schools, universities, communities, and lifelong-learning institutions to help learners understand complex socio-ecological systems and to act responsibly within them. UNESCO’s Education for Sustainable Development (ESD) roadmap places policy, learning environments, educators, youth, and communities within a common implementation architecture, while the Sustainable Development Goals identify education as both a goal in itself and an enabling condition for wider transformation [1–4]. This shift has encouraged educational research to move beyond the transmission of environmental facts toward competencies, values, agency, collaboration, and institutional change.

Within this broader landscape, ecological civilization education (ECE) has emerged as a distinctive and rapidly developing field. It is usually associated with education that helps learners understand human–nature relations, develop ecological responsibility, and participate in forms of production, consumption, governance, and everyday life that are compatible with ecological limits. The concept is strongly rooted in China's ecological civilization discourse, but its educational implications overlap with long-standing traditions of environmental education (EE) and ESD. This overlap is productive but also creates ambiguity. Wu and Liu argued that ECE remains conceptually underdefined and proposed models linking educational goals, program design, and outcomes [5]. Policy-focused studies have likewise shown that the relationship among EE, ESD, and ecological civilization has changed over time and that domestic policy discourse may narrow, reframe, or selectively emphasize particular sustainability dimensions [6,7].

The research field has now reached a point where another conventional keyword-map article would add limited value. A 2025 review already examined 446 Chinese and international publications on ECE from 2000 to 2024 and identified a nascent stage, a developmental stage, and a rapid-growth stage, while also reporting a strong concentration on universities and ideological–political frameworks [8]. A broader bibliometric study of Chinese ESD research analyzed 1,092 records from 1998 to 2023 and found a complex research landscape centered on environmental education, educational reform, school education, ideology, and methodological questions [9]. In Japan, a 2026 knowledge-mapping study examined 681 papers on environmental education and ESD and identified more specialized practice-oriented themes including forest environmental education, energy education, life cycle thinking, consumer education, experiential learning, and school–community cooperation [10]. The broader ecological civilization literature also displays a large difference in research scale and framing between Chinese and international databases [11]. Together, these studies provide enough quantitative evidence to move from simple mapping toward synthesis.

This review therefore adopts a two-layer design. The first layer is a light bibliometric evidence synthesis. Instead of rebuilding a near-duplicate co-occurrence network from a single database, it compares the quantitative signals reported by major mapping studies with transparent corpora. The second layer is a thematic review that asks what ECE is becoming pedagogically. It examines six interconnected pathways: conceptual foundations; curriculum and whole-school integration; place-based, field-based, and experiential learning; school–community collaboration; digital transformation and virtual fieldwork; and assessment, teacher capacity, institutional conditions, and equity. The aim is to explain not only what topics are visible in the literature, but also how ECE can become an implementable educational model.

Three questions guide the review. First, what do existing bibliometric evidence bases collectively reveal about the growth, thematic orientation, and regional variation of ECE-related research? Second, which pedagogical pathways appear most important for translating ecological civilization from policy discourse into learning processes and outcomes? Third, which research gaps should be prioritized if ECE is to develop into a coherent, evidence-based, and internationally intelligible field? The final contribution is the PLACE framework, which integrates Place-based experience, Learning integration, Action competence, Collaborative governance, and Evaluation, equity, and enabling technology. The framework is intended as a practical research architecture rather than a fixed definition of ECE.

2. Materials and Methods

2.1. Review Design

This article uses an integrative review design that combines quantitative evidence synthesis with narrative thematic synthesis. The bibliometric layer does not merge raw records from different databases because the available studies use different search vocabularies, languages, database coverage, and inclusion rules. Direct statistical pooling would therefore create false comparability. Instead, the review treats each mapping study as an evidence unit and extracts comparable descriptors: database, time span, corpus size, publication trajectory, dominant keywords or clusters, practical themes, and explicitly reported gaps. This approach is closer to comparative bibliometric evidence synthesis than to a new single-database bibliometric analysis.

The thematic layer was constructed through citation tracing from the included mapping and conceptual studies, supplemented by targeted searches of peer-reviewed journal platforms and authoritative international reports. The purpose was interpretive integration rather than exhaustive systematic review. Priority was given to sources that clarified educational goals, sustainability competencies, action competence, outdoor and place-based learning, real-world learning, whole-school approaches, teacher competence, virtual fieldwork, environmental literacy assessment, and long-term educational effectiveness. Figure 1 summarizes the review logic.

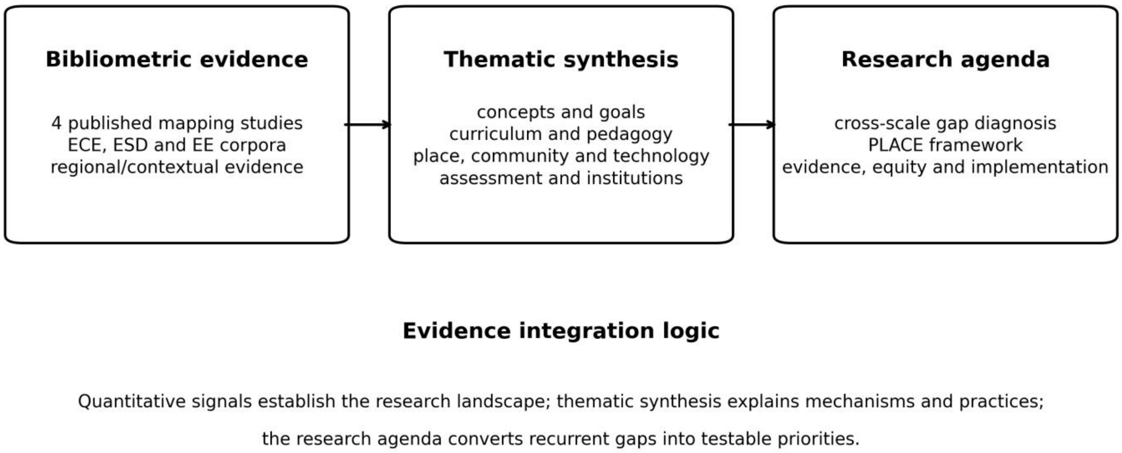

Figure 1. Review design and evidence integration logic.

