

Introduction to the special issue on “Sustainable Development Goals and Education: Rethinking Teaching Practices, Curriculum, and Institutional Roles”

Guest Editors

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Sustainability Education beyond Content: From Commitment to Action

Sustainability is no longer adequately understood as a discrete environmental topic to be added to existing curricula. The Sustainable Development Goals (SDGs), particularly SDG 4 and Target 4.7, position education as both an objective of sustainable development and an enabling condition for achieving the broader 2030 Agenda. Education for Sustainable Development (ESD) accordingly calls for cognitive, socio-emotional, and behavioral learning outcomes that enable learners not simply to understand sustainability challenges but to participate in addressing them (UNESCO, 2017, 2020). This shift is also reflected in scholarship on sustainability competencies, which has progressively moved attention from knowledge acquisition toward systems thinking, anticipatory and normative competence, strategic action, collaboration, and the capacity to participate in sustainability transformations (Redman & Wiek, 2021; Wiek et al., 2011).

Yet increased recognition of sustainability in educational policy does not necessarily mean that it has become meaningfully embedded in educational practice. Institutions may adopt sustainability strategies without substantially changing governance or organizational routines; curricula may reference the SDGs while leaving dominant teaching practices intact; and educators may endorse sustainability without having sufficient opportunities, competencies, or institutional support to translate that commitment into classroom practice. Studies of professional learning similarly show that participation in development activities does not necessarily lead to changes in teaching when contextual, financial, organizational, or resource-related barriers constrain implementation (Parry & Kumi, 2026). In digitally mediated education, sustainable change likewise depends on professional competence being supported by context-sensitive planning and opportunities for practice and reflection (Çengel & Acar, 2026; Mohafa et al., 2026). The importance of implementation quality is also evident in research on school wellbeing. Nurgabdeshev et al. (2026) identify staffing capacity, role clarity, leadership coordination, and resource mobilisation as conditions shaping how institutional strategies are experienced in everyday school relationships. Their findings help explain why formal provision needs to be examined alongside the practices through which it becomes part of educational experience.

A second challenge concerns the relationship between knowledge and action. Sustainability education frequently assumes that increasing knowledge, literacy, or awareness will eventually produce environmentally responsible decisions and practices. Environmental education research has long demonstrated that knowledge is only one component of pro-environmental behavior (Kollmuss & Agyeman, 2002), while competency-oriented approaches emphasize the need for learners to apply knowledge, engage with uncertainty, collaborate, and act on authentic problems (Redman & Wiek, 2021). This distinction is especially important in increasingly digital educational

environments, where access to information can expand rapidly without necessarily producing deeper understanding, agency, or responsible behavior.

The eight contributions to this Special Issue illuminate different parts of this translation problem. At one end are institutional questions concerning governance, policy alignment, stakeholder participation, organizational culture, and the capacity of universities to embed sustainability structurally. At another are questions concerning teachers and pedagogy: how professional competence becomes curriculum design, how learning environments can become transformative, and what distinguishes a genuinely sustainability-oriented pedagogy from an instructional innovation that merely increases engagement. Other contributions move closer to learners by examining creativity, environmental care, plant awareness, scientific and technological literacy, self-regulated learning, 21st-century skills, and pro-environmental behavior.

Although environmental sustainability is especially visible across the collection, the contributions collectively demonstrate that sustainability education cannot be reduced to environmental content. Environmental problems become educationally meaningful through governance, professional competence, curriculum decisions, pedagogical design, culture, social participation, and learner agency. This broader perspective is also evident in sustainability-oriented teacher education, where ecological literacy and sustainability competencies become meaningful when learners connect disciplinary understanding with their professional responsibilities and future practices (Bayram & Aslan, 2025; Kuzu & Çubukçu, 2026). Read together, the contributions can be understood through three interconnected strands: from institutional commitment to educational enactment; transformative pedagogies organized around authentic sustainability challenges; and the movement from literacy toward ecological awareness and action. Across these strands, a common argument emerges: sustainability education is a multilevel process in which institutional conditions enable or constrain educational practice, educators translate broad commitments into pedagogical experiences, learners develop competencies and agency, and those capacities may ultimately become visible in sustainability-oriented awareness, problem solving, and action.

