Pedagogical Approaches for Developing Sustainability Competencies

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Abstract: The escalating global crises of climate change and social inequality require a paradigm shift in education toward holistic Sustainability Competencies. While the UNESCO "Head-Heart-Hands" model is well-established in Higher Education, much research papers in various levels of school education which is a critical period for value formation remains scarce. This paper critically reviews pedagogical approaches, including Problem-Based Learning and Transformative Pedagogy, to evaluate their efficacy in bridging the "knowledge-action gap." Analysis reveals that while traditional transmissive methods dominate due to institutional rigidities, they fail to develop essential normative and strategic competencies. The study concludes by proposing an Integrated Pedagogical Framework tailored for middle school education. This framework synthesizes cognitive inquiry (Head), socio-emotional engagement (Heart), and behavioural action (Hands) to effectively nurture sustainable lifestyles in young learners.

Keywords: Education for Sustainable Development (ESD), Sustainability Competencies, Transformative Pedagogy, Middle School, Sustainable Lifestyles.

1. INTRODUCTION

The global society is witnessing an unimaginable synthesis of environmental deterioration, social inequality, and economic instability, requiring a fundamental adjustment in how civilisations function and progress. This urgency arises from the realisation that our world is in a precarious balance, with possible outcomes that require immediate response (Aada, 2024). Climate change, diminishing resources, loss of biodiversity, and public health issues are among the distinctive challenges of the twenty-first century, all of which have a significant impact on the health and well-being of mankind and the planet. Modern economies are increasingly marked by a sense of danger and urgency, emphasising that quick adjustments in behavioural patterns are required to prevent the devastating consequences of these interlinked crises (Marouli, 2021). In light to these challenging difficulties, the notion of sustainable development has arisen as a conceptual system, aiming to balance human growth with environmental integrity and social equality (Cebrián et al., 2021; Sposab & Rieckmann, 2024). The educational sector is pivotal to this transformation, tasked with providing current and future generations the knowledge, skills, and values essential for confronting issues related to sustainability (Cebrián et al., 2020; Kioupi & Voulvoulis, 2022; Scarff Seatter & Ceulemans, 2017). The rapid changes in the Earth system have created an unparalleled necessity for society to alter its trajectory, indicating a profound shift towards sustainability (Holst, 2022). This intersection signifies a pivotal opportunity and simultaneously an intellectual challenge, as today's society confronts a multitude of global challenges that are jeopardising planetary sustainability, including the climate crisis, biodiversity loss, social inequality, poverty, and hunger, which emerge as urgent issues necessitating educational focus (Solorzano, 2023). Conventional educational methods, which have traditionally emphasised the dissemination of knowledge and skills, have demonstrated inadequacy in confronting the urgency, mobility, and global unsustainability inherent to the Anthropocene (Solorzano, 2023). The belief that awareness alone drives action is becoming contested, suggesting educational strategies that extend beyond ecological consciousness to facilitate genuine transformation (Cuevas-Cancino et al., 2024).

Sustainable Development

The strive for sustainable development has emerged as a critical global requirement, fuelled by the acknowledgement that existing patterns of resource utilisation and environmental deterioration jeopardise the enduring sustainability of humanity. These difficulties are marked by their level of complexity and multifaceted nature, necessitating a comprehensive response that acknowledges the complicated interrelations among social, economic, and ecological domains (Konieczny, 2024). Ensuring a satisfactory quality of life and well-being for roughly 10 billion individuals by 2050, while preserving the natural boundaries of our planet and its resources, constitutes one of the gravest difficulties and obligations humanity has encountered (Price et al., 2021). The international community has mobilised to tackle this significant challenge through frameworks like the United Nations 17 Sustainable Development Goals, which signify the intensified efforts to establish a world that is sustainable following the 2015 Education Decade for Sustainable Development (Kusumaningrum et al., 2023).

Education for Sustainable Development

Education for Sustainable Development (ESD) is emerging as an effective approach to provide learners with the knowledge, skills, values, and attitudes essential for contributing to a future that is sustainable, while also acting as a vital catalyst for attaining the Sustainable Development Goals, especially SDG 4 (Anwar et al., 2025). This objective highlights the significance of providing inclusive and equitable quality education while fostering lifelong learning opportunities for all, acknowledging education as a fundamental human right and a potent catalyst for societal development (Dumitrache et al., 2022). The objective of ESD is to promote competencies that equip individuals to reflect on their activities by evaluating their present and future social, cultural, economic, and environmental implications from both local and global viewpoints (Kusumaningrum et al., 2023).