2.2. Quantitative Evidence Base

Four quantitative studies were selected as the main bibliometric evidence base because together they provide complementary views of the field. Liu and Feng analyzed 446 ECE publications from CNKI and Web of Science between 2000 and 2024 [8]. Tian et al. analyzed 1,092 Chinese ESD records spanning 1998–2023, combining text mining, latent Dirichlet allocation, social network analysis, and sentiment analysis [9]. Ren and Gao examined 681 Japanese publications on environmental education and ESD in J-STAGE since 2000, using publication trends, author and journal analysis, keyword co-occurrence, and thematic interpretation [10]. Li et al. mapped the wider ecological civilization research landscape using 9,196 CNKI records and 664 Web of Science records published between 2000 and 2019 [11]. The fourth study is contextual rather than education-specific, but it helps explain the discursive environment in which ECE developed.

The evidence units differ substantially in search scope. For example, the Japanese study uses environmental education and ESD as operational proxies for ecological civilization education, whereas the Chinese ECE study searches the field directly. The broader ecological civilization study includes governance, economy, urbanization, ethics, and environmental science alongside educational topics. Consequently, corpus sizes in Figure 2 should be interpreted as reported research landscapes rather than comparable prevalence estimates. Their value lies in triangulation: recurring themes across differently constructed corpora are more informative than the absolute size of any single dataset.

Table 1. Quantitative evidence bases used in the bibliometric evidence synthesis.

Evidence unit	Database and period	Records	Primary contribution to this review
China ECE mapping [8]	CNKI + WoS; 2000–2024	446	Direct field trajectory; institutional concentration; policy-driven growth
China ESD mapping [9]	CSSCI/CNKI; 1998–2023	1,092	Broader sustainability-education themes, reform signals, and topic diversity
Japan EE/ESD mapping [10]	J-STAGE; since 2000	681	Practice specialization, experiential learning, life cycle thinking, and school–community cooperation
Ecological civilization context [11]	CNKI + WoS; 2000–2019	9,196 + 664	Discursive context and China–international differences in thematic framing

Note: Record counts are reported by the original studies and should not be interpreted as directly comparable estimates of field size.

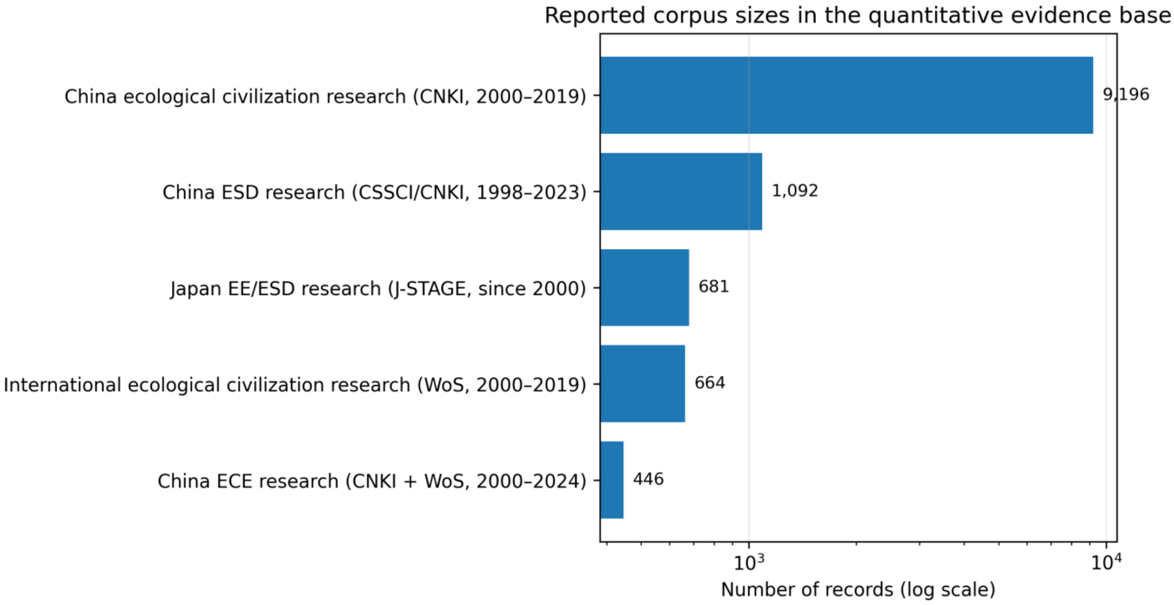

Figure 2. Reported corpus sizes in the quantitative evidence base. Corpus sizes are not directly comparable because database coverage and search scope differ.

2.3. Thematic Coding and Synthesis

Thematic synthesis proceeded in three steps. First, recurrent concepts and practice domains reported in the mapping studies were listed. These included environmental literacy, universities, school education, curriculum, ESD, ecological ethics, sustainable development, forest and energy education, life cycle thinking, consumer education, experiential activities, community cooperation, information technology, and evaluation. Second, related concepts were grouped into pedagogical domains based on their role in educational design. Third, the grouped domains were compared with established research on sustainability competencies, action competence, real-world learning, teacher education, outdoor learning, and assessment [12–18].

This process produced six thematic pathways and five future-oriented framework dimensions. The distinction is intentional. The six pathways summarize how the existing literature is organized, whereas the five dimensions of the PLACE framework reorganize the evidence around implementation needs. This separation prevents the future framework from merely reproducing the field's current thematic structure.

