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OVERVIEW ARTICLE

Operational principles for fostering transformative qualities and capacities in higher education sustainability science and practice

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Abstract

Education for sustainability is widely recognised as a critical pathway for driving the transformations needed to address today's polycrisis. Despite growing theoretical and conceptual advancements in sustainability education, current approaches have not achieved the deep systemic changes required. While university networks and individual institutions increasingly integrate sustainability into their education, concerns persist that transformative learning agendas often remain superficial. In particular, they frequently fail to equip learners with the emotional resilience and skills necessary to engage effectively with complex global challenges, as well as educators with the pedagogical framework to facilitate such learning. This article emphasises the need to advance transformative learning in sustainability science and practice in higher education by addressing the inner dimensions of sustainability: our individual and collective values, beliefs, worldviews, and associated transformative qualities and capacities. This means targeting deep leverage points and meaningful change by supporting more relational approaches, including an integrated inner–outer change in being, thinking, and acting. We provide seven operational principles for supporting the inner–outer transformation towards sustainability in learning and teaching sustainability science and practice, especially in geography and related fields. These principles highlight the importance of nurturing five clusters of transformative qualities and capacities—awareness, connection, insight, purpose, and agency—guided by relational approaches required to support profound and integrative learning experiences. We provide concrete examples of how to implement these principles. The proposed principles aim to inspire educators and learners to deeply engage with sustainability challenges to contribute to transformative change across individual, collective, and system levels.

Keywords Emotional resilience · Inner dimensions · Relational approaches · Sustainability education · Systemic change · Transformative learning

Introduction

Education for sustainability science and practice is often touted as the foremost avenue to drive sustainability transformations (Fazey et al. 2021) necessary to address today's intertwined environmental and socio-economic crises [e.g. climate change, biodiversity loss, mental health problems, poverty, and political turmoil which are also called global polycrisis (Lawrence et al. 2022)]. Efforts to integrate sustainability into higher education stem from global frameworks such as the United Nations' Sustainable Development Goals (SDGs), which aim to address these complex polycrises. Sustainability education involves mental models, competencies, and innovations that support more sustainable lifestyles (Wals 2014). It can, at the general higher education level, include promoting inter- and transdisciplinary research around the SDGs, mobilising students for action, including SDGs in institutional practices and the development of advocacy policies towards SDGs (Žalėnienė and Pereira 2021). Sustainability education can vary across disciplines. For example, teaching in geography and related fields aim to provide learners with factual knowledge about socio-ecological systems and place-based approaches and methodologies. However, whilst these approaches are important, they are

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not sufficient. Evidence shows that they have not catalysed the necessary change (Burns et al. 2019). Revolutionising teaching and learning in sustainability science to address today's polycrisis is still urgently needed (Vasconcelos and Calheiros 2022).

Recent research has developed the theoretical discussion on, and competency frameworks for, how higher education should embrace transformative learning towards sustainability. Transformative learning promotes a shift in teaching and learning that disrupts and transforms problematic frames of reference—sets of fixed assumptions and expectations—to make them more inclusive, open, and reflective (Mezirow 2003, p. 58). Transformative learning supports profound changes in thoughts, feelings, perspectives, beliefs, and behaviours because it aims to radically shift consciousness in a way that permanently alters our way of being in the world (Simsek 2012). One example of transformative learning frameworks in sustainability science is the Key Competencies in Sustainability framework as described by Wiek et al. (2011) and Redman and Wiek (2021), which includes systems, futures, values, and strategies thinking as well as inter- and intra-personal competencies. In conjunction, there has also been a rapid growth in transdisciplinary learning, knowledge co-creation, and solutions-oriented sustainability education (e.g. Grindsted and Nielsen 2022; Yang et al. 2024).

Related education policy initiatives aim to push into action global policies and initiatives associated with biodiversity restoration, climate change adaptation, and the integration of nature into society and the economy (European Commission 2019, European Parliament 2020). Examples of such are the European Union education policy initiative learning for the green transition and sustainable development (European Commission 2022) and the GreenComp framework that identifies key competencies for promoting empathy, responsibility, and care for our planet and public health (Bianchi et al. 2022). As this science–policy space has evolved, several university networks globally and individual universities have emerged to promote sustainability in education, which is now becoming common practice. At the same time, there are concerns that the current transformative learning agenda within sustainability science and practice in higher education often remains superficial, instead of enabling disparate disciplines, actors, and researchers to educate people skilled in coping emotionally and effectively with the plethora of challenges and their root causes (Moser and Fazey 2021; Grund et al. 2024). Such skills would be needed to address the mental health crisis and increasing ecoanxiety (Hickman et al. 2021), acting to build a radically better future.