2. Conceptualizing Sustainability Competencies

To effectively cultivate the knowledge, skills, and values required for sustainable development, it is essential to first define and understand the specific attributes that constitute sustainability competencies. These competencies are understood as the combination of cognitive skills, practical abilities, and ethical values and attitudes mobilized in a real situation or context related to sustainability (Cebrián et al., 2021). This concept of competence is particularly relevant because it extends beyond the mere acquisition of knowledge to encompass the transformation of attitudes and other dispositions related to motivations and the attitudinal domain (Álvarez et al., 2024). Various frameworks have been proposed in the academic literature to operationalize these competencies, offering distinct yet complementary perspectives on the essential capabilities required for addressing complex sustainability challenges.

Overview of Sustainability Competency Frameworks

Over the last decades, an emerging body of literature has sought to define these key competencies, with researchers such as Lozano et al., Vare et al., and Moreno Pires et al. identifying a range of critical competencies necessary to handle the complexity of sustainability issues (Pires et al., 2022). Among these, key competencies such as systems thinking, anticipatory thinking, normative thinking, strategic thinking, and interpersonal collaboration are frequently highlighted as essential for enabling learners to navigate the wicked nature of sustainability problems (Cebrián et al., 2020; Lemarchand et al., 2023). Building on these foundational contributions, the UNESCO framework synthesizes these capabilities into a comprehensive model that categorizes eight key competencies essential for sustainable development: systems thinking, anticipatory, normative, strategic, collaboration, critical thinking, self-awareness, and integrated problem-solving (Vaughter et al., 2022). This comprehensive model posits that distinct yet interconnected cognitive skills, such as systems thinking, strategic thinking, futures thinking, values thinking, interpersonal thinking, and intrapersonal thinking, collectively contribute to an integrated problem-solving competency essential for sustainability (Annelin & Boström, 2022).

The UNESCO Sustainability Competency Framework

The UNESCO framework distinguishes itself through its identification of eight cross-cutting competencies—Systems Thinking, Anticipatory Competence, Normative Competence, Strategic Thinking, Collaboration, Critical Thinking, Self-awareness, and Integrated Problem-solving—which are designed to function

interdependently rather than as isolated skills (Strachan et al., 2021). This interdependence is crucial because each competency contributes a specific function to the overall sustainability problem-solving process, which involves steps such as problem analysis, developing future scenarios, and determining transition strategies (Brundiers et al., 2021). Integrated problem-solving is viewed as a framework competency that enables the mastery of sustainability challenges through the interaction with the other seven competencies (Hammer & Lewis, 2023). This integrative capacity implies that learners must effectively synthesize systems thinking to understand complex interconnections, apply anticipatory competence to envision future scenarios, utilize normative competence to evaluate sustainability values, and employ strategic thinking to implement solutions, all while fostering collaboration, critical thinking, and self-awareness throughout the process (Álvarez et al., 2024; Wiek et al., 2011). Systems-thinking competency aims to develop the ability to address sustainability problems from a wider and more holistic perspective, focusing on understanding the intermediate and root causes of complex problem constellations (Sá et al., 2022). Anticipatory competency enables individuals to think in terms of future actions, consequences, and risks, while normative competency enlightens the ideological context in which individuals exist and provides opportunities to negotiate conflicting situations mindful of all concerned (Joseph, 2023). Strategic competency is defined as the ability to collectively develop and implement innovative actions that further sustainability at the local level and further afield (Wawer, 2023). Interpersonal competency is essential for engaging and motivating diverse stakeholders, requiring the ability to empathically work with collaborators' different ways of knowing and communication styles (Brundiers et al., 2021). Collaboration competency is further characterized by the capacity to facilitate participatory and collaborative problem-solving processes, which are indispensable for navigating the multi-stakeholder nature of sustainability challenges (Korolyova et al., 2021). Critical thinking competency equips learners with the ability to question norms, practices, and opinions by reflecting on the arguments behind them, while self-awareness competency involves the ability to reflect on one's own role in the local community and in a global society (Griswold et al., 2018).