3. Bibliometric Evidence on the Development of the Field

3.1. Expansion with Uneven Disciplinary and Institutional Concentration

The most consistent quantitative signal is expansion. The dedicated Chinese ECE corpus grew from a small, dispersed literature in 2000–2007 to a developmental period in 2008–2012 and then a rapid-growth phase after 2013 [8]. The timing reflects the interaction between educational scholarship and the wider institutionalization of ecological civilization. However, growth in publication volume has not automatically produced a balanced educational evidence base. The 2025 mapping study found strong attention to universities and ideological–political frameworks and comparatively weaker interdisciplinary integration and societal engagement [8].

The Chinese ESD corpus presents a related but not identical pattern. Tian et al. reported a rise followed by decline and partial revival across more than two decades [9]. Their thematic mapping indicates that ESD research has been pulled simultaneously by environmental education, educational ideas and reform, school education, higher education, informationization, and wider social-development concerns. The field is therefore broader than ECE narrowly defined, yet its thematic complexity also demonstrates a structural challenge: sustainability education is often divided among separate educational sectors and conceptual labels rather than accumulated through a coherent program of theory testing and long-term evaluation.

The Japanese evidence base reveals a more practice-differentiated pattern. Ren and Gao found 681 papers and highlighted forest environmental education, energy environmental education, life cycle assessment and life cycle thinking, consumer education, experiential activities, integrated studies, and school–community cooperation [10]. This pattern is important because it illustrates what happens when an educational field matures through domain-specific practices. Rather than centering only on a broad civilizational concept, the literature becomes distributed across settings, age groups, teaching materials, community partnerships, and specialized environmental problems.

The broader ecological civilization map provides a final contextual signal. Li et al. found 9,196 CNKI publications but only 664 Web of Science publications for 2000–2019 [11]. In the international corpus, ecological civilization co-occurred with sustainability, ecological footprint, ecosystem services, sustainable development, ecological ethics, low-carbon economy, evaluation, urbanization, and ecological economy. In the Chinese corpus, educational, ideological, and philosophical themes formed one of the major clusters. This asymmetry helps explain why ECE is both educationally rich and internationally difficult to translate: it sits at the intersection of a national policy discourse and globally circulating educational traditions.

3.2. Convergence Around Five Research Signals

Across the quantitative evidence bases, five signals recur. The first is the close relationship between ecological education and sustainable development. Even where ecological civilization is the primary term, sustainable development remains a major conceptual neighbor [6,8,11]. The second is the persistent importance of formal institutions, particularly universities and schools. The third is the expansion from general awareness toward specialized pedagogies and content domains. The fourth is growing attention to participation, collaboration, technology, and practical activities. The fifth is the unresolved problem of evaluation: many studies discuss goals, values, pathways, and policy significance, but fewer demonstrate durable changes in learner competence, behavior, collective action, or environmental outcomes.

These signals suggest that the field is experiencing a transition from discursive establishment to implementation research. Early and policy-oriented work was necessary to define the legitimacy of ecological civilization as an educational concern. The next stage requires stronger connections among curriculum, pedagogy, learning environment, teacher capacity, community institutions, and outcome evaluation. Quantitative mapping can reveal the direction of travel, but it cannot by itself explain the educational mechanisms that connect ecological learning to action. The following thematic synthesis focuses on those mechanisms.

3.3. A Cumulative Conceptual Transition from EE to ESD and ECE

The relationship among EE, ESD, and ECE is best understood as cumulative rather than substitutive (Figure 3). Environmental education established the importance of ecological knowledge, awareness, attitudes, and stewardship. ESD broadened this foundation by emphasizing interdependence among environmental, social, economic, and cultural systems and by placing competencies and transformation at the center of learning [1–4,12–14]. ECE adds a context-specific civilizational perspective in which human–nature relationships, ecological values, collective responsibility, governance, production and consumption patterns, and long-term societal transition are brought into educational discussion [5–7].

The cumulative view also clarifies a key risk. When ECE is treated only as policy communication, learners may acquire terminology without developing systems thinking, problem-solving capacity, or agency. Conversely, if ECE is translated directly into generic ESD language, the specific historical, cultural, institutional, and governance context that gives the concept meaning may be lost. A productive research program must therefore examine both common sustainability-learning mechanisms and context-specific meanings.

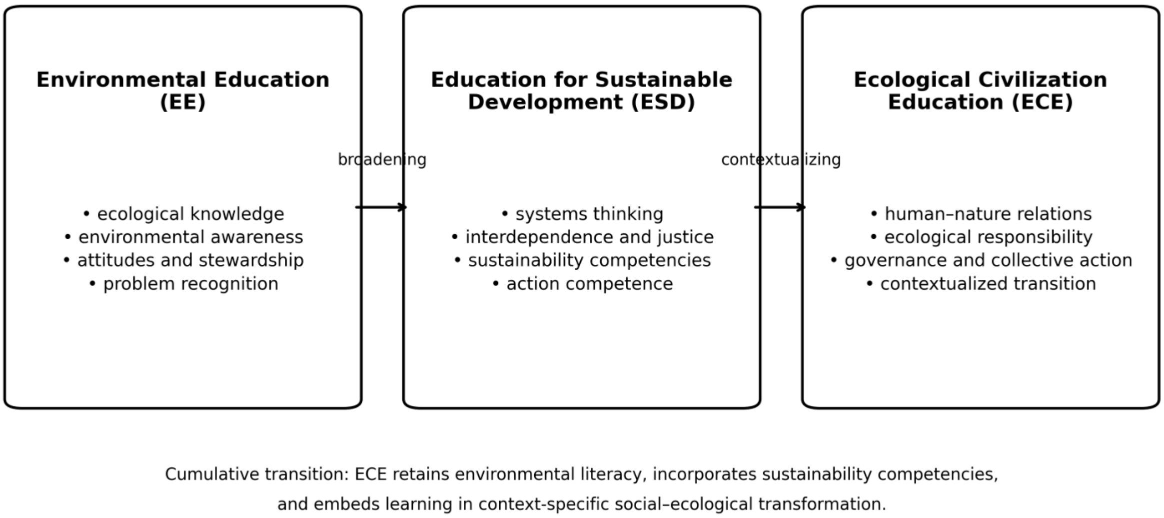

Figure 3. Cumulative conceptual transition from environmental education to education for sustainable development and ecological civilization education.