Wamsler et al. (2021) argue that the dominant discourse for understanding sustainability challenges and identifying solutions to the current polycrisis relies heavily on the external socio-economic structures, governance dynamics, and technology change, which fails to address the fact that these challenges are rooted in internal individual and collective mental states. Hence, there is a need to shift the discourse in sustainability science, practice, and education to better address the inner dimensions of sustainability, that is: people's individual and collective values, beliefs, worldviews/paradigms, and associated transformative qualities and capacities needed to reach deep leverage points and foster transformative change across individual, collective, and system levels (Wamsler 2020). This argumentation is based on an emerging field of academic work that is denoted inner transformation, inner–outer transformation, or existential sustainability (Ives et al. 2023), a field that is increasingly recognised by key actors in the field (Wamsler et al. 2022a; IPCC 2023a, b; IPBES 2024). Key to integrated inner–outer transformation is the aim to change our approaches to sustainability education and the associated science towards more relational approaches that break out of our current paradigms and approaches, and instead apply relational thinking, being, and acting (Walsh et al. 2021; Ives et al. 2023).

To improve transformative learning in sustainability science and practice, we need to better understand why and operationalise how transformative qualities and capacities can be nurtured (Woiwode et al. 2021; Ives et al. 2023). Currently, there is a significant body of literature related to teachers' professional skills in transformative learning (e.g. Earle and Bianchi 2021), but limited practical guidance and examples for educators in sustainability science and practice for learning and teaching that can lead to an integrated inner–outer transformation and the associated relational being, thinking, and acting needed to deliver sustainability across individual, collective, and system levels. We believe that higher education educators could benefit from principles that can help them to operationalise the well-elaborated theoretical, conceptual, and institutional work highlighted above. Such principles also respond to the growing demand from students for learning approaches that can help to build agency, resilience, intrinsic motivation, and hope to foster meaningful engagement and transformation.

In this article, we suggest seven principles for linking transformative learning to inner–outer transformation towards sustainability and how these principles can be concretely fostered through learning and teaching sustainability science and practice. The seven principles were formulated by a group of thirteen experienced scholars and educators during a 3-day in-person workshop in August 2023, followed by 1 year of intense online discussion and further refinement. We defined the principles based on emergent research and our individual experiences as researchers and teachers in sustainability science and practice in higher education institutions in European and North American universities. Our

expertise broadly covers disciplines of geography, landscape planning, natural resource management, environmental education, and social science, with an inherent background in socio-ecological systems thinking, contextual place-based approaches, and connecting science and practice in teaching and learning for sustainability transformations.

The identified seven principles build on sustainability science literature, the emergent field of inner–outer transformations, and Wamsler et al. (2021) who identify five clusters of transformative qualities and capacities: awareness, connection, insight, purpose, and agency (presented in detail in the next section), crucial for facilitating the culture and system change needed for a more sustainable future. Our goal as educators is to improve the adoption of transformative learning in teaching and learning in our fields in higher education and through this action push forward sustainability practices at an institutional level across our universities (Higgins and Thomas 2016; Plieninger et al. 2021).

Theoretical framework: qualities and capacities for integrated inner–outer transformation

In their systematic review, Wamsler et al. (2021) identify, as part of their inner–outer transformation model (IOTM), five clusters of transformative qualities and capacities: awareness, connection, insight, purpose, and agency (Table 1). They include cognitive, emotional, and relational qualities and capacities that have been shown to support cultivation of values, beliefs, and worldviews regarding how people relate (or reconnect) to themselves, others, nature, and future generations in ways that can support transformation (Wamsler et al. 2022a). IOTM and the associated clusters of transformative qualities and capacities are based on empirical research (Wamsler et al. 2020) and a systematic literature review (Wamsler et al. 2021). The IOTM has been utilised and evaluated in various training, leadership and education programmes and aligns with the Inner Development Goals framework that evolved afterwards (IDG Initiative 2021). The IOTM offers both higher education teachers and learners a transformative framework aimed at unleashing the human inner potential to care, commit to, and effect change for a better life across individual, collective and system levels (Wamsler 2020; Wamsler et al. 2021, 2022a).

Seven principles for operationalising integrated inner–outer transformation

This section presents the seven principles we propose for operationalising the transformative qualities and capacities for integrated inner–outer transformation (Table 2, Fig. 1). First, we describe each principle and how it connects to awareness, connection, insight, purpose, and agency. Subsequently, we give concrete examples of how to foster each principle in teaching and learning sustainability science and practice. Examples of pedagogical approaches and tools that can be effective in developing sustainability competencies are numerous (see e.g. Barth et al. 2007; Bürgener and Barth 2018; Corres et al. 2020; Bianchi et al. 2022; Lewis et al. 2024; Wamsler et al. 2024a). In the context of this article, we have chosen examples that align with the chosen theoretical framing and are based on our experience as educators in sustainability science, emphasising systems thinking and contextual place-based methods and approaches. Hence,

Table 1 Five clusters of qualities and capacities crucial for integrated inner–outer transformation towards sustainability as identified by Wamsler et al. (2021)