3.　　　Pedagogical Approaches for Cultivating Sustainability Competencies

While most of the pedagogical approaches are majorly focused on higher education there is a need to adapt these frameworks to adolescence which is a crucial age for value formation. Having established the comprehensive nature of sustainability competencies, it is imperative to examine the specific pedagogical strategies that effectively cultivate these multidimensional skills in learners. Research indicates that specific teaching and learning strategies, such as project-based learning, service learning, and action learning, are instrumental in fostering the necessary skills to deal with sustainability, including critical and creative thinking, problem-solving abilities, action competence, collaboration, and futures thinking. These active learning methodologies shift the focus from passive knowledge acquisition to student-centered engagement, thereby creating empowered and globally-responsible citizens capable of acting as positive change agents in their professional and personal lives (Cebrián & Junyent, 2015). Among these methodologies, Problem-Based Learning stands out as a prominent approach that situates students at the center of the learning process by engaging them with complex, real-world sustainability challenges that lack clear-cut solutions (Balslev & Andersson, 2020). By requiring students to analyze these ill-structured problems, define their own learning issues, and propose viable solutions, Problem-Based Learning effectively cultivates systems thinking, critical thinking, and integrated problem-solving competencies (Guerra et al., 2020; Vesala-Varttala et al., 2024).

Problem-Based Learning

Problem-Based Learning is frequently highlighted as a robust pedagogical strategy for integrating sustainability into higher education, particularly because its core learning principles such as interdisciplinarity, collaborative learning, contextual problem orientation, and self-directed learning—align closely with the demands of sustainability education (Bolstad et al., 2023). This alignment is essential because PBL not only engages students with sustainability content but also actively involves them in the process of understanding and addressing sustainability challenges through up-to-date case studies and practical projects (Nguyen et al., 2024). Research indicates that when students engage with real-world, up-to-date, and transversal problems, they are better positioned to develop systems thinking, normative thinking, and integrated problem-solving skills (Carrió & Bastida, 2023). By exposing students to authentic situations that require managing complexity and making decisions based on trade-offs, PBL provides opportunities to learn "how to think" rather than "what to think," thereby fostering capabilities to improvise, adapt, and innovate (Kioupi & Voulvoulis, 2022; Thomas, 2009). This student-centered approach immerses learners in real-world problem solving to cultivate active learning, where students identify knowledge gaps, develop solutions, and collaborate through iterative cycles of planning, action, and reflection (Chien et al., 2025).

Through this iterative process, learners actively internalize sustainability principles by conducting research, engaging in discussion, and developing solutions for tangible issues, which transforms them from passive recipients into active problem-solvers capable of addressing complex environmental and societal challenges (Carrió & Bastida, 2023; Nguyen et al., 2024). Furthermore, a systemic PBL approach that combines pedagogical principles with education for sustainability can promote engineering students' agentic experiences in team projects and support sustainability-related competencies such as systems thinking, critical thinking, anticipatory thinking, complex problem-solving, collaboration, and self-awareness (Guerra et al., 2022).

Project-Based Learning

Project-Based Learning serves as a complementary yet distinct pedagogical approach that emphasizes the creation of tangible artifacts or deliverables through extended inquiry, thereby fostering deep interdisciplinary skills essential for sustainability. For instance, in sustainability projects, students are required to synthesize knowledge from environmental science, economics, sociology, and other disciplines to analyze and solve complex real-world problems, thereby fostering interdisciplinary thinking and integrated application abilities (Ma & Wu, 2025). This process of synthesis is crucial because sustainability challenges are rarely confined to a single discipline, requiring learners to navigate the intersections between technical, social, and ecological dimensions to create holistic solutions (Frimodt-Møller et al., 2018). By working in teams over sustained periods, students develop collaboration and communication competencies while negotiating the diverse perspectives inherent in sustainability issues (Guerra et al., 2024). Studies have demonstrated that project-based learning linked to real transdisciplinary projects is the most adequate pedagogy to learn sustainability competences, as it prepares students to be responsible through introspection about their values, ethics, and beliefs (Servant et al., 2020). This introspective process is vital for developing the normative and self-awareness competencies necessary for responsible decision-making in a global context (Bernhard et al., 2020).