From Institutional Commitment to Educational Enactment

The first group of contributions draws attention to an issue that often remains implicit in ESD: global aspirations must pass through multiple organizational and professional layers before they can influence learners. UNESCO's ESD for 2030 roadmap similarly identifies policy, education and training environments, educator capacity, youth engagement, and local action as interconnected priority areas rather than independent initiatives (UNESCO, 2020). Sustainability commitments therefore become educationally consequential only when they are supported by governance structures, translated into curricula, and enacted within learning environments.

Ofem et al. (2026) address this question at the level of higher education governance. Their analysis shows that university sustainability is associated with an interconnected configuration of leadership commitment, policy alignment, institutional adaptability, stakeholder engagement, and organizational culture. Importantly, these variables do not contribute uniformly. Policy alignment emerges as particularly influential for social and overall sustainability, while institutional adaptability and stakeholder engagement are prominent for economic sustainability, and stakeholder engagement is especially important for environmental sustainability. Leadership commitment is associated with sustainability, although its relative contribution becomes less pronounced once structural and relational dimensions are considered.

This finding has implications for how sustainability leadership is understood. Leadership can be consequential for organizational learning more generally; a meta-analysis by Tosuntaş and Danişman (2015), for example, found a large overall effect of leadership on organizational learning. Institutional sustainability, however, appears less as the product of individual commitment than as a problem of organizational coherence. Leaders may articulate a sustainability vision, but vision alone cannot compensate for fragmented policy, weak stakeholder relationships, inflexible institutional structures, or cultures that do not sustain change. Sustainability thus becomes

institutionalized when commitments are embedded in mutually reinforcing arrangements rather than remaining dependent on isolated projects or individual champions. The research on university strategy formulation further illustrates the importance of these institutional conditions. Makatova et al. (2026) find that strategic planning in Kazakhstan's universities is shaped by regulatory requirements, ownership, and stakeholder participation, with formal plans supplemented by managerial responses to changing circumstances. Their findings suggest that understanding how universities pursue sustainability requires attention to who participates in setting institutional priorities and how those priorities are interpreted in practice.

Asare et al. (2026) move the discussion from institutional structures toward the professional actors responsible for curriculum enactment. Their findings indicate that teacher competencies are positively associated with the integration of the SDGs into curriculum design, while pedagogical innovation partially mediates this relationship. Teacher competence therefore matters directly, but part of its educational significance lies in teachers' capacity to translate professional knowledge and skills into innovative forms of practice. This interpretation is consistent with ESD scholarship that treats sustainability teaching as a profession-specific competence rather than simple familiarity with sustainable development concepts (Bertschy et al., 2013). It also aligns with evidence that professional learning can have limited impact when teachers lack resources, institutional support, or opportunities to implement what they have learned (Parry & Kumi, 2026).

The implication is significant for SDG integration. Sustainability should not become another set of curriculum statements that teachers are expected merely to cover. Meaningful integration requires educators to connect sustainability concerns with disciplinary content, local contexts, inquiry, systems thinking, collaboration, assessment, and opportunities for learner participation. Asare et al. (2026) therefore reposition pedagogical innovation as a potential explanatory pathway through which sustainability competence becomes visible in practice. Their findings support professional development approaches that engage teachers not only with the content of the SDGs but also with curriculum redesign, experimentation, collaboration, and reflective pedagogical decision-making.