Quality/capacity	Definition
Awareness	The ability to meet situations, people, others, and one's own thoughts and feelings with **openness, presence, and acceptance**. This cluster is thus about our ability to be aware, i.e. **to be present, self-reflexive, and attentive**, with an open-minded and accepting attitude
Insight	The ability to see, understand, and bring in more perspectives for a broader, **relational understanding of oneself, others, and the whole**. Hence, this cluster is about our ability to gain insight, i.e. to think from a relational, equitable, and systems perspective that recognises complexity and interconnectedness, **and to seek and hold different perspectives**
Connection (or belonging)	The ability and desire **to see and meet oneself, others, and the world with care, humility, and integrity**, from a place of empathy and compassion. This capacity is about our ability to connect, i.e. **to relate with a pro-social, servant attitude, embracing our common humanity and nature**
Purpose	The ability to navigate oneself through the world based on insights into what is important (intrinsic, universal values). In other words, this cluster is about our ability to find and live our purpose, i.e. **to commit to and collaborate based on intrinsic, universal values**
Agency	The ability to see and understand broader and deeper patterns and our own role in the world in this regard, and **to have the intention, optimism, and courage to act** on them. From a place of awareness, connection, and understanding of our interconnectedness and place in the world, we can develop a deep sense of **individual and collective agency** and to move into acting—with resilience, active and stubborn hope, and courage

Table 2 Principles to operationalise the five clusters of transformative qualities and capacities as defined by Wamsler et al. (2021) with concrete examples for teaching and learning in sustainability science

Principle	Summary of the links between the principle and the key aspects of the five clusters of transformative qualities and capacities to promote integrated inner–outer transformation	Examples for teaching and learning
Principle 1: Acknowledge diverse and dynamic positionalities	● Learners and teachers become *aware* of their positionality and beliefs and the influence they have on behaviour and actions ● Acknowledgement of their own power, privilege, and biases and the inherent power structures creates *insight* and context ● Understanding the dynamic behaviour of one's positionality or situatedness influences the relatedness of in classroom or project settings and can improve *connection* and co-creation productivity ● Determining one's positionality and the external influence of bias relative to action and relatability provides avenues to define *purpose* and create *agency* through the recognition of the central importance of the "inner dimension" for change in achieving sustainable futures	● 'Item of significance' (Puente et al. 2023) ● 'Story of self' ● 'Bubble hopping' (Stenström n.d.) ● Acknowledging positionalities throughout a teaching event ('traffic light' or 'line approach')
Principle 2: Foster compassionate approaches	● Compassionate practices are interpersonal and educational processes that focus on our ability to *connect* ● Extends our perceptions of community and in doing so is critical to the development of a sense of *agency* ● Provides for empathetic intention, or *purpose*, to compassionate action on behalf of the human and more than human biotic community ● Learners gain *insight*, i.e. the ability to think from a relational perspective, to be *aware* of different ways of knowing and being with deep consideration for broader collective well-being	● Extracurricular ecology club (Hartsell 2006) ● Compassionate letter writing to self ● Community gardening at campus ● Forum play (Lehtonen and Hakkarainen 2025) ● Nature-based mediation practices: nature walks (Wamsler et al. 2024a), 'sit spot practice' (Holmwood 2021)
Principle 3: Ground educational experience in place	● Place-based approaches provide understanding by which learners gain *insight* of the association between the biophysical elements, place-related values, emotional attachment, and worldviews linked to a specific place ● Sustainability challenges can be recognised, increasing responsibility, affinity, empathy, care and stewardship towards nature eliciting *awareness* of deep leverage points and *connection* ● Learners are imbued with *agency*, being empowered to shape places by improving social and environmental well-being	● Local places as learning sites (Gosselin et al. 2016) ● Transdisciplinary activities to build relationships between learners and societal actors (Bartholomaeus 2006)
Principle 4: Acknowledge progressive contextualisation and temporality	● Learners are encouraged to actively contextualise and expand the scope of narrow, targeted inquiries—adding additional layers of information and analysis—to build a richer, systemic comprehension of context-sensitive, connected phenomena (i.e. *insight*). In this context, learners are encouraged to expand their time horizons (past, present, future) and train related cognitive, emotional, and relational capacities ● Systems thinking applied to constructing solid, rich case studies, recognising one's own positionality (cf. principle 1) is integral to contextualising actionable knowledge and thus *agency*	● Weekly exercises where learners contextualise topics, adding new layers of analysis ● Comparative analytical approaches to reveal the underlying patterns (Andersson et al. 2024; Böhme et al. 2024) ● 'Iceberg model' (Lewis et al. 2024) ● Portfolio approach (Çimer 2011)

Table 2 (continued)