4. Major Thematic Pathways of Ecological Civilization Education

4.1. Conceptual Foundations: From Awareness to Transformative Capability

ECE begins with ecological literacy but cannot end there. Knowledge of ecosystems, resource constraints, pollution, biodiversity, climate change, and environmental governance is necessary, yet information alone does not explain why learners act or how institutions change. Sustainability education research therefore increasingly emphasizes competence frameworks. Wiek et al. identified systems-thinking, anticipatory, normative, strategic, and interpersonal competencies as central to sustainability problem solving [12]. Rieckmann similarly emphasized future-oriented competencies that enable learners to participate in complex transformation processes [13]. Action competence research adds an explicitly educational distinction between prescribed behavior and the capacity to make informed, intentional, and collectively meaningful decisions [14].

This distinction is particularly relevant to ECE. A narrow behavioral model may define success as recycling, saving water, or reducing electricity use. These practices matter, but transformative education also requires learners to understand trade-offs, identify actors and power relations, interpret spatial and temporal consequences, compare alternative futures, deliberate about values, and participate in problem solving. The educational objective therefore shifts from ecological obedience to ecological agency. Wu and Liu’s conceptual discussion of ECE similarly points toward the need to align goals, program design, and learning outcomes rather than treating the field as a collection of environmental messages [5].

The conceptual challenge is to preserve normative direction without turning learning into one-way persuasion. Ecological civilization clearly carries ethical commitments, including respect for ecological limits and responsibility for human–nature relations. Educationally, however, these commitments should be explored through evidence, inquiry, dialogue, and action. Learners need opportunities to encounter uncertainty and conflict: renewable energy may reduce carbon emissions while creating land-use conflicts; protected areas may conserve biodiversity while restricting local livelihoods; compact urban development may reduce travel emissions while intensifying heat exposure. Such problems make ECE intellectually demanding and create opportunities for systems thinking and reasoned judgment.

A mature ECE framework should therefore organize learning outcomes across at least four levels: knowledge and systems understanding; values and ecological responsibility; competencies for inquiry, deliberation, planning, and collaboration; and individual or collective action. Environmental literacy frameworks and sustainability competence research provide useful foundations, but ECE research must test whether these constructs travel across school levels, cultural contexts, and forms of learning [12,15].

4.2. Curriculum Integration, Teacher Capacity, and the Whole-School Approach

The second pathway concerns institutional integration. Ecological civilization education is frequently advocated as cross-disciplinary, but cross-disciplinary aspirations are difficult to implement when responsibility is dispersed across subjects and no teacher has sufficient time, materials, or assessment incentives. UNESCO's recent curriculum guidance emphasizes age-progressive learning outcomes and integration across climate science, ecosystems, justice, resilience, sustainable economies, and lifestyles [2,3,35]. For ECE, a comparable curriculum architecture could prevent repetition of broad environmental slogans and establish progression from observation and care in early grades to systems analysis, spatial evaluation, scenario reasoning, and civic participation in later stages.

Subject disciplines can contribute different forms of knowledge. Geography can analyze spatial patterns, human–environment relations, resource flows, accessibility, and scale. Biology can examine ecosystem function, biodiversity, and adaptation. Chemistry can connect materials, pollution, and circularity. Economics can analyze incentives, externalities, and transition pathways. Civics and social studies can address institutions, participation, rights, responsibility, and environmental justice. Language and arts can explore ecological narratives, communication, and cultural meanings. Integration should not eliminate disciplinary depth; it should coordinate disciplinary perspectives around shared ecological questions.

Teacher capacity is the main institutional hinge. Bertschy et al. showed that ESD implementation requires educators to combine content knowledge, pedagogical knowledge, reflection, systems understanding, and the capacity to design learning environments around sustainability questions [17]. A systematic review of teacher education for sustainable development has likewise described the area as an emerging field that needs deeper integration into mainstream teacher education rather than remaining a niche specialization [33]. These findings apply directly to ECE. Teachers need more than policy familiarity: they need access to local cases, field methods, risk management procedures, geospatial tools, community partners, assessment rubrics, and professional learning communities.

The whole-school approach expands ECE beyond curriculum documents. Research on whole-school ESD emphasizes the alignment of teaching, school organization, leadership, operations, participation, and community relationships [18]. In an ECE context, campus energy and water management, food systems, waste, biodiversity, mobility, procurement, and green space can become learning infrastructures. Students can investigate real data, propose interventions, communicate with administrators, and evaluate outcomes. The school becomes a small social–ecological system rather than a place where sustainability is discussed only in textbooks.

However, whole-school approaches also risk symbolic implementation. A school can install recycling bins and display green slogans without changing learning. The educational criterion should therefore be whether institutional practices create structured opportunities for inquiry, participation, feedback, and competence development. This requires clear connections between school operations and classroom learning, as well as teacher time and leadership support.

4.3. Place-Based, Field-Based, and Experiential Learning

The third pathway is learning through direct engagement with ecological places. This is especially important for ECE because many core concepts—ecosystem processes, land-use change, environmental risk, resource dependence, landscape value, and human–nature interaction—are spatial and experiential. Systematic review evidence indicates that nature-specific outdoor learning can support engagement, social collaboration, academic learning, self-concept, and well-being, although outcomes vary with program design and study quality [19]. An integrative review of nature experience and learning also concluded that contact with nature can support academic learning, personal development, and environmental stewardship through multiple mechanisms [20].