Rekalde-Rodríguez (2026) extends this argument by examining the learning environment itself. Ocean i3, developed in response to plastic pollution along the Basque-Neoaquitaine coastline, brings together interdisciplinarity, challenge-based learning, collaboration with external social actors, alternative learning spaces, and translanguaging. Teachers perceive these characteristics as central to the environment's transformative potential. The importance of space and participation should not be underestimated. Learning is not restricted to planned activity inside formal classrooms; out-of-school and community-connected environments can link disciplinary learning with authentic problems, everyday experience, collaboration, and broader social contexts (Arabacı & Danişman, 2025). The research on school common areas likewise shows that spaces not conventionally defined as classrooms can acquire pedagogical significance through the relationships and activities they support (Zagkotas, 2026). Institutional partnerships can also connect curricula with learning beyond the classroom. Reviewing university-industry collaboration in post-Soviet states, Moldashev et al. (2026) identify opportunities for curriculum reform and work-based learning alongside structural and cultural barriers to collaboration. Their review highlights the institutional conditions that can enable or constrain the educational contribution of external partnerships.

This perspective also changes the teacher's role. Rather than guaranteeing transformative learning, teachers create conditions in which transformation becomes possible. They design spaces for inquiry, collaboration, uncertainty, reflection, and engagement with real problems. Related evidence from nature-based teacher education shows that authentic tasks situated in natural environments can simultaneously support professional learning, environmental awareness, curiosity, creativity, and technological self-efficacy (Uluçınar & Sezer, 2026). Taken together, Ofem et al. (2026), Asare et al. (2026), and Rekalde-Rodríguez (2026) locate sustainability across interconnected layers: institutional governance provides enabling structures; teacher competencies

and curriculum decisions translate broad commitments into educational possibilities; and transformative environments provide contexts in which those possibilities can be experienced.

Transformative Pedagogies for Authentic Sustainability Challenges

The second strand of the Special Issue turns from institutional and professional conditions to what learners actually experience. Sustainability-oriented pedagogy has frequently been associated with learner-centered, project-based, problem-based, experiential, interdisciplinary, and collaborative approaches because sustainability problems demand more than the reproduction of established knowledge (Lozano et al., 2017). Real-world sustainability learning can further connect academic knowledge with actors, constraints, and decision contexts beyond the classroom, creating opportunities for students to understand the practical consequences of what they learn (Brundiers et al., 2010). In the related field of employability education, Harte et al. (2026) examine virtual internships through curriculum governance, experiential learning, and students' reflective and self-regulatory processes. Their analysis offers a useful parallel: authentic experiences need pedagogical structure and opportunities for reflection if learners are to recognise and articulate what they have learned.

Fikri et al. (2026) provide a concrete example through an inquiry-design-based STEM water purification project. Students were not simply taught about water scarcity and purification; they were asked to engage in iterative ideation, prototype construction, testing, evaluation, and redesign. The intervention produced stronger improvements than conventional inquiry learning in fluency, flexibility, and originality, indicating that the addition of iterative design created particular opportunities for creative thinking. The educational significance of the study extends beyond creativity. SDG 6 becomes an organizing context for disciplinary inquiry rather than an external policy statement. Learners encounter sustainability through the practical challenge of constructing a low-cost purification device with locally available and recycled materials, which requires scientific knowledge to be used to generate, evaluate, modify, and justify possible solutions.

This interpretation is consistent with competency-oriented sustainability education, in which learners need repeated opportunities to mobilize knowledge, skills, creativity, and judgment around meaningful tasks (Redman & Wiek, 2021; Wiek et al., 2011). Evidence from other educational domains similarly suggests that learner-centered pedagogies can support practical skill acquisition and engagement when students are required to apply knowledge rather than receive it passively (Okanya et al., 2025). The common point is not that one particular pedagogical label guarantees success, but that instructional design can create structured opportunities for purposeful participation.

Saputri et al. (2026) approach transformation through a complementary route. Their ecopedagogy-based experiential learning model emphasizes direct experience, reflection, ecological values, and continuing action among preservice elementary teachers. Biocentrism, ecoconsciousness, humanism, and sustainability were all associated with environmental care attitudes, while the experiencing and continuing components were particularly prominent. Whereas the inquiry-design STEM study foregrounds solution generation and iterative design, ecopedagogy foregrounds the relationship between experience, ecological interpretation, values, and action. This distinction is productive rather than contradictory. Sustainability challenges have technical and scientific dimensions, but they also concern how individuals understand their relationship with ecological and social systems. Related research with preservice teachers likewise indicates that ecological literacy can be strengthened when environmental concerns are connected with professional identity and future teaching responsibility (Kuzu & Çubukçu, 2026).