Principle	Summary of the links between the principle and the key aspects of the five clusters of transformative qualities and capacities to promote integrated inner–outer transformation	Examples for teaching and learning
Principle 5: Emphasise process and emergence rather than outcome	● Learners gain knowledge and know-how for addressing interrelationships of systemic real-world challenges, which fosters *insight* that practical problem-solving in sustainability science will often rely on non-conclusive data about all potential options and their manifold impacts ● Helps learners to navigate themselves in the world by recognising how their own choices about steps and approaches in the problem-solving process influences the way issues are framed and solutions delivered (i.e. *purpose*) ● Learners need to be aware of principles for a good dialogue, including meeting situations, people, others, and one's own thoughts and feelings with openness (i.e. *awareness*) and listening with empathy and compassion and bringing assumptions into the open (i.e. *connection*)	● Design studio workshops (or other project-based learning tools) (Albert et al. 2015) ● Learning journals (Moon 2006) ● Communication tools to foster constructive dialogue
Principle 6: Foster practice-oriented engagement for building self-efficacy and collective action	● To develop *agency*, learners participate in sustainability activities and initiatives to support inner–outer transformations ● Participation in sustainability activities and initiatives contributes to learners finding their own role and *purpose*, triggering new behaviours and value shifts through raised *awareness* ● Both individual and collective learning are triggered and lead to deep relational *connection* ● Self-efficacy holds potential for leading to a self-reinforcing dynamic and collective action (i.e. *purpose*)	● Real-world engagement, e.g. through walking tours of urban food systems (Carrus et al. 2018) ● Problem-oriented approaches that allows learners' experiences to be included, e.g. 'participatory risk management' during field courses (Beery 2020)
Principle 7: Address power, politics and structures	● Educating learners about the political systems underpinning sustainability challenges and associated outer and inner dimensions, recognising their deep-rooted power dynamics, fosters *awareness* and encourages reflexivity ● Helps to establish a sense of *purpose* rooted in environmental justice, enabling learners to navigate power, politics, and structures ● Cultivates *agency*, empowering active participation in transformative processes	● Role play and forum play (Alejandro et al. 2024; Mochizuki et al. 2021; Castellazzi et al. 2024) ● Serious gaming (Asplund et al. 2019) ● Real-life case studies

we acknowledge that the listed examples are non-exhaustive selection. The given examples are a mix of socio-cognitive, emotional, embodied, creative, place- and nature-based, and ethical approaches—as recommended by recent policy and research approaches in the field (Bianchi et al. 2022; Wamsler et al. 2024b).

Principle 1: Acknowledge diverse and dynamic positionalities

Raising awareness of the learners' and teachers' positionality for transformative learning requires acknowledgement of the different ways in which they utilise situational knowledge claims in specific, but diverse contexts (Haraway 1988), and informs their professional or personal identity (Hakkarainen et al. 2023). Positionality refers to recognising one's power, privilege, and biases, which influence how we engage with diverse contexts and with others (Madison 2012). This awareness includes understanding the privileges and prejudices that shape learners' and teachers' identities, starting from early education (Powell 2022), and reflecting on factors such as gender, cultural negotiation, intersectionality, and how individuals perform their identities (Simandan 2019). Positionality evolves and can lead to perspective transformation (Rowe 2014), priming our inner selves' reflection of how we view the world and how we learn and relate to others. Teaching positionality encourages critical reflection on personal backgrounds, place-based worldviews, ethical considerations, and relational contexts, fostering critical consciousness and unlearning (Puente et al. 2023).

This principle means that learners and teachers become *aware* of their positionality and beliefs and their influence on behaviour and actions while recognising the diverse and dynamic nature of positionality. Acknowledging their power, privilege, biases, and inherent power structures creates *insight* and context. Understanding the dynamic behaviour of one's positionality or situatedness influences the relatedness of in classroom and can improve *connection* and co-creation productivity. Determining one's positionality and the external influence of bias relative to action and relatability provides avenues to define *purpose* and create *agency* through the recognition of the central importance of the inner dimension for change in achieving sustainable futures.

Self-reflection activities can effectively raise awareness of positionality. One example is the 'item of significance' assignment, where learners present something that reflects their identity or heritage and/or cultures, helping them explore their sense of self and place (Puente et al. 2023). Thus, through deeper reflection, learners are able to discover the roots that lead to their worldviews and how these branch out from their beliefs to take action that can create the individual's or groups' socio-ecological identity. Another activity is the 'story of self,' where learners reflect on personal experiences shaping their worldview and decision-making while also reflecting on the power structures in which learning occurs. In addition, the 'bubble hopping' method is useful for creating new perspectives in a divided society and improves students' empathy between social groups (Stenström n.d.). Recognising the positionality of each team member enhances knowledge co-production and improves outcomes (Maclean et al. 2022; Ives et al. 2023). Incorporating positionality exercises, such as the 'traffic light' or 'line approach' (how you may feel different according to the context) activities at the beginning and throughout a course helps contextualise learning and promotes transformative growth. By understanding how context influences feelings of difference, these practices foster deeper reflection and engagement, ultimately supporting more meaningful and impactful learning experiences.

Principle 2: Foster compassionate approaches

Sustainability crises stem from the inability to relate to ourselves, others, and the environment in compassionate and caring ways (Wamsler et al. 2021), and fostering such relations needs to be at the core of transformative learning. Sustainable action arises from recognising our shared humanity and nature through embodied compassion, empathy, and self-awareness (Lees 2021; Harris and Jones 2023). We often act on behalf of those in our communities, with empathy leading to compassionate action (Goralnik and Nelson 2011). Understanding our role within social and biotic communities is crucial for sustainability (Leopold 1970), as it expands the concept of community to include kinship between humans and the more than human world. This also helps to nurture agency across individual, collective and system levels for sustainable transformation (Ives et al. 2023).