Experiential Learning

Experiential learning constitutes a vital pedagogical approach that bridges the gap between theoretical frameworks and the practical application of sustainability concepts by immersing students in direct engagement with real-world scenarios. This hands-on involvement enables students to actively engage with situations and challenges from the real world, allowing them to acquire practical skills, critical thinking abilities, and a heightened awareness of the environmental and social consequences of their actions (Singha & Singha, 2024). By emphasizing the cycle of concrete experience, reflective observation, abstract conceptualization, and active experimentation, this approach ensures that learners not only grasp theoretical frameworks but also develop the skills and aptitudes necessary for active participation in the sustainable development agenda (Aada, 2024; Singha & Singha, 2024).

Service-learning represents a distinct pedagogical strategy that integrates academic study with meaningful community service to enrich the learning experience, teach civic responsibility, and strengthen communities while addressing sustainability challenges. This method requires students to apply theoretical knowledge to address community-identified needs, thereby fostering a deep understanding of the social, economic, and environmental interdependencies that define sustainability issues (Veckalne & Tambovceva, 2022). Research indicates that service-learning activities are particularly effective for enhancing systemic thinking and personal engagement in the sustainable development transition process, as they are educational paths based on the convergence of community needs (Cavicchi, 2021) and academic learning objectives, which allows students to witness the tangible impact of their interventions on local ecosystems and social structures (Hafeez et al., 2023). By engaging directly with community stakeholders, students cultivate empathy and ethical reasoning, which are essential for navigating the cultural nuances and power dynamics often inherent in sustainability initiatives (Perkiss et al., 2020). For example, students could collaborate with local businesses to devise sustainability strategies or conservation efforts, gaining hands-on experience and a deeper appreciation of the complexities involved in environmentally conscious business practices (Kopnina et al., 2024). Place-based learning initiatives further exemplify this approach by partnering students with local community groups to address real-world issues such as enhancing biodiversity, implementing local growing schemes, or designing transport plans to encourage physical activity (Education for Sustainable Development: Guidance for UK Higher Education Providers, 2015).

Game-Based Learning and Gamification

Game-based learning utilizes interactive simulations and digital platforms to model complex, dynamic systems, thereby enabling students to visualize the non-linear relationships and feedback loops inherent in sustainability challenges. Through the manipulation of variables within a safe virtual environment, learners can experiment with different strategies to achieve sustainable outcomes, thereby developing strategic thinking and anticipatory competencies without the risks associated with real-world trial and error (Biancardi et al., 2023). This pedagogical approach is particularly effective for fostering systems thinking, as it compels learners to understand the interconnectedness of ecological, social, and economic variables within a simulated context (Adorno et al., 2025). By engaging with these models, students are better equipped to understand the intricate cause-and-effect relationships that characterize 'wicked problems', moving beyond linear cause-and-effect reasoning to grasp the multi-dimensional nature of environmental and social systems (Kinnula et al., 2024; Lozano et al., 2022). Simulations and role-playing activities further enhance this understanding by allowing students to experiment with different value positions and political perspectives, thereby developing empathy for alternative viewpoints and employability skills suited to professional contexts (Education for Sustainable Development: Guidance for UK Higher Education Providers, 2015).

Transformative Pedagogy

Reflective practice serves as a foundational mechanism for cultivating critical thinking by requiring students to continuously examine their assumptions, values, and the broader implications of their decisions on environmental and social systems. This process of critical reflection is essential for transformative learning, as it moves beyond mere knowledge acquisition to challenge the underlying worldviews and paradigms that often perpetuate unsustainable practices (Education for Sustainable Development: Guidance for UK Higher Education Providers, 2015). Through structured introspection, learners can analyze the driving forces behind their actions and reactions, thereby fostering a critical awareness of personal and sociocultural values that influence sustainability outcomes (Wall et al., 2025). Transformative pedagogy distinguishes itself from other approaches by explicitly aiming to induce a fundamental shift in the learner's perspective, often described as a metanoia or a change in mindset, rather than simply adding new knowledge to an existing framework (Scarff Seatter & Ceulemans, 2017). This paradigm shift requires a move away from teaching sustainability as a fixed, definable subject toward a pedagogy that embraces the contested and multiple ways in which sustainability is understood (Stenderup et al., 2021). Unlike traditional transmission models that prioritize the delivery of content, transformative pedagogy is characterized by its emphasis on the learner's prior knowledge and beliefs, deep engagement, and the potential for critical thinking that leads to a fundamental restructuring of frames of reference (Scarff Seatter & Ceulemans, 2017). This process involves moving toward a frame of reference that is more inclusive, discriminating, self-reflective, and integrative of experience, thereby fostering autonomous thinking and the ability to critically question dominant norms rather than relying on un-critically assimilated explanations from external authorities (Scarff Seatter & Ceulemans, 2017).