Place-based education provides a useful theoretical bridge. It connects curriculum with local ecological and cultural settings and asks learners to investigate the places in which they live [21–23]. For ECE, place is not merely a convenient backdrop. It is where abstract sustainability problems become visible and contested. A river can be studied simultaneously as an ecosystem, water source, cultural landscape, hazard corridor, governance space, and site of unequal access. A forest park can be examined as habitat, carbon sink, recreational space, educational resource, and management institution. An urban neighborhood can reveal heat risk, green-space distribution, mobility behavior, waste systems, and environmental inequality.

Field-based ECE should therefore move beyond guided sightseeing. Effective designs can follow an inquiry cycle: preparation and problem framing; field observation and data collection; interpretation using maps, models, statistics, or interviews; deliberation over trade-offs; proposal of interventions; and reflection on learning and responsibility. Real-world learning research in sustainability suggests that authentic problems and stakeholder interaction can support competence development when tasks are carefully scaffolded and linked to curricular goals [24].

Geospatial technologies are particularly relevant because ecological civilization questions are rarely spatially uniform. GIS, remote sensing, web mapping, and location-based data allow learners to connect field observations with regional patterns. Research on geospatial technologies in geography education has shown that well-designed lessons can support relational thinking about spatial processes [25]. In ECE, these tools can help students compare ecological supply and human demand, evaluate land-use conflicts, map environmental exposure, examine ecosystem-service flows, or analyze the accessibility of ecological learning sites.

An important research frontier is educational accessibility. Ecological resources may be abundant while actual learning opportunities remain uneven because schools differ in transport connectivity, travel time, funding, safety capacity, teacher expertise, and schedule flexibility. This means that the educational value of a natural site depends not only on ecological quality but also on whether learners can reach, use, and repeatedly engage with it. The equity implications are substantial: students in peripheral, mountainous, rural, or poorly connected regions may live close to important ecosystems yet have fewer organized opportunities for field learning. Future ECE research should therefore treat access as an educational variable and examine spatial matching among ecological resources, schools, transport systems, and alternative digital opportunities.

The place-based pathway also helps internationalize ECE without erasing context. The same educational architecture—local inquiry, systems interpretation, stakeholder engagement, and action—can be applied to different ecological settings, while the questions, values, institutions, and practices remain locally grounded. This makes place-based learning a practical bridge between a concept rooted in China and global environmental and sustainability education research.

4.4. School–Community Collaboration and Social Learning

The fourth pathway extends learning beyond the school boundary. Bibliometric evidence from Japan highlights school–community cooperation as an important practice pattern [10], while ESD frameworks emphasize communities as one of the major implementation domains [1]. Community collaboration matters because many ecological problems cannot be reproduced inside classrooms. Water governance, waste management, habitat restoration, agricultural transition, disaster risk, and urban greening involve multiple actors, uneven knowledge, contested values, and long time horizons.

Community-linked ECE can take several forms: citizen science, service learning, participatory mapping, ecological monitoring, interviews with resource users, co-design projects, intergenerational knowledge exchange, museum or park partnerships, and local problem-solving studios. The strongest designs avoid using communities merely as sites from which students extract information. Instead, teachers and learners can work with local agencies, protected-area managers, nongovernmental organizations, farmers, businesses, and residents to define questions and share findings.

Environmental education research provides evidence that programs can contribute to conservation and environmental quality, but a systematic review also found that direct environmental outcomes are difficult to document and that program design and evaluation need to be more intentional [26]. Climate change education research similarly suggests that effective interventions often combine personally meaningful information, active and engaging teaching methods, deliberation, and opportunities to address misconceptions [27]. These lessons imply that ECE should connect cognitive understanding with situated participation rather than assuming that awareness naturally becomes action.

Collaboration also raises governance questions. Who defines the educational problem? Whose ecological knowledge counts? Which groups have access to participation? How are conflicts handled? ECE research often celebrates participation at a general level, but these questions require empirical attention. Community partnerships can reproduce existing inequalities if schools work only with highly visible institutions or if students' proposals have no channel for response. Social learning should therefore include reciprocal communication and feedback.

4.5. Digital Transformation, Virtual Fieldwork, and AI-Supported Learning

Digital technology has become a visible component of sustainability education, yet its role should be defined pedagogically rather than technologically. For ECE, digital tools can perform at least four functions: extending access to ecological places, supporting spatial analysis, enabling collaborative inquiry, and providing feedback or simulation. The key question is not whether technology is advanced, but whether it helps learners observe relationships, compare scenarios, interpret evidence, or participate in ecological problem solving.

Virtual fieldwork is a particularly relevant example. Early research on international virtual field trips argued that digital environments can support and enhance physical fieldwork and can increase participation for learners facing financial or physical constraints [29]. More recent immersive studies have demonstrated the educational possibilities of guided virtual field trips and spatial learning, while systematic reviews of K–12 virtual field trips emphasize that learning outcomes depend on the pedagogical activities built around the virtual experience [30–32]. For ECE, virtual fieldwork should usually be treated as augmentation and access expansion rather than a universal replacement for direct experience.

A useful blended model has three stages. Before a physical visit, digital maps, remote sensing, panoramic images, and short simulations can help learners develop questions and spatial orientation. During fieldwork, mobile mapping, sensor data, photographs, and geotagged observations can structure evidence collection. After fieldwork, students can integrate local observations with regional datasets, compare sites, build narratives, and communicate recommendations. Where physical access is impossible, high-quality virtual fieldwork can preserve some elements of observation, inquiry, and place comparison.

Artificial intelligence introduces additional opportunities and risks. AI can help teachers generate differentiated questions, organize environmental datasets, support coding of field notes, provide formative feedback, and build scenario narratives. However, ECE should not use generative systems as substitutes for evidence or ecological observation. Learners need explicit data literacy: they should distinguish model-generated claims from measured data, inspect sources, understand uncertainty, and recognize that algorithmic systems carry environmental footprints and governance implications. AI integration therefore belongs inside ecological and digital literacy, not outside it.