This principle emphasises that a compassionate approach aims to foster the development of learners' relational capacities. Compassionate approaches are interpersonal and educational processes that focus on our ability to *connect*, i.e. relate, emphasising a common humanity and nature. Further, compassionate approaches extend our perceptions of community and in doing so, they are critical to the development of a sense of *agency*; for example, empathetic intention or *purpose*, to compassionate action on behalf of the human and more than human biotic community. This principle ultimately means that learners gain *insight*, i.e. the ability to think from a relational perspective, to be *aware* of different ways of knowing and being with deep consideration for broader collective well-being.

Educational activities that promote compassion for other people and living things include, for example, the extracurricular ecology club, which meets beyond the regular curriculum to foster deeper respect and compassion for living

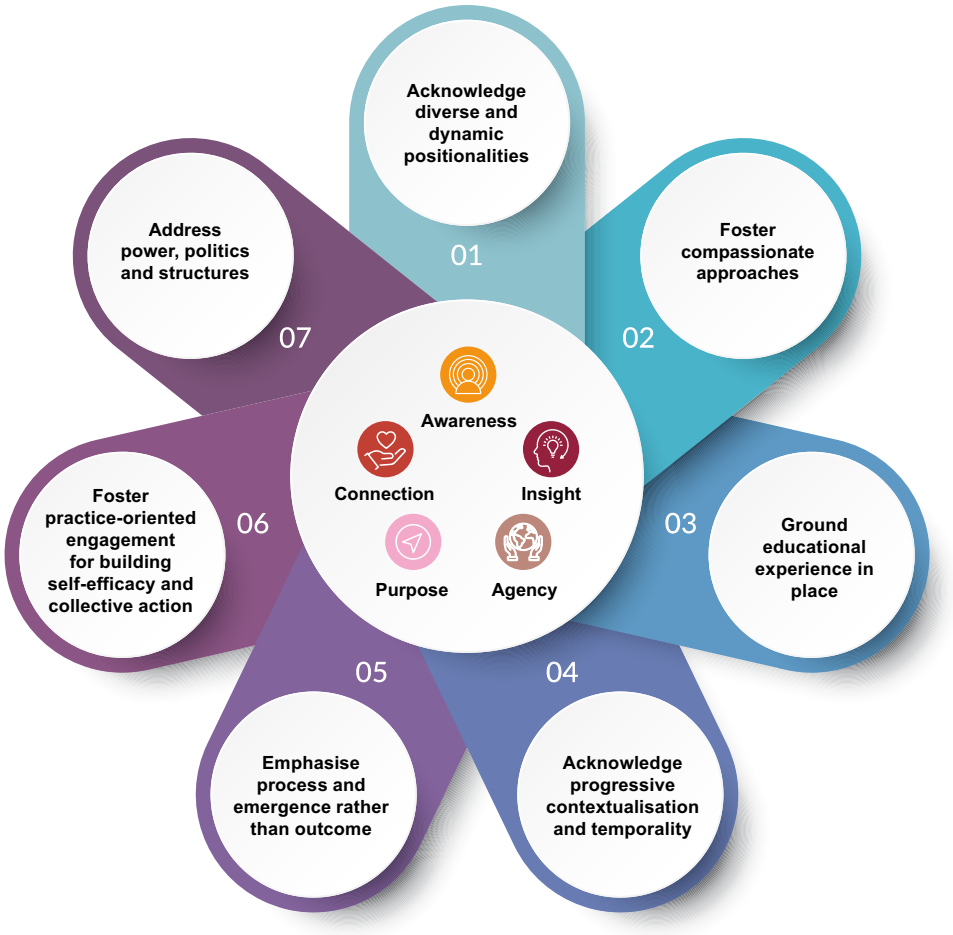

Fig. 1 Seven principles to operationalise transformative qualities and capacities of awareness, connection, insight, purpose, and agency

things (Hartsell 2006). It is important to encourage students to promote self-compassion, such as treating oneself with the same kindness, concern, and support you would show to a good friend (Neff and Dahm 2015); for example, through compassionate letter writing to self. Another example is activities that promote connections to the non-human aspects of the community. For example gardening can create experiences of belonging that reach beyond the human (Bell-Williams et al. 2021) and can take place as community gardening on campus. Forum play can encourage students to think creatively and critically, imagining different ways of making decisions that include all beings (Lehtonen and Hakkarainen 2025). Nature-based meditation practices are also a scientifically sound way to foster connection to self, others and nature (Wamsler et al. 2018; Djernis et al. 2019), for example through mindful nature walks (Wamsler et al. 2024a) or the 'sit spot practice' (e.g. Holmwood 2021), a simple nature observation exercise.