4.   Challenges in Developing Sustainability Competencies

The implementation of effective sustainability education is frequently impeded by structural rigidities within educational institutions, where traditional disciplinary silos and standardized assessment protocols hinder the integration of interdisciplinary, competency-based learning (Hasrul & Irawan, 2023). These institutional barriers often manifest as misaligned incentive structures for faculty, rigid credit hour systems that do not accommodate field-based or experiential requirements, and departmental boundaries that discourage the cross-disciplinary collaboration necessary for addressing complex sustainability issues (McCarthy & Eagle, 2021). Furthermore, the holistic and often contradictory nature of sustainability demands that students adopt critical and reflective practices to navigate the values, ethics, and geopolitical issues that are inextricably linked to the international sustainability discourse (McCarthy & Eagle, 2021; O'Grady, 2023).

Curriculum Integration and Institutional Barriers

Integrating sustainability competencies into established curricula is often hindered by the rigid, bureaucratic structures inherent in traditional educational systems, which struggle to accommodate the experiential and interdisciplinary nature of Education for Sustainable Development (Walsh et al., 2020). These structural constraints frequently result in a fragmented approach where sustainability is treated as an add-on topic rather than a core, transversal element, thereby limiting the potential for transformative learning experiences that require a reorientation of curricula and teaching methods (Galleli et al., 2022). Consequently, the

compartmentalization of academic disciplines creates significant obstacles to the holistic understanding required for sustainability, as faculty members often lack the institutional support or collaborative frameworks necessary to design and deliver interdisciplinary courses that transcend traditional departmental boundaries (Cebrián et al., 2021). This lack of structural support is often compounded by institutional resistance to change, where faculty members may perceive sustainability integration as an additional burden rather than a core academic responsibility, further entrenching disciplinary silos (Park, 2024).

Teacher Training and Professional Development Gaps

A significant barrier to effective implementation is the lack of understanding of Education for Sustainable Development among teaching staff, many of whom have not received extensive training in sustainability concepts and may fear that the topic is unrelated to their specific discipline (Mokski et al., 2022). This limited awareness and understanding often leads to a lack of confidence in delivering complex, interdisciplinary content, as many educators do not possess the specialized abilities, expertise, or self-assurance required to successfully teach sustainability concepts (Rodríguez et al., 2024; Veckalne & Tambovceva, 2022). Moreover, the absence of formalized training programs and professional development opportunities specifically designed for sustainability pedagogy leaves faculty ill-equipped to adopt the innovative teaching methods necessary to foster these competencies (Álvarez et al., 2024; Mondragón et al., 2023). Compounding this issue is the scarcity of high-quality, contextually appropriate resources, as financial and time constraints restrict access to the instructional materials needed for effective implementation (Veckalne & Tambovceva, 2022). Even though many agree with the need for innovative and active learning, data suggest that still many prefer rely on traditional methods as illustrated in Figure 1, lecturing remains the most frequently used pedagogical approach (mean score ~3.0), whereas transformative strategies such as eco-justice and community service learning are utilized minimally.
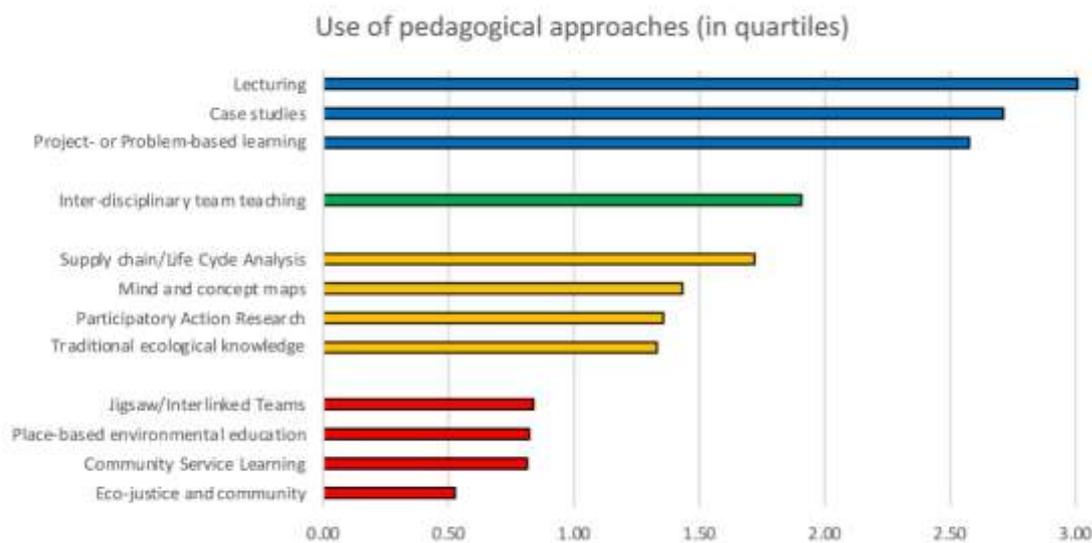