Digital inclusion is also part of educational equity. A technology-heavy ECE model can reduce geographical barriers while increasing inequalities related to device access, connectivity, software, teacher skill, and language. Research should compare the distributional effects of physical, virtual, and hybrid learning models and identify which combinations serve different school contexts.

4.6. Assessment, Longitudinal Evidence, and Institutional Constraints

The sixth pathway concerns evidence of effectiveness. The literature contains many statements about the importance of ecological awareness, values, literacy, and behavior, but program evaluation is often short-term and self-reported. Sustainability competence research has produced increasingly sophisticated assessment discussions, yet reviews still find inconsistency in constructs, instruments, and alignment between teaching and assessment [15]. Longitudinal ESD research demonstrates the value of examining how action competence changes over time rather than relying only on post-course attitudes [16].

ECE assessment should be aligned with the learning theory of the program. A field investigation designed to develop systems thinking should not be evaluated only by satisfaction. A community project aimed at collaborative problem solving should not be judged only by factual recall. A whole-school initiative should not be judged only by campus resource savings without examining participation and learning. Multi-dimensional assessment may include conceptual knowledge, systems models, spatial reasoning, value reasoning, perceived agency, collaboration quality, action planning, behavioral practice, and documented environmental or institutional outcomes. Existing competency-assessment and pedagogy–competence alignment frameworks provide useful design foundations, but their constructs need adaptation to ECE contexts [15,36].

Assessment also needs time. Immediate gains in knowledge may fade, while changes in identity, responsibility, and participation may emerge slowly. Repeated measures and mixed methods are therefore important. Quantitative scales can measure changes across cohorts; interviews and reflective portfolios can explain mechanisms; observation can document participation; school operational data can test whether projects affect resource use; and spatial data can reveal unequal access or environmental outcomes. Environmental literacy assessment frameworks provide useful starting points, but ECE requires explicit validation of constructs in different cultural and educational settings [34]. Longitudinal and comparative ESD studies further show why effectiveness claims should be based on changes measured over time and across learning contexts [16,28].

Institutional constraints may be as important as pedagogy. Zhou's just-transition analysis identifies persistent problems including insufficient professional training, exam pressure, uneven participation of education stakeholders, and fragmented policy support [7]. Similar barriers appear across sustainability education research. Teachers may value ECE but lack time, confidence, fieldwork approval procedures, partner networks, assessment space, or access to reliable teaching materials. Future studies should therefore examine implementation conditions rather than attributing weak outcomes to learner motivation alone.

A final constraint is the mismatch between policy scale and classroom scale. National concepts are broad and normative, while teaching requires age-appropriate questions, concrete places, manageable tasks, and assessable outcomes. Translational research is needed between these levels. Curriculum standards, teacher education, local ecological resources, and school organization should be studied as interacting parts of an implementation system.

Table 2. Major thematic pathways, pedagogical mechanisms, and recurring evidence needs.

Pathway	Core mechanism	Illustrative pedagogies	Evidence need
Concepts and competencies	Move from awareness to systems understanding, judgment, agency, and action	Inquiry, scenario analysis, deliberation, problem solving	Validated constructs and mechanism studies
Curriculum and whole-school integration	Align subjects, progression, teacher learning, leadership, and operations	Interdisciplinary units, school sustainability audits, project learning	Implementation fidelity and teacher-capacity evidence
Place and field learning	Connect abstract ecological knowledge with lived social–ecological systems	Field inquiry, participatory mapping, GIS, ecological monitoring	Accessibility, comparative designs, and longitudinal outcomes
School–community collaboration	Learn through reciprocal engagement with real actors and institutions	Citizen science, service learning, co-design, local interviews	Governance, reciprocity, participation, and power
Digital and hybrid learning	Extend access, analysis, simulation, and collaboration	Virtual fieldwork, remote sensing, web GIS, AI-supported feedback	Equity effects and learning comparisons across modes
Assessment and institutions	Align evaluation with intended learning mechanisms and enabling conditions	Performance tasks, portfolios, observation, mixed methods, repeated measures	Long-term competence, behavior, action, and institutional outcomes

5. Discussion

5.1. What Makes Ecological Civilization Education Distinct?

The synthesis suggests that ECE should neither be reduced to environmental awareness nor treated as a simple translation of ESD. Its potential distinctiveness lies in connecting education with a broad account of civilizational transition: human–nature relations, ecological ethics, production and consumption, governance, spatial development, public participation, and collective responsibility. The broader ecological civilization literature already connects the concept with sustainable development, ecological ethics, low-carbon development, ecosystem services, evaluation, urbanization, and green development [11]. ECE can translate these connections into learning questions.

At the same time, distinctiveness should be demonstrated through educational theory and evidence. A policy concept does not automatically become a pedagogical model. The field needs to show how learners develop understanding, values, agency, and competence; how schools organize cross-disciplinary learning; how communities participate; and how outcomes are assessed. The cumulative EE–ESD–ECE model in Figure 3 provides one way to frame this relationship. ECE inherits environmental literacy from EE and transformative competencies from ESD, while adding context-specific ethical, institutional, and civilizational questions.

This framing also helps address international communication. Ecological civilization remains much more prominent in Chinese-language research than in international literature [11]. Rather than presenting ECE as a universally fixed label, researchers can describe its educational mechanisms in concepts that travel—systems thinking, place-based inquiry, action competence, participation, ecological responsibility, and educational equity—while explaining the specific political and cultural context in which the term developed.

5.2. The Main Evidence Gap Is the Chain from Policy to Learning to Action

The field's central weakness is not a lack of themes. It is a weak causal and evidential chain. Policy documents can create legitimacy and curriculum space, but they do not guarantee teaching quality. Courses can increase knowledge, but knowledge does not automatically become action. Experiential activities can be memorable, but memory does not necessarily produce systems understanding. School projects can reduce resource use, but operational improvement does not necessarily prove student learning. The next phase of research should make these links explicit.

