

Reframing Sustainability Pedagogy in Higher Education: An Integrated Framework Based on Marzano's Dimensions of Learning

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Abstract. The integration of the Sustainable Development Goals (SDGs) into higher education has become a central priority within Education for Sustainable Development (ESD), as universities are expected to prepare graduates to address complex sustainability challenges. However, existing sustainability pedagogies remain fragmented and predominantly emphasize technical competencies and problem-solving skills while giving limited attention to the affective, ethical, and metacognitive dimensions required for transformative sustainability learning. This study aims to synthesize contemporary pedagogical approaches for embedding the SDGs in higher education, examine their contribution to transformative sustainability learning, and develop an integrated pedagogical framework based on Marzano's Dimensions of Learning. A Critical Interpretive Synthesis (CIS) reviewed peer-reviewed literature published between 2022 and 2026. Studies indexed in Scopus were purposively selected based on their relevance to sustainability pedagogy, transformative learning, and higher education. The synthesis identified project-based learning, experiential education, and service learning, and transformative pedagogies as the dominant approaches to SDGs integration. These approaches effectively promote systems thinking, interdisciplinary collaboration, and sustainability problem-solving but remain largely competency-oriented, with limited attention to ethical agency, reflective practice, self-system processes, and productive habits of mind. The study concludes that current SDGs pedagogies require a more holistic learning framework. Marzano's Dimensions of Learning offers an integrative scaffold linking cognitive, affective, behavioral, and metacognitive domains to strengthen transformative sustainability learning. The proposed framework provides practical guidance for curriculum redesign, faculty development, assessment reform, and institutional strategies supporting comprehensive SDGs integration in higher education.

Keywords: sustainability pedagogy; higher education; education for sustainable development; transformative learning; marzano's dimensions of learning.

INTRODUCTION

The global commitment to the Sustainable Development Goals (SDGs) has reshaped higher education, positioning universities as critical sites for sustainability transformation. As UNESCO (1992) emphasizes, education must not only transfer knowledge but also cultivate values, skills, and dispositions aligned with sustainable development. Although many higher education institutions demonstrate a commitment to sustainability, this has not yet been fully integrated into global academic assessment mechanisms, thereby encouraging institutions to adopt practices that genuinely contribute to global sustainable development (Wilhelm et al., 2025). Despite growing efforts, the pedagogical integration of SDGs into higher education remains inconsistent, often characterized by fragmented initiatives, isolated modules, or symbolic adoption rather than systemic change. Learning should motivate students not only to memorise and reflect on the

SDG goals, but also to play an active part in tackling the challenges associated with the SDGs (Huang et al., 2024; Wahjoedi et al., 2020).

Scholars have highlighted a pressing need for pedagogical frameworks that can translate the normative aspirations of the SDGs into actionable learning outcomes (Dlouhá et al., 2019). Yet, most existing approaches lack theoretical grounding in learning sciences and fail to provide educators with structured guidance for curriculum design. This article responds to that gap by examining pedagogical approaches through the lens of Marzano's Dimensions of Learning, an evidence-based framework that has rarely been applied in sustainability education.

In recent years, significant progress has been made in integrating sustainable development into university curricula (Oliveira et al., 2025). Previous studies have examined best practices for embedding sustainability within higher education systems, including curriculum transformation initiatives in the United Arab Emirates (Abo-

Khalil, 2024). Despite these developments, the pedagogical implementation of SDGs in higher education remains conceptually fragmented and uneven across institutional contexts (Christou et al., 2024; Hickmann et al., 2024; Molina et al., 2023; Zhou, 2024). To generate a nuanced synthesis, this study applies Critical Interpretive Synthesis (CIS), an interpretive review methodology suited for analyzing complex and heterogeneous bodies of literature (Dixon-Woods et al., 2006). Unlike traditional systematic reviews, CIS emphasizes the development of theoretical insight, allowing the researcher to move beyond aggregation toward conceptual innovation. The central research question guiding this inquiry is: How can pedagogically approaches for embedding the SDGs in higher education be synthesized and reframed through Marzano's Dimensions of Learning. The following is an expansion of our original study questions, which were influenced by the frameworks previously described:

RQ1. What pedagogical approaches are currently used to embed the SDGs in higher education?

RQ2. To what extent do these pedagogical approaches support transformative sustainability learning?