Figure 1: Average frequency of use of pedagogical approaches in Higher Education Institutions (Source: Lozano et al., 2022).

Assessment of Sustainability Competencies

Evaluating the acquisition of sustainability competencies presents a complex challenge due to the multidimensional nature of sustainability, which encompasses cognitive, socio-emotional, and behavioral domains that are difficult to capture through traditional testing methods (Rodríguez et al., 2024). Current assessment is focused mostly on self-surveys assessment, which are often inadequate for measuring the development of critical thinking, ethical reasoning, and the capacity for collaborative action that are central to sustainability competency frameworks (Abo-Khalil, 2024). Consequently, educators must rely on alternative assessment strategies, such as reflective portfolios, scenario-based assessment, peer evaluations, and performance-based tasks, to effectively gauge the holistic development of students' abilities to navigate complex sustainability issues (Mokski et al., 2022; Sebire & Flores, 2023). Despite the pedagogical intent, fostering sustained student engagement in sustainability education remains difficult, as learners often struggle to connect abstract global challenges with their immediate personal and professional contexts.

Conclusion

This paper has examined the critical role of pedagogical approaches in developing sustainability competencies, highlighting that effective Education for Sustainable Development requires a fundamental shift from content transmission to transformative, learner-centered methodologies. The analysis underscores that while various frameworks such as the UNESCO model provide a necessary structure for defining these competencies, their successful cultivation depends heavily on the adoption of active, interdisciplinary, and experiential pedagogies that engage students in real-world problem-solving (Cebrián et al., 2021; Lozano et al., 2022). However, the implementation of these transformative pedagogies is frequently obstructed by institutional barriers, including rigid disciplinary silos, misaligned incentive structures, and a significant lack of professional development opportunities that leave educators ill-equipped to facilitate complex, competency-based learning (Cebrián et al., 2020). Furthermore, the assessment of these transversal competencies remains a persistent challenge, as traditional evaluation methods often fail to capture the critical reflection and behavioral changes indicative of deep learning (Strachan et al., 2021). Future research must therefore prioritize the development of robust, adaptive assessment frameworks that can effectively measure the nuanced acquisition of sustainability competencies across different educational contexts (David, 2025; Kövesi, 2009). Specifically, educators must be equipped with the specialized abilities and expertise required to foster sustainability competencies through creative and dynamic teaching adjustments, as their own professional development is essential for restructuring educational processes and improving learning outcomes toward sustainability (Chen, 2023). Ultimately, achieving the ambitious goals of sustainable development necessitates a concerted effort to overcome these systemic barriers and foster a learning culture where sustainability is deeply embedded in the core values and practices of higher education institutions (Mondragón et al., 2023).

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