A useful program theory can be expressed as five linked questions. What ecological or sustainability problem is the program addressing? Which learning processes are expected to change students' knowledge, values, competencies, or agency? Which teaching activities and settings activate those processes? Which institutional conditions enable implementation? Which short-, medium-, and long-term outcomes provide evidence of success? Studies that answer all five questions will be more cumulative and comparable than studies that only describe teaching activities or survey general attitudes.

The evidence chain also requires stronger design diversity. Cross-sectional questionnaires are useful for describing literacy and attitudes, but they cannot establish change. Quasi-experiments, longitudinal cohorts, comparative case studies, design-based research, mixed-method evaluations, and spatial analyses can address different questions. The mapping studies reviewed here show that the field has expanded; the next methodological challenge is to connect growth with credible learning evidence.

5.3. Equity and Accessibility Should Become Core ECE Questions

Educational equity is underdeveloped in the dominant ECE discourse. Yet ecological learning opportunities are spatially, socially, and institutionally uneven. Some schools have immediate access to parks, wetlands, coastlines, forests, museums, monitoring stations, universities, and community organizations. Others face long travel times, weak transport, limited teacher capacity, safety constraints, or poor connectivity. Learners may therefore experience very different versions of ecological civilization education even under the same curriculum policy.

This gap has theoretical implications. If ECE values direct human–nature relationships and participation, access to ecological learning environments becomes part of educational justice. Future research can map the supply of ecological learning sites, the distribution of school demand, travel-time thresholds, program costs, teacher capacity, and digital alternatives. It can then ask whether hybrid strategies reduce or reproduce inequality. This connects educational research with geography, transport analysis, ecosystem services, and spatial planning and offers a clear interdisciplinary frontier.

Equity also concerns voice. Community-based projects may privilege actors with institutional resources and overlook indigenous, rural, migrant, or otherwise marginalized knowledge. Digital systems may privilege well-connected schools. Assessment instruments may reflect urban or university populations. A justice-sensitive ECE therefore needs to examine both distribution—who gets access—and recognition—whose knowledge and values shape learning.

5.4. The PLACE Framework

Based on the synthesis, this review proposes the PLACE framework (Figure 4). PLACE is an implementation-oriented framework with five mutually reinforcing dimensions.

P—Place-based experience. ECE should connect learners with real social–ecological places through observation, field inquiry, local cases, and situated environmental problems. Place includes both ecological processes and cultural meanings. Physical experience is valuable, while virtual and remote tools can extend access when direct engagement is limited.

L—Learning integration. Ecological civilization should be embedded across curriculum progression, teacher learning, school organization, and the wider educational environment. Integration means coherence rather than indiscriminate addition. Different disciplines contribute different analytical lenses, while whole-school practices create opportunities to investigate sustainability in operation.

A—Action competence. Learning should develop the capacity to understand systems, anticipate futures, reason about values, collaborate, design strategies, and participate in responsible action. Programs should distinguish learner agency from compliance with prescribed behaviors.

C—Collaborative governance. Schools are not isolated institutions. ECE should create reciprocal relationships with communities, public agencies, protected areas, museums, universities, nongovernmental organizations, and relevant businesses. Collaboration includes co-definition of problems, knowledge exchange, feedback, and attention to participation and power.

E—Evaluation, equity, and enabling technology. Evaluation should be aligned with intended learning mechanisms and should include longitudinal and mixed-method evidence where feasible. Equity should be examined in access to sites, teachers, digital tools, and participation. Technology should enable observation, analysis, collaboration, simulation, and access, but its value must be assessed against educational aims and distributional consequences.

The PLACE framework is not intended as a new taxonomy of environmental topics. Its purpose is to organize research designs and program evaluation. For example, a forest-education program can be examined by asking whether students meaningfully encounter place (P), whether the activity connects to curriculum and teacher preparation (L), whether learners develop inquiry and action competence (A), whether park managers and communities participate reciprocally (C), and whether outcomes and access are evaluated over time (E). This common architecture could improve comparability across otherwise diverse ECE programs.