RQ3. How can Marzano's Dimensions of Learning provide an integrative framework for SDGs pedagogy in higher education?

METHODS

This study reviews existing research to develop fresh theoretical insights on the pedagogical approaches used to embed the Sustainable Development Goals (SDGs) in higher education, analyzing how these strategies align with Marzano's Dimensions of Learning and their implications for transformative sustainability education. It is concerned with the range of teaching and learning practices adopted across higher education, whether curricular or co-curricular, disciplinary or interdisciplinary, formally mandated by policy or emerging from faculty innovation.

There are multiple forms of literature review that follow established procedures to systematically and transparently identify, evaluate, and synthesize evidence from empirical studies (Gough et al., 2012). In education, the most common type of systematic review is aggregative, which combines findings from multiple observations of the same phenomenon (Noblit & Hare, 1988). Such reviews require that

the concepts or variables used to summarize the data are already well-defined, stable, and clearly specified (Dixon-Woods et al., 2006, p.2).

Compared to other well-established research areas, the pedagogical integration of the SDGs in higher education has received limited scholarly attention. While sustainability-oriented practices such as project-based learning, experiential education, and service learning, and transformative pedagogies are frequently mentioned in the literature, they are often treated as peripheral examples rather than the central focus of systematic analysis. Moreover, no comprehensive attempts have been made to map these approaches across different institutional or national contexts, leaving a significant gap in understanding how pedagogical strategies can be structured to meaningfully embed the SDGs.

This conceptual gap provides the rationale for adopting an interpretive rather than aggregative review design. Critical Interpretive Synthesis (CIS), originally developed in health research, has since evolved as a robust method for theory-building through the synthesis of heterogeneous forms of evidence (Dixon-Woods et al., 2006). It draws on strategies familiar in qualitative inquiry, such as the iterative refinement of research questions, a dynamic interplay between evidence selection and inductive analysis, and the construction of a synthesising argument (Dixon-Woods et al., 2006, p.10). Unlike aggregative reviews, where inclusion depends on formal quality appraisals, CIS prioritises conceptual relevance, purposively selecting sources based on their potential to advance theoretical insight (Depraetere et al., 2020). In line with recommendations for methodological transparency since its introduction in 2006, this study adheres to established CIS reporting standards.

For this study, the initially searched titles and abstracts of publications in Scopus using the keywords ("sustainability pedagogy" OR "pedagogy for sustainability" OR "sustainability education" OR "education for sustainable development") AND ("higher education" OR university). Articles published between 2022 - 2026 were considered. The initial search yielded 18.600 records from Scopus articles resulting in a total of 400 records. To complement this, I conducted targeted searches with refined strings such as "embedding SDGs", "curriculum design and sustainability", and "teacher education and sustainable development" to capture additional literature likely to discuss pedagogical practices in

higher education.

In line with the principles of Critical Interpretive Synthesis (CIS), I also applied purposive selection with flexible inclusion criteria, prioritising sources for their conceptual relevance rather than methodological uniformity (Depraetere et al., 2020). This meant that, beyond peer-reviewed journal articles. Publications by international scholars outside the higher education field were also considered where their insights offered significant theoretical value. The review thus did not aim to capture all available literature exhaustively, but rather to curate a body of evidence most relevant for developing a synthesising argument on pedagogical approaches to embedding the SDGs in higher education.

RESULTS AND DISCUSSION

Pedagogical Approaches for Embedding the SDGs in Higher Education

The synthesis identified a diverse range of pedagogical approaches for embedding the Sustainable Development Goals (SDGs) in higher education. The most prevalent include experiential learning, project-based learning, problem-based learning, inquiry-based learning, service learning, participatory learning, and interdisciplinary

pedagogies, all of which emphasize active, student-centred learning through community engagement, collaborative inquiry, and authentic sustainability challenges. Emerging approaches, including transdisciplinary living laboratories, Indigenous knowledge integration, futures-oriented learning, arts-based sustainability education, and technology-enhanced learning, further expand the pedagogical landscape by incorporating experiential, contextual, and values-based perspectives into sustainability education.