Principle 3: Ground educational experience in place

Grounding education in place is a powerful approach for transformative learning. The concept of place acts as a "boundary object," helping learners recognise, articulate and solve sustainability challenges in relevant ways (Potschin and Haines-Young 2013; Zurba 2022). Place-based education is 'an umbrella term for pedagogical practices that prioritise experiential, community-based, and contextual/ecological learning to cultivate greater connectivity to local contexts, cultures, and environments' (Yemini et al. 2023). It fosters an understanding of socio-ecological systems, emphasising both their biophysical aspects and human dimensions. Central to place-based education are the concepts of 'place meaning' (the significance and values attached to a place) and 'place attachment' (emotional connections to a place), which together form a person's 'sense of place' (Semken 2005). A sense of place can promote empathy, care, and stewardship for nature, while contributing to learners' health and well-being (Chawla 2020). Developing a sense of place in a specific environment can be considered a precondition for responsibility to it, and thus, a valuable mechanism to foster a transformation towards sustainability (Smith and Sobel 2010). At the institutional level, place-based education has been shown to narrow equity gaps, enhance students' sense of belonging and improve academic performance and retention rates (Johnson et al. 2020).

This principle highlights that place-based learning supports the transdisciplinary nature of sustainability science, acknowledges the multiplicity of meanings of place, and evokes experiential learning opportunities. Hence, learners gain *insight* of the association between the biophysical elements, place-related values, emotional attachment, and worldviews linked to a specific place. Identifying sustainability challenges in a place-based way increases responsibility, affinity, empathy, care, and stewardship towards people and nature, eliciting *awareness* of deep leverage points and *connections*. Through systemic understanding of a place, the sense of place, and the socially critical approach learners are imbued with *agency*, being empowered to shape the conditions of places by improving social and environmental well-being individually and in cooperation with other actors (Gruenewald 2003).

Place-based education often involves outdoor activities, special equipment, and long-term project-based approaches and requires coordination between many actors (Yemini et al. 2023). Gosselin et al. (2016) provide examples of place-based pedagogy at the course level that illustrate how local places—on-campus, the surrounding community, and regional landscapes—provide opportunities for students to connect factual knowledge to real-world challenges. At the programmatic level, Bartholomaeus (2006) provides examples relevant to building transdisciplinary relationships between learners, local communities, entrepreneurs, and other societal stakeholders.

Principle 4: Acknowledge progressive contextualisation and temporality

Sustainability science and practice require a systemic perspective, but this does not necessarily mean starting with an all-encompassing 'bigger picture'. Instead, learners can be guided to actively, step-by-step contextualise and expand the scope of narrow, targeted inquiries and adding additional layers of information and analysis to gradually develop a richer, systemic comprehension of context-sensitive, interconnected phenomena and their causes and consequences (Vayda 1983; Andersson et al. 2024). Hence, systems-thinking offers a relational mindset. The core to the practice is the focus on relationships and feedback, explicit questioning of boundaries, and the attempt to anticipate emergent properties and change. Teachers play a key role in guiding how knowledge is produced and addressing the ontological and epistemological challenges this raises (Repko and Szostak 2016).

In progressive contextualisation, learners actively contextualise and expand the scope of narrow, targeted inquiries—adding additional layers of information and analysis—to build a richer, systemic comprehension of context-sensitive, connected phenomena (*insight*). In this context, learners should also be encouraged to expand their time horizons (past, present, future) and train related cognitive, emotional, and relational capacities. Systems thinking applied to constructing solid, rich case studies, acknowledging one's positionality (cf. Principle 1) is integral to contextualising actionable knowledge and, thus, *agency*. This principle enables deeper exploration of (place-based) case studies by gradually integrating technical, theoretical, practical, or normative insights.

For example, an exercise that starts with spatially mapping ecosystem services can evolve into examining the justice of their distribution, the roots of inequality, or potential changes due to regional or global shifts (Herreros-Cantis and McPhearson 2021). Adding questions and new relational layers of analysis often requires additional methods to provide missing data or new analytical tools. This can be done through sequential and integrated method designs to add dimensions to a study case (Böhme et al. 2024), or by employing different comparative analytical approaches to investigate under which circumstances certain patterns emerge (e.g. Andersson et al. 2024). Another example is the 'iceberg model', a systems thinking tool that uses the metaphor of an iceberg to illustrate how the surface-level sustainability challenges are underpinned by less visible individual and collective inner dimensions (Lewis et al. 2024). In courses, progressive contextualisation can be built up gradually, with students adding data to the same case each week, creating a portfolio of applied knowledge, a collection of contextualised and applied case-specific knowledge and experiences. Every theoretical or methodological part is thereby applied to the same case step-by-step. Such a portfolio approach has proven useful to direct and enhance learning (Çimer 2011).

Principle 5: Emphasise process and emergence rather than outcome

The field of inner–outer transformation links to complexity thinking, which emphasises the process and emergence rather than the outcome of transformative learning (Wamsler et al. 2022b). This process involves conveying concepts, methods, and practices of how to structure, implement, and evaluate collaborative problem deliberation, meaning-making, and solution development (Marouli 2021). It stresses the importance of steps and cyclicity in the development of and experimentation with integrated solutions to sustainability challenges (Dare et al. 2023). Instead of simply working towards fixed bodies of knowledge, the principle aims to center stage complex inner–outer processes and changing settings and issues.