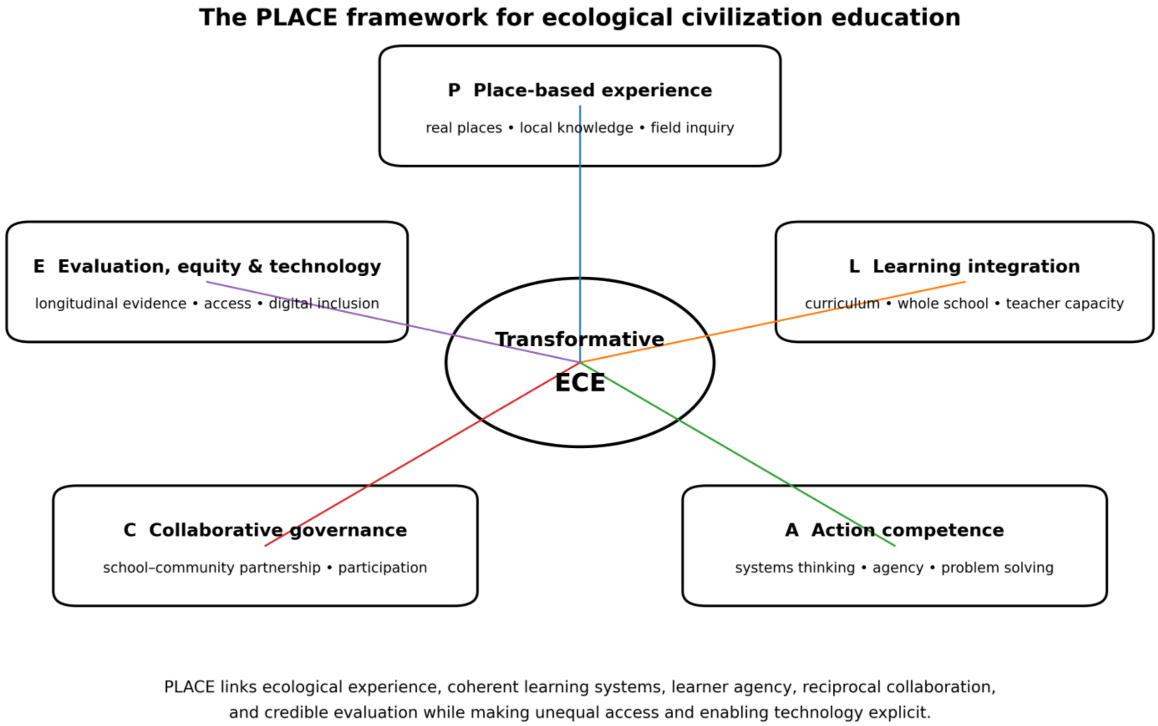

Figure 4. The PLACE framework for future ecological civilization education research and practice.

5.5. Research Agenda

The future research agenda should prioritize mechanisms and implementation. First, conceptual research should clarify the relationship among ecological literacy, sustainability competence, ecological responsibility, and action competence within ECE. Second, curriculum research should test progression models across age groups and subjects. Third, field-based research should compare physical, virtual, and hybrid ecological learning under different geographical conditions. Fourth, community studies should analyze governance, reciprocity, and learning across stakeholders. Fifth, assessment research should validate multi-dimensional and longitudinal measures. Sixth, spatial research should make accessibility and educational resource distribution visible.

Three design principles can guide this agenda. The first is comparative context: the same program mechanism should be studied in different regions, school types, and social settings. The second is mixed evidence: self-report should be combined with performance tasks, observation, artifacts, environmental or institutional data, and longitudinal follow-up. The third is transparent theory of change: studies should specify how teaching activities are expected to generate outcomes and which contextual conditions may strengthen or weaken the pathway.

The bibliometric evidence also points to the need for stronger international dialogue. Research should compare ECE with ESD, environmental education, climate education, conservation education, and other culturally embedded sustainability-learning traditions without assuming that one vocabulary should replace the others. Comparative work can identify shared educational mechanisms and meaningful differences in governance, ethics, curriculum organization, and learner agency.

Table 3. Priority research questions derived from the PLACE framework.

Dimension	Priority questions	Recommended evidence
P – Place-based experience	Which ecological settings and forms of direct experience produce which learning mechanisms? How does accessibility shape participation?	Comparative field studies; travel-time/accessibility analysis; observation; place-attachment measures
L – Learning integration	How should ECE progress across ages and subjects? Which teacher and school conditions enable sustained implementation?	Curriculum mapping; implementation studies; teacher professional learning research; whole-school case comparison
A – Action competence	How do systems thinking, value reasoning, collaboration, and agency develop and persist?	Performance tasks; validated scales; longitudinal cohorts; behavioral and action records
C – Collaborative governance	How do schools and communities co-define problems, exchange knowledge, and share decisions?	Stakeholder network analysis; participatory evaluation; interviews; governance process tracing
E – Evaluation, equity & technology	Do physical, virtual, and hybrid models produce different outcomes and distributional effects?	Mixed-method evaluation; quasi-experiments; digital access data; spatial equity metrics

6. Conclusions

Ecological civilization education is entering a transition from conceptual and policy expansion toward questions of pedagogy, implementation, evidence, and equity. The quantitative evidence reviewed here shows rapid growth in Chinese ECE research, a broader and thematically diverse ESD landscape, practice specialization in Japanese environmental and sustainability education, and a large discursive gap between Chinese and international ecological civilization research. These patterns indicate a field with substantial momentum but uneven theoretical integration.

The thematic synthesis identifies six major pathways: conceptual development from awareness toward transformative capability; curriculum and whole-school integration; place-based and field-based learning; school–community collaboration; digital and virtual augmentation; and stronger assessment combined with attention to teacher capacity and institutional constraints. Across these pathways, the most important gap is the evidence chain from policy commitment to teaching process, learner competence, participation, and durable outcomes.

The proposed PLACE framework organizes future ECE around Place-based experience, Learning integration, Action competence, Collaborative governance, and Evaluation, equity, and enabling technology. Its main proposition is simple: ecological civilization education becomes educationally meaningful when ecological knowledge is connected to lived places, coherent learning systems, learner agency, reciprocal social participation, and credible evidence. Future research can use this framework to design comparative studies, evaluate programs, and connect ECE with the wider international field of sustainability education while preserving its contextual specificity.

7. Perspective

The next generation of ECE research should become more empirical, spatial, comparative, and longitudinal. Publication growth has already established the field’s visibility. The more difficult task is to understand which forms of learning work, for whom, in which places, under which institutional conditions, and with what lasting effects. This requires collaboration among education researchers, geographers, ecologists, psychologists, planners, data scientists, teachers, and community organizations.

A particularly promising direction is the integration of educational research with spatial analysis. Mapping schools, ecological learning sites, travel-time networks, environmental risks, digital infrastructure, and community partners can reveal where policy ambitions are easiest or hardest to implement. These analyses can then be paired with field studies of teaching quality and learning outcomes. Such work would move ECE from general advocacy toward geographically differentiated educational planning.

At the same time, technology should be used with restraint and purpose. AI, virtual reality, remote sensing, and GIS can expand observation and access, but direct engagement with ecological systems and communities remains central. The strongest future model is likely to be hybrid: local experience for meaning and relationship, digital tools for scale and comparison, collaborative governance for relevance, and rigorous evaluation for learning.

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Conflicts of Interest

The author declares no conflict of interest.

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