Across the reviewed studies, SDGs pedagogy is predominantly competency-oriented, with a strong emphasis on developing sustainability literacy, systems thinking, critical thinking, interdisciplinary collaboration, and practical problem-solving skills. Engineering, environmental science, business, and economics programmes primarily adopt project and competency-based models, whereas teacher education and the social sciences more frequently employ reflective, participatory, and values-oriented practices. Despite this diversity, implementation remains fragmented across institutions, with innovative pedagogies often confined to localized initiatives rather than institution-wide practice.

Table 1. A Synthesis of Sustainability Pedagogical Approaches

Sustainability Pedagogical Approaches	Description
A geospatial curriculum approach (Ramachandran et al., 2024)	The geospatial curriculum approach for sustainability is a learning method that integrates spatial technology (such as SIG/GIS and participatory mapping) to analyze and solve environmental and social problems realistically based on location (space and time).
Artificial Intelligence (Devi et al., 2025)	The Role of AI-Driven Marketing Tools in Shaping Emotional Engagement with Sustainability
Arts-based sustainability education (Hannigan et al., 2025)	Arts-based sustainability education integrates creative expression with ecological learning to build climate literacy and foster an emotional connection to nature. By bypassing traditional text-heavy methods, it uses visual arts, theater, and storytelling to make complex socio-ecological topics personal, experiential, and actionable.
Children's agency (Öner & Üyüyük, 2026)	Children's agency refers to how children are introduced to their role as active participants in learning and their environment. In Denmark, this is understood as an inherent right, where children are seen as capable decision-makers who actively participate in shaping their learning through dialogue and shared responsibility. In Türkiye, agency is viewed as a developing moral capacity, gradually nurtured through teacher guidance and structured participation within defined boundaries.

Collaborative Approaches (Chau et al., 2025; Ebsen & Rieland, 2026; Peters et al., 2024; Van De Wetering et al., 2022)	A collaborative approach is a method of working where multiple parties cooperate, share knowledge, and communicate openly to achieve mutually beneficial goals. It replaces traditional, top-down structures with shared ownership, making it highly effective for solving complex problems, resolving conflicts, and driving innovation.
Experiential Learning (Chau et al., 2025; Xu & Dai, 2025)	Experiential Learning is an educational framework emphasizing the idea that knowledge is continuously created through direct, hands-on experience and subsequent reflection. Rooted heavily in Kolb's theory, it involves a four-stage cycle: Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation.
Game simulation (Peters et al., 2024; Ramachandran et al., 2024; Tarraya et al., 2025)	Put students in the role of decision-maker and exposed them to the tradeoffs experienced by various stakeholders such as industry and government.
Indigenous knowledge integration (Druker-Ibanez & Caceres-Jensen, 2022)	Indigenous knowledge integration blends Traditional Ecological Knowledge (TEK) and local cultural frameworks with modern science, education, and policymaking. In Indonesia, this merges traditional systems like <i>Pranatamangsa</i> (agricultural calendars) or customary forest management with global sustainability and national educational standards.
Interpretive and pluralistic approaches(Ebsen & Rieland, 2026; Royet et al., 2024)	An approach that encourages students to examine sustainability issues from diverse perspectives, value differing viewpoints, and develop critical thinking skills before reaching conclusions.
Learner-centered approaches (Ebsen & Rieland, 2026)	Discussion, work groups, case study, field, trip, and fieldwork; to a lesser extent they apply some other techniques, such as demonstration, role-playing, and brainstorming.
Learning in multiple settings (Ebsen & Rieland, 2026)	Learning in multiple settings is commonly found among vocational students, whose education focuses on developing skills and competencies that are closely aligned with their future professions. Through learning experiences in various settings, both inside and outside the classroom, students are able to connect theoretical knowledge with real-world practice and professional contexts.
Multidisciplinary approach (Chau et al., 2025; Peters et al., 2024; Serafimova & Andreeva, 2023; Thomas et al., 2022; Xu & Dai, 2025)	Covers the various elements of sustainability in different study courses, in whole or in part, emphasizing the individual aspects. Sustainability issues are included as parts of separate topics in more significant foundational business and management courses, or can be taught as different courses through more narrowly profiled academic disciplines.
Nature pedagogy in early childhood (Oktay & Derman, 2026; Rum et al., 2024; Spiteri, 2024; Townley et al., 2024; Valdes et al., 2025)	Nature Pedagogy is a way of working with children and creating settings for care and education that embraces nature. It includes the educational environments we create, the process of assessment and planning, and the learning journeys that we encourage children and families to take throughout childhood.
Participatory teaching (Chau et al., 2025)	Participatory teaching, as explored in contemporary educational research represents a shift from traditional, lecture-based methods toward learner-centered environments. It emphasizes active student engagement, collaboration, and critical thinking (Nuryana et al., 2024).
Place-based environmental education (Romera et al., 2024;	Place-based environmental education uses local ecosystems, culture, and community dynamics as the foundation for