This principle focuses on process and emergence and allows learners to gain knowledge and know-how for addressing the multiple connections and interrelationships

of systemic real-world challenges, even if the complexity of reality cannot be fully captured within the time and resource limitations of educational exercises. Embracing complexity fosters the *insight* that practical problem-solving in sustainability science often relies on non-conclusive data about all potential options and their manifold impacts. With that, this principle helps learners to navigate themselves in the world by recognising how their own choices about steps and approaches in the problem-solving process influence the way issues are framed and solutions delivered. (i.e. *purpose*). Finally, with active deliberation and co-creation as one of the prominent means of knowledge generation within sustainability science, learners need to be aware of principles for a good dialogue, including meeting situations, people, others, and one's thoughts and feelings with openness (i.e. *awareness*) and listening with empathy and compassion and bringing assumptions into the open (i.e. *connection*).

Intensive design studio workshops can foster this principle in land use and landscape planning. For example, the Cagliari workshop (Albert et al. 2015) enabled students to learn and apply a framework for alternative future studies within just 5 days (Steinitz 2012). Instead of using sophisticated geospatial methods and disciplinary models, students applied simplified heuristics and conceptual models informed by local experts. This allowed them to understand the overall process and to produce inspirational input for debates with local stakeholders—even though the outcomes require more in-depth analyses in cases where they shall be applied for actual decision-making (Albert et al. 2015). Another example is the implementation of learning journals, as a voluntary activity, but potentially also as part of a graded exam (Moon 2006). A learning journal requires students to actively engage with their learning process, rather than just a fixed outcome. The end of the learning journey can be considered in the context of the students' starting points and the "learning curve" they underwent. Any communication tools to foster constructive dialogue are also important.

Principle 6: Foster practice-oriented engagement for building self-efficacy and collective action

A vital component of all transformative learning processes is to foster learners' engagement in sustainability activities and initiatives. Learners can engage in various roles, such as facilitators or investigators (Kruijf et al. 2022), and at different stages, from early niche formation—where innovative approaches or products are developed—to later stages involving monitoring and scaling outcomes (Rodríguez Aboytes and Barth 2020). Empowering learners to take action, i.e. fostering their self-efficacy both individually and collectively, is essential for shaping and achieving sustainable futures. Practice-oriented engagement encourages learners to call for action from decision-makers and those in power (Bianchi et al. 2022).

In this principle, learners aim to engage in sustainability activities and initiatives to foster inner–outer transformation through hands-on experiences, which help them develop a sense of *agency*. When students actively participate in sustainability initiatives in their education, it helps them discover their own role and *purpose* and promotes new behaviours and shifts in values by raising *awareness*. This involvement aims to spark both individual and social learning and lead to deep and relational *connection* into the issues at stake. This motivation can increase self-efficacy, creating a positive cycle that leads to collective action as learners become more aware of their roles, opportunities, and limitations (i.e. *purpose*). Research shows that while eco-anxiety can hinder agency, positive emotions and a strong human–nature connection support political engagement and well-being (Wamsler and Bristow 2022).

An example of an educational activity that fosters this principle is exploring the connection between cultural processes, social norms, and food choices in urban settings through walking tours of urban food systems. This hands-on approach incorporates lived experiences and highlights walkability and restorative environments as positive urban affordances in pursuit of sustainable lifestyles (Carrus et al. 2018). Another example can be seen in problem-oriented approaches that allow learners experiences to be included; for example, engaging students in participatory risk management during field courses offers a practical way for them to see how they can contribute to positive well-being outcomes and take responsibility for themselves and others (Beery 2020).

Principle 7: Address power, politics, and structures

Engaging with power, politics, and structures in transformative learning challenges the conventional view of science being objective and detached from the issues it studies. Understanding and addressing inner–outer transformation processes without assessing related structures that influence these misses the point (Ives et al. 2023). Sustainability science is inherently normative and value laden, requiring educators to acknowledge the political nature of their teaching topics (Vogt and Weber 2020). Educators may struggle to incorporate these political dimensions in teaching, fearing negative reactions and loss of control of the process. The misconception that sustainability science must remain purely objective can limit its effectiveness, reinforcing dominant narratives. Instead of pursuing objectivity, it is more important to recognise the multiple values underlying sustainable development and relate them to each other (Wals and Jickling 2002). Understanding the political systems and power

dynamics at the root of sustainability challenges is key to fostering transformation.

Acknowledging that sustainability challenges are inherently political is crucial for nurturing inner–outer transformation. Educating learners about the political systems underpinning sustainability challenges and associated outer and inner dimensions, recognising their deep-rooted power dynamics, fosters *awareness*, and encourages reflexivity, enabling individuals to situate themselves within the issues. It also establishes a sense of *purpose* rooted in environmental justice, enabling individuals to navigate power, politics, and structures. This purpose can lead to cultivation of *agency*, empowering active participation in transformative processes from both an individual and collective involvement perspective (Wamsler et al. 2022b).