A third contribution provides an especially useful counterpoint. Ahmar et al. (2026) examine 343 senior high school students across eight schools using a locally grounded green-chemistry context and four complementary analytical strategies. Despite the motivational promise often associated with gamified instruction, student-reported gamification experience showed no reliable association with scientific literacy achievement or misconception profiles. The findings also suggest that the

consistency of implementation may be more important than students' favorable experience of game elements alone.

This null finding reported by Ahmar et al. (2026) is important because pedagogical innovation can easily become conflated with transformation. Increased participation, enjoyment, or technological novelty may be educationally desirable without necessarily producing deeper conceptual change. The contribution of Ahmar et al. (2026) is therefore not to suggest that gamification “does not work,” but to show that the educational effects of an innovation depend on what is implemented, how consistently it is implemented, and which outcome is being examined. Across the contributions in this strand, a broader pedagogical principle emerges: the important distinction is not simply between traditional and innovative pedagogy, but between pedagogies that attract participation and pedagogies that organize participation around sustained inquiry, experience, reflection, design, revision, and action.

From Literacy to Ecological Awareness and Action

The third strand addresses a persistent question in ESD: what enables knowledge and literacy to become environmentally meaningful? Environmental education research has long documented that knowledge is only one of numerous factors associated with pro-environmental behavior (Kollmuss & Agyeman, 2002). Competency-oriented perspectives similarly resist reducing ESD to the acquisition of correct information and instead emphasize learners' capacity to interpret complex problems, work with others, and participate in possible responses (Redman & Wiek, 2021; Wiek et al., 2011).

Syahriani et al. (2026) investigate this issue through plant awareness among biology students. Rather than defining plant awareness as factual botanical knowledge, the study conceptualizes it through attention, ecological understanding, concern, sensitivity, and action orientation. Science literacy and digital literacy are positively associated with plant awareness, and self-regulated learning functions as a partial mediator in both relationships. The mediating role of self-regulated learning is conceptually important. Scientific understanding and access to digital information create learning resources, but students must still select, organize, evaluate, monitor, and integrate those resources. This interpretation is consistent with evidence that self-regulated learning involves active management of goals, strategies, and learning processes (Arrafii et al., 2025), and with meta-analytic evidence showing a positive relationship between self-regulation and student achievement across a large body of educational research (Danişman, 2017).

The study also draws attention to the specificity of ecological awareness. Plants underpin biodiversity, ecosystem functioning, food systems, and human life, yet they can receive limited attention in education and everyday experience. Syahriani et al. (2026) therefore contribute to sustainability education by treating plant awareness as an educational outcome in its own right and by showing how scientific, digital, and self-regulatory capacities can be integrated in activities such as plant identification, digital herbaria, campus flora observation, reflective portfolios, and conservation-oriented learning.

Magfirah et al. (2026) examine a related transition from literacy toward self-reported pro-environmental behavior. Their model positions scientific and technological literacy as cognitive resources and creativity, critical thinking, collaboration, and communication as an integrated competence-enactment mechanism. The 21st-century skills construct emerges as the strongest pathway toward self-reported pro-environmental behavior. Scientific literacy retains a small direct relationship as well as an indirect pathway, whereas technological literacy operates indirectly through the 21st-century skills construct. This asymmetry matters. Technological competence should not be assumed to have environmental value merely because technology is being used. It becomes sustainability-relevant when learners use technological resources to evaluate evidence, investigate problems, develop alternatives, collaborate, and communicate.

The distinction is consistent with broader evidence showing that sustainable digital education requires more than access to digital tools; it depends on professional and learner capacities that allow technology to become pedagogically meaningful (Çengel & Acar, 2026; Mohafa et al., 2026).