Spiteri, 2024; Xu & Dai, 2025)	learning
Play-based pedagogies in early childhood education (Öner & Üyünük, 2026)	Educational approaches that use play as a central method of learning. Instead of relying only on formal instruction, students learn through structured and unstructured play activities such as games, simulations, role-play, exploration, and creative activities.
Problem-based Learning (Peters et al., 2024)	Problem-based Learning (PBL) is a student-centered pedagogical strategy where learners engage with open-ended, real-world problems to simultaneously acquire disciplinary knowledge, research skills, and collaborative competencies. It shifts students from passive listeners to active problem solvers (Amin et al., 2021)
Project-Based Learning (David, 2025; Ramachandran et al., 2024; Wibawa et al., 2025)	Project-Based Learning (PjBL) is an instructional methodology that shifts classrooms away from traditional, teacher-centered instruction and toward deep, student-driven exploration. By organizing education around complex, real-world problems, students actively build knowledge through sustained inquiry, collaboration, and the creation of tangible outputs
Research-based and entrepreneurial-oriented educational approaches (Cruz Salinas et al., 2026; Ramírez-Montoya et al., 2025; Serafimova & Andreeva, 2023)	Research-based, an approach that engages students in inquiry, investigation, and evidence-based learning. Students learn by conducting research, analyzing data, evaluating information, and developing solutions to sustainability issues through a scientific and analytical process. Entrepreneurial-oriented, an approach that encourages students to develop innovation, creativity, initiative, and opportunity-recognition skills to create sustainable solutions, products, services, or ventures that address environmental, social, and economic challenges.
Service Learning (Aramburuzabala & Cerrillo, 2023; Rodríguez-Zurita et al., 2025)	A teaching approach that combines academic goals and the character education through community service activities.
Technology (Chaka, 2022; David, 2025; Husamah et al., 2022; Llanos-Ruiz et al., 2025; Zainuddin et al., 2025)	Technology-driven quizzes enhance digital literacy and real-time feedback, individual essays improve research and analytical skills, and structured group projects foster collaboration while ensuring equitable participation.
The competence-oriented educational approach (Serafimova & Andreeva, 2023)	An approach that focuses on developing the knowledge, skills, values, and attitudes students need to address sustainability challenges and take responsible action in real-life situations. Rather than emphasizing content memorization, it prioritizes competencies such as critical thinking, systems thinking, collaboration, problem-solving, and decision-making.
The Hope Wheel (Finnegan & d'Abreu, 2024)	An emotionally informed pedagogical framework that addresses the limitations of predominantly cognitive and behavior-oriented sustainability education by integrating hope, emotional resilience, and transformative action.
The training for sustainability (Dube, 2026; Serafimova & Andreeva, 2023)	An approach that prepares learners with practical abilities and professional skills needed to promote and implement sustainable practices in their future careers, organizations, and communities. It emphasizes action, application, and behavioral change toward sustainability goals.
Transdisciplinary living laboratories (Leal Filho et al., 2023;	Transdisciplinary living laboratories are physical or virtual environments where researchers, citizens, policymakers, and

Steffansen et al., 2026)	industry experts co-create and test real-world solutions. They integrate values and expertise from both academic and non-academic sources to address complex societal and environmental challenges.
Two-Eyed educational approach (Mbah & Ezegwu, 2024; Serafimova & Andreeva, 2023)	The Two-Eyed educational approach encourages students to learn from both scientific knowledge and Indigenous traditional knowledge to develop a more holistic understanding of sustainable development.