Addressing the political dimension in classrooms requires incorporating both cognitive and emotional elements, recognising power imbalances, and fostering a participative and pluralistic atmosphere that embraces diverse perspectives and conflicts (Sund and Öhman 2014). Depending on the context, approaches to address power and politics in the classroom range from breaking normative patterns to consensus-building through social learning and participatory and relational methodologies (Böhme et al. 2024) or highlighting conflicts to help students grasp the complex realities of sustainability (Håkansson et al. 2019). Strategies for engaging with power and politics include connecting course content to students' lives and examining the power, political processes, and structures behind sustainability challenges. Useful tools include role playing (e.g. Mochizuki et al. 2021; Alejandro et al. 2024; Castellazzi et al. 2024) and serious gaming (e.g. Asplund et al. 2019) that uses real-life case studies for hands-on, action-oriented learning (cf. Principles 3 and 4).

Discussion

The principles we have suggested stem from the increasing realisation that addressing the polycrises in today's world requires more than just recognising their visible impacts and understanding material causes, technology, and associated solutions development. The focus must shift towards fundamentally transforming the mainstream sustainability discourse, how we understand and teach about sustainability challenges and how we address them in more relational ways to address the root causes and recognise the intertwined nature of inner–outer change processes (Wamsler et al. 2021; Ives et al. 2023). Hence, the suggested principles are formed around a relational approach (West et al. 2020; Walsh et al. 2021; Fazey et al. 2021) to promote deep, constructive, and meaningful learning that extends beyond simple knowledge acquisition, supporting learners in critically shaping their understanding of the world and their role in it (Simsek 2012; Ives et al. 2023). Engaging with intertwined inner–outer transformation processes and associated inner (individual and collective) capacities, positionalities, power, politics, structures, temporality and place, whilst emphasising the processes of emergence in transformative learning challenges the conventional view on science being objective and detached from the problems it studies.

The suggested principles aim to operationalise transformative learning as a cornerstone of higher education's response to the polycrisis, through integrated inner–outer transformation across individual, collective, and system levels. The principles show how transformative qualities and capacities can be fostered, filling a gap in the current literature and discussion on transformative learning, especially in geography and related fields. Thus, the aim is to address the mind–sustainability nexus in such a way that it leads towards a virtuous cycle of increasing individual, collective, and planetary regeneration and well-being (Wamsler and Bristow 2022), which we can also call triple well-being (ThoughtBox Education 2024).

The principles are interconnected and should be continuously revised based on new knowledge and developments in transformative learning. We also note that it is crucial to integrate the factual science-based socio-ecological system knowledge and competencies with the transformative qualities and capacities, and that these should work in tandem. The examples of pedagogical approaches and tools provided for each principle aim to support this integration.

Applying these principles will require, from teachers, attention to constructive alignment in teaching and learning (i.e. alignment between intended learning outcomes, structure, activities, and assessment of a course or learning event, Biggs and Tang 2011). For instance, real-world and place-based approaches often demand fieldwork instead of gathering for a lecture or networking with stakeholders, which necessitates additional resources or addressing challenges and risks not present in classrooms or online environments. Teaching transformative qualities and capacities can also encounter learning resistance, for example, among those coming from traditional sciences who may not see their value (Wamsler 2019). Both learners and teachers are on unique paths in their educational journeys, and this should be acknowledged.

A key aspect of future development is assessing the qualities and capacities of inner–outer transformation that promote the questioning and challenges of unsustainable societal structures, cultures, norms, and paradigms. Traditional grading methods may not align well with this approach's relational and holistic nature. However, several alternative methods can have the potential to evaluate these qualities and capacities, such as self-assessment and reflection, peer assessment, narrative, storytelling,

and art-based methods that allow to express learning in personal and creative ways, questionnaires to assess the impact of activities, and the provision of qualitative feedback (Romano 2018; Melacarne 2019).

The suggested principles challenge the prevailing neoliberal or growth-focused paradigms linked to forms of outcome-based education. These paradigms are increasingly criticised for being managerial, technical-reductionist, and behaviouristic, and not primarily concerned with supporting inner development or personal growth for sustainability (Wamsler et al. 2021), nor fulfilling, for instance, the criteria for tenure-track assessment of a teacher. Many higher education programmes follow rigid disciplinary structures, and institutions are often ill-prepared to support inter- and transdisciplinary learning environments (Bauer et al. 2021), even more so if they concern inner–outer transformation processes. One way to leverage sustainability agendas and education is through a bottom-up process (Weiss et al. 2021). Hence, striving to build collaborations (within and beyond teaching environments) of inter- and transdisciplinary teams of educators from other disciplines and sectors is one important aspect to build an understanding of how to design curricula in sustainability science (see e.g. University Coalition for Student Inner Development 2024). In addition, looking for opportunities to learn and exchange pedagogical experiences (e.g. through courses, conferences, and formal and informal networks) is a way to develop teachers' individual competencies.

We suggest utilising the presented principles to empower learners, teachers, and institutions to engage with relational approaches and transformative qualities and capacities to explore parallels between inner–outer relationships and transformative learning to deliver sustainability. We hope that the principles provide valuable inspiration for operationalising transformative learning across the diverse fields of study that underpin sustainability science, practice, and education.

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Declarations

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