Taken together, the two studies identify different but complementary mechanisms. Self-regulated learning emphasizes the learner's capacity to organize and monitor learning, whereas integrated 21st-century skills emphasize capacities for critical, creative, collaborative, and communicative enactment. The central educational question therefore changes. Rather than asking only whether students possess scientific, environmental, digital, or technological literacy, it becomes necessary to ask what enables them to use those literacies. The governance of digital learning also deserves attention. Pinar's (2026) comparison of 29 education jurisdictions examines public control of educational data, infrastructure provision, platform dependence, and data protection. For sustainability education, this raises a further question about whether the digital environments supporting participation also protect learners' rights and allow educational institutions to exercise meaningful oversight.

From Embedding to Action: A multilevel Perspective on Sustainability Education

When the eight contributions are considered together, they suggest a useful multilevel interpretation of sustainability education. This interpretation can be summarized through four processes: embedding, enacting, developing, and acting. The framework should not be read as a causal model empirically tested by the Special Issue as a whole. Rather, it is a synthetic heuristic derived from the relationships and levels of analysis represented across the collection.

Embedding concerns the institutional conditions through which sustainability becomes structurally present in educational systems. Policy coherence, leadership, organizational culture, institutional adaptability, resources, and stakeholder engagement help determine whether sustainability remains primarily rhetorical or becomes integrated across institutional practice. Ofem et al. (2026) demonstrate especially clearly why a multidimensional view is necessary: different governance variables show different patterns of association with social, economic, environmental, and overall sustainability.

Enacting concerns translation into curriculum, pedagogy, and learning environments. Asare et al. (2026) show how teacher competencies are linked with SDG integration partly through pedagogical innovation, while Rekalde-Rodriguez (2026) demonstrates how interdisciplinarity, external actors, challenge-based learning, alternative spaces, and multilingual interaction can form a transformative sustainability environment. Together, these studies indicate that institutional intentions acquire educational meaning through professional interpretation and pedagogical design.

Developing refers to the competencies and forms of agency cultivated within those environments. Scientific literacy, technological and digital literacy, creativity, critical thinking, collaboration, communication, self-regulated learning, ecological values, and reflective capacities recur across the collection. Sustainability competence is therefore neither singular nor purely cognitive. It is better understood as a configuration of capacities that enables learners to interpret complexity, evaluate information, imagine alternatives, work with others, and participate in possible responses (UNESCO, 2017; Wiek et al., 2011). A related perspective appears in Gassanova's (2026) review of career self-efficacy, which connects personal agency with social learning and support and identifies educational and sociocultural conditions shaping career development. Although concerned with career outcomes, the review offers a useful parallel for understanding how learners' confidence and capacity to participate develop within educational contexts.

Acting concerns opportunities for sustainability-oriented participation and action. The contributions examine different outcomes relevant to this process, including attitudes, awareness, task-based responses and self-reported behaviour; these should not be treated as equivalent evidence of sustained environmental action. Nor can these outcomes be assumed to follow from sustainability-oriented teaching. Ahmar et al. (2026) show that student-reported engagement with gamification does not necessarily translate into measured scientific literacy, while the mediation studies show that literacy may acquire environmental meaning through additional regulatory and competence-based mechanisms. The synthesis can therefore be understood as a progression from

institutional embedding to pedagogical enactment, from pedagogical enactment to the development of competencies and agency, and ultimately toward sustainability-oriented awareness and action. Authenticity and participation cut across this sequence: authentic challenges provide reasons for disciplinary knowledge to be mobilized, while participation connects sustainability with collaboration, stakeholder engagement, community contexts, and learner agency. These processes are analytically connected rather than fixed stages; learning and participation may also reshape pedagogical practice and institutional priorities.