Sources: Own-study (2026)

The Contribution of Pedagogical Approaches to Transformative Sustainability Learning

Environmental education predominantly strengthens cognitive outcomes, while affective, intentional, and behavioral outcomes show comparatively smaller, albeit positive, effects (Su et al., 2026; Versteijlen & Wals, 2023). Behavioral transformation remains relatively underdeveloped (Lörzing & Bartelmeß, 2025) because knowledge acquisition alone is insufficient to overcome the psychological and social barriers that hinder sustainable action (Ramachandran et al., 2024). For example, family environments and parenting practices significantly influence children's willingness to engage in energy-saving behaviors (Wang et al., 2022). Therefore, sustainability education should move beyond instrumental knowledge transmission toward facilitating meaningful and lasting behavioral change (Van De Wetering et al., 2022).

The synthesis indicates that current Sustainable Development Goals (SDGs) pedagogical approaches predominantly emphasize cognitive, attitudinal, and applied dimensions of sustainability learning. Environmental education effectively fosters environmental knowledge, attitudes, intentions, and pro-environmental behaviors, while experiential, inquiry-based, and project-oriented pedagogies consistently promote systems thinking, critical analysis, collaboration, and sustainability problem-solving competencies. These approaches position students as active participants who address real-world sustainability challenges through interdisciplinary projects, case studies, and community-based learning. Technical and instrumental sustainability competencies are particularly dominant in engineering, environmental studies, economics, and business education, where sustainability learning is closely associated with innovation, employability, and strategic problem-solving. Consequently, pedagogical success is often evaluated through measurable competencies, project outcomes, and applied learning performance. However, affective, ethical, and metacognitive dimensions remain comparatively underdeveloped. Although service-

learning and transformative pedagogies contribute to the development of empathy, civic responsibility, ethical reflection, and self-awareness, these dimensions are frequently treated as supplementary rather than systematically embedded within curriculum structures and assessment systems.

The findings further suggest that most current SDGs pedagogies support instrumental rather than transformative sustainability learning. Many approaches primarily prepare students to respond effectively to sustainability challenges within existing institutional and economic systems, while relatively few explicitly encourage critical reflection on values, worldviews, and broader socio-ecological transformation. This imbalance represents a significant limitation of contemporary sustainability education because sustainability challenges require not only technical competence but also ethical judgment, reflective capacity, emotional resilience, and long-term behavioral commitment (Finnegan & d'Abreu, 2024). Furthermore, emotional dimensions remain substantially underrepresented within current sustainability competence frameworks despite the growing prevalence of ecological grief and eco-anxiety among learners. Competencies related to emotional awareness, emotional processing, emotional resilience, and emotional integration have received limited attention. As (Wickson et al., 2025) argue, sustainability pedagogies continue to prioritize cognitive and behavioral outcomes while neglecting the emotional and metacognitive dimensions necessary for transformative sustainability learning. Without stronger integration of affective, emotional, and reflective learning processes, higher education risks producing graduates who possess sustainability knowledge but lack sustainability agency and transformative commitment. The Awareness handrail highlights that self-reflection is core to the transformative learning process and is initiated by developing critical awareness of the nested interconnections linking the self, others and the more-than-human world. Therefore, there is a pressing need for holistic pedagogical frameworks

that coherently integrate cognitive, affective, behavioral, emotional, and reflective dimensions of sustainability learning to support genuinely transformative educational outcomes.

The synthesis identified several recurring tensions within the implementation of SDGs pedagogy across higher education contexts. Although many universities publicly endorse sustainability and Education for Sustainable Development (ESD) agendas, pedagogical implementation frequently remains uneven and compartmentalized. Sustainability initiatives are often introduced through elective courses, short-term projects, or extracurricular activities rather than embedded within coherent institutional learning systems. A major tension emerges between the interdisciplinary nature of sustainability challenges and the disciplinary structures that continue to dominate higher education. While sustainability problems require integrated and collaborative approaches, university curricula often remain organized within disciplinary silos (Ramachandran et al., 2024) that limit cross-sectoral learning and pedagogical integration. Educational interventions often overemphasize knowledge acquisition while underaddressing the complex psychological and social mechanisms necessary for behavioral change (Van De Wetering et al., 2022). The findings also reveal tensions between global sustainability agendas and local educational realities. In many contexts, SDGs pedagogies are shaped by internationally dominant sustainability frameworks that may not fully align with local socio-cultural conditions, institutional capacities, or community priorities. This challenge is particularly visible in developing countries where sustainability initiatives are frequently constrained by limited institutional resources and uneven policy support.

Another recurring issue concerns the growing influence of market-oriented and competency-driven educational models. Sustainability education is increasingly associated with employability, innovation, and measurable performance indicators, which may encourage instrumental rather than transformative forms of learning. As a result, universities may adopt sustainability language and isolated initiatives without fundamentally transforming curriculum structures, pedagogical philosophies, or assessment systems. These findings suggest that fragmentation in SDGs pedagogy reflects broader structural contradictions within higher education systems. Universities are expected to support

sustainability transformation while simultaneously operating within performance-oriented, discipline-based, and market-driven institutional environments. Consequently, sustainability education often remains project-based and symbolic rather than systematically integrated across institutional cultures and teaching practices. Addressing these limitations requires institution-wide commitment to sustainability-oriented curriculum transformation, interdisciplinary collaboration, faculty development, and reflective pedagogical practice. More importantly, sustainability must be repositioned not as an additional curriculum component, but as a guiding framework for educational transformation across teaching, learning, and institutional governance.

Marzano's Dimensions of Learning as an Integrative Framework for SDGs Pedagogy

The synthesis of evidence from RQ1 and RQ2 demonstrates that current SDGs pedagogies in higher education remain constrained by fragmented implementation, cognitive dominance, and limited integration across learning domains. Existing pedagogical approaches predominantly emphasize knowledge acquisition and applied competencies while providing comparatively limited opportunities for ethical reflection, metacognitive regulation, values formation, and sustained behavioral transformation. Consequently, sustainability learning is frequently implemented through isolated pedagogical practices rather than as a coherent educational process that systematically connects cognitive, affective, behavioral, and reflective dimensions.

To address this limitation, the present synthesis positions Marzano's Dimensions of Learning as an integrative pedagogical framework capable of organizing diverse SDGs pedagogies within a unified learning architecture. Rather than replacing existing pedagogical approaches, the framework explains how they function as complementary learning experiences across five interconnected learning dimensions. Positive attitudes and perceptions establish learners' readiness to engage with sustainability issues (Dimension 1); knowledge acquisition and integration support conceptual understanding of sustainable development (Dimension 2); knowledge extension and refinement facilitate systems thinking, critical analysis, and interdisciplinary reasoning (Dimension 3); meaningful knowledge use enables learners to

apply sustainability concepts through authentic problem-solving, project-based learning, and community engagement (Dimension 4); while productive habits of mind cultivate reflective thinking, ethical responsibility, self-regulation, and long-term sustainability-oriented dispositions (Dimension 5). Collectively, these dimensions transform fragmented instructional practices into a coherent learning process that promotes holistic sustainability competence.

The synthesis further indicates that Marzano's framework aligns closely with the multidimensional goals of Education for Sustainable Development (ESD). Unlike competency-based approaches that often prioritize measurable learning outcomes, Marzano conceptualizes learning as a progressive and

interconnected process in which cognitive, affective, behavioral, and metacognitive development continuously reinforce one another. This integrated structure enables sustainability education to move beyond the acquisition of individual competencies toward the formation of reflective, ethically responsible, and action-oriented graduates capable of addressing complex sustainability challenges. At the same time, the synthesis suggests that the framework should be implemented as an adaptive pedagogical scaffold rather than a prescriptive instructional model, allowing educators to accommodate interdisciplinary perspectives, socio-ecological complexity, and context-specific sustainability issues across diverse higher education settings.