Directions for Future Research

The collection also reveals several areas in which sustainability education research can advance. First, the environmental dimension is highly visible across the contributions. Plant awareness, water purification, pollution, environmental care, green chemistry, and pro-environmental behavior are all important and timely concerns. At the same time, the SDGs demand a broader conception of sustainability that includes social, cultural, economic, ethical, and justice-oriented dimensions. The Ofem et al. (2026) study partly addresses this by distinguishing social, economic, and environmental sustainability, while Ocean i3 brings environmental concerns into contact with language, culture, regional actors, and collaboration. Future work could more deliberately study these intersections rather than treating the dimensions of sustainability as parallel domains. The social dimension could be examined through wellbeing, belonging, and the conditions of participation. Sarzhanova and Nurgabdeshev (2025) identify individual psychological capacities alongside social and institutional support as important dimensions of wellbeing in education. Sarzhanova et al. (2026) further find that school and family support are positively associated with students' school connectedness, although these associations become weaker at higher levels of perceived environmental comfort. These findings provide a starting point for examining how educational environments and targeted support interact in supporting the social dimensions of sustainability.

Second, the research should continue moving from self-reported dispositions toward observed practice and action. Several contributions rely on cross-sectional or self-report data, which are appropriate for studying perceptions and associations but cannot establish how reported tendencies become behavior over time. Magfirah et al. (2026), for example, explicitly caution that self-reported pro-environmental behavior should not be equated with objectively observed environmental action. Longitudinal, observational, performance-based, multi-source, and mixed-method designs would also be valuable for examining teacher implementation, environmental care, plant awareness, and institutional sustainability.

Third, the field would benefit from research that crosses levels of analysis. Institutional governance, teacher competence, pedagogical implementation, and learner outcomes are frequently studied separately even though the contributions in this Special Issue suggest that they are interconnected. Future multilevel research could examine whether policy alignment and institutional support affect the quality with which teachers implement sustainability-oriented pedagogy, and whether implementation quality subsequently explains differences in learner competencies or environmental outcomes. Evidence from professional development research also challenges the assumption that teachers will apply new knowledge in classroom practice regardless of the contextual conditions in which they work (Parry & Kumi, 2026).

Finally, sustainability education research should become more precise when evaluating pedagogical innovation. Questions such as whether gamification, project-based learning, or technology 'works' conceal considerable variation in implementation, duration, scaffolding, learner activity, assessment, and outcome definition. More useful questions concern how, under what conditions, through which mechanisms, for whom, and toward which outcomes an intervention works. The contrasting studies in this Special Issue illustrate this point especially well. Inquiry-design STEM and ecopedagogical experiential learning provide structured opportunities for authentic problem solving, reflection, and repeated action, whereas the findings of Ahmar et al.

(2026) caution against assuming that a positive or engaging gamification experience will necessarily correspond to stronger scientific literacy outcomes.

Conclusion

The contributions to this Special Issue demonstrate that the relationship between the SDGs and education cannot be understood simply by asking whether sustainability is mentioned in institutional plans, curricula, or classroom activities. Sustainability becomes educationally meaningful through processes of translation. Institutions create or constrain the conditions for change; educators interpret sustainability commitments and turn them into curricula and learning environments; learners develop knowledge, competencies, values, and agency; and these capacities can create opportunities for informed and responsible action.

Across different contexts and methodologies, the studies point to a shared caution: commitments and capabilities need support if they are to bring about meaningful change. Institutional commitment offers no guarantee of institutional transformation, while teacher competence may remain underused without opportunities for pedagogical innovation. Scientific or technological literacy alone provides limited grounds for expecting environmental action, just as learner engagement should not be taken as evidence of deeper learning. Understanding these relationships requires attention to organizational coherence, professional judgment, authentic experience, self-regulation, collaboration, reflection, creativity, and opportunities for action.

The central lesson of this Special Issue is therefore that sustainability should be understood not only as something education must teach, but as something educational systems must learn to organize, enact, and practice. Advancing the SDGs through education requires sustainability to be embedded institutionally, translated pedagogically, developed as learner capability, and connected with meaningful opportunities for participation and responsible action. In this sense, rethinking teaching practices, curriculum, and institutional roles is not merely a response to the sustainability agenda; it is part of the educational transformation that the sustainability agenda itself requires.

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