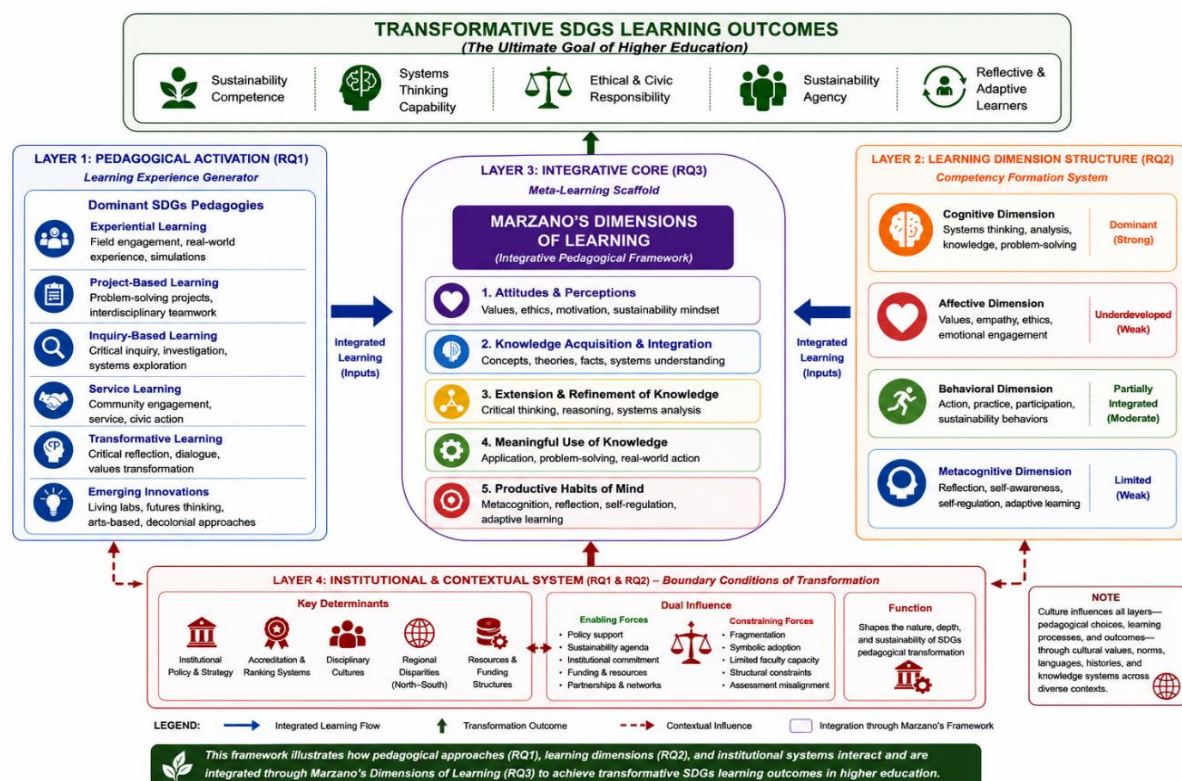


Figure 1. Integrated Framework of Transformative SDGs Pedagogy in Higher Education

Figure 1 presents an integrated conceptual framework of transformative SDGs pedagogy in higher education synthesized from the findings of RQ1, RQ2, and RQ3. The framework conceptualizes sustainability learning as a multi-layered and systemic educational process shaped by the dynamic interaction among pedagogical activation, learning dimensions, institutional structures, and contextual influences. Central to the framework, Marzano's Dimensions of Learning operates as a meta-integrative scaffold

that connects cognitive, affective, behavioral, and metacognitive domains within sustainability education. The model further demonstrates that transformative SDGs learning outcomes are produced not merely through pedagogical innovation, but through the alignment of curriculum design, institutional capacity, policy environments, reflective learning processes, and culturally situated educational contexts. Within this framework, culture functions as a contextual influence that shapes learning processes, meaning-

making, values formation, participation, and the interpretation of sustainability across diverse educational settings. Accordingly, the framework positions sustainability pedagogy as a transformative educational ecosystem that integrates knowledge formation, ethical engagement, critical reflection, and real-world sustainability action.

CONCLUSION

This Critical Interpretive Synthesis found that SDGs in higher education are primarily embedded through experiential learning, project-based learning, inquiry-based learning, service learning, and interdisciplinary approaches. These pedagogies have strengthened sustainability literacy, systems thinking, collaboration, and problem-solving, demonstrating their contribution to sustainability competencies. However, their implementation remains fragmented and largely competency-oriented, with limited attention to affective, ethical, reflective, and metacognitive dimensions. Consequently, current pedagogical approaches only partially support transformative sustainability learning.

To address this limitation, this study proposes Marzano's Dimensions of Learning as an integrative framework for SDGs pedagogy in higher education. By connecting attitudes and perceptions, knowledge acquisition, knowledge refinement, meaningful knowledge use, and productive habits of mind, the framework integrates cognitive, affective, behavioral, and metacognitive learning into a coherent process. This provides a stronger conceptual foundation for transformative sustainability education and offers a basis for future empirical studies to validate its application across diverse higher education contexts.

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