

## Article

# Education for Sustainable Development: A Systemic Framework for Connecting the SDGs to Educational Outcomes

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**Abstract:** The UN 2030 agenda of Sustainable Development Goals (SDGs) envisions a future of inclusive equity, justice and prosperity within environmental limits, and places an important emphasis on education as stated in Goal 4. Education is acknowledged as a means for achieving the remaining Goals, with sustainability as a goal for education in target 4.7. However, the interconnectedness of the SDGs and the complexity of sustainability as a concept make it difficult to relate the SDGs to educational learning outcomes, with what Education for Sustainable Development (ESD) aims to achieve, left in ambiguity. Using systems thinking, we developed a framework that redefines ESD as a tool that can deliver the transformation required for society to reach a sustainable state. Using the SDGs as end points for this state, and through a participatory approach, education stakeholders and learners work together to construct a common vision of sustainability, identify the competences needed, and develop appropriate pedagogies and learning strategies. The framework allows for the development of evaluation tools that can support educational institutions to monitor and manage their progress in transforming societies towards sustainability.

**Keywords:** sustainable development goals (SDGs); systems thinking; sustainability competences; education for sustainable development; participatory approach

## 1. Introduction

Humanity faces many sustainability challenges, products of complex, often nonlinear, interactions between people and the environment. Our understanding of them is often incomplete and in part clouded by profound uncertainties [1,2]. Human behaviour, although not intentionally malicious, is widely recognised as the root cause of most sustainability challenges. Individual and collective choice can exacerbate environmental, economic and social problems [3]. Consequently, addressing pressing sustainability challenges, such as transgressing critical planetary boundaries [4], requires changes in public perceptions, values, attitudes and behaviours, and the right conditions for these changes to happen [5,6]. It requires fundamental changes in the way we think, act, and relate to other biotic and abiotic systems. Arguably, *education* is the most important tool to reshape worldviews and values and has enormous potential to address the sustainability challenges facing humanity [7–10]. It can empower learners to embrace sustainability as a lifestyle choice [11]. However, lifestyle choices are often the outcome of external influence by institutions, structures and practices that are beyond the control of the individual [12] and so personal responsibility needs to be seen in a dialectical relationship with collective responsibility.

The Sustainable Development Goals (SDGs) Agenda of the United Nations adopted by world leaders in 2015 include poverty eradication, climate change mitigation and universal access to education. The SDGs provide a framework of sustainability goals and targets that is universally accepted and

summarise priority action areas to help society achieve justice, prosperity and environmental security [4]. The UN 2030 Agenda acknowledges Quality Education (SDG#4) as a means for achieving the remaining SDGs, with sustainability as a goal for Education in target 4.7 [4]. Despite these aspirations, what education for sustainability aims to achieve is not clear. Earlier policy statements include:

- *Environmental Education* (EE) in 1977: The world's first intergovernmental conference on environmental education was organized by the United Nations Education, Scientific, and Cultural Organization (UNESCO) in cooperation with the U.N. Environment Programme (UNEP) and was convened in Tbilisi, Georgia (USSR) from 14–26 October 1977.
- The introduction of *Education for Sustainable Development* (ESD) during the Earth Summit in Rio in 1992: The United Nations Conference on Environment and Development (Rio Summit, Earth Summit) and Chapter 36 of Agenda 21 consolidated international discussions on the critical role of education, training and public awareness in achieving sustainable development.
- The announcement of the *Decade for ESD* in 2002 during the World Summit on Sustainable Development: A proposal for the Decade of Education for Sustainable Development (ESD) was included in the Johannesburg Plan of Implementation. The United Nations General Assembly, at its 57th session in December 2002, adopted a resolution to start the UN Decade of Education for Sustainable Development (DESD) from January 2005.
- The launch of the *Global Action Programme* (GAP) for ESD in 2014: UNESCO World Conference on ESD launched the Global Action Programme on ESD.
- The *Incheon Declaration*: The Incheon Declaration (Education 2030: Towards Inclusive and Equitable Quality Education and Lifelong Learning for All) was adopted at the World Education Forum, Incheon, Korea R, in 2015, and stressed the important role of education as a main driver of development and realisation of the SDGs.

It is also unclear whether these initiatives have been successful in transforming curricula and teaching approaches towards sustainability [13].

Empirical studies on the effectiveness of ESD have been limited [14]. The few studies that have reviewed the learning concepts and educational practices used in ESD highlight discrepancies, incongruence of approaches and deficits in curricula [15,16]. Educational strategies and policy recommendations for implementing ESD are considered to have had limited positive impact, heavily reliant on perceived beneficial outcomes that have not been assessed objectively [3]. Furthermore, studies have found learners increasingly disengaged from ESD [17]. Students and teachers often feel overwhelmed by sustainability concepts [18], and misconceptions about the nature of sustainability and the limited feasibility of making a difference have been further shown to provoke pessimism and diminish motivation [19]. Sustainability has often been used to manoeuvre students into particular viewpoints [20], rather than empowering them to reach their own conclusions based on critical reflection of the available opinions and evidence. There have been calls to reevaluate ESD efforts due to the disconnect between environmental education and personal responsibility [21].

The concept of Quality Education is based on the premise that educational aims are met and purposes fulfilled, with quality seen “in light of how societies define the purpose of education” [22]. While education, including formal, informal and non-formal awareness and training has been recognised as “a process by which human beings and societies can reach their fullest potential”, for years, the purpose of education in industrialized countries has been to educate a workforce, aiming at excellence in a few core disciplines [23]. A study conducted recently in 22 Asian countries showed that education places emphasis on preparing students for competitive participation in the global economy, rather than to become critical and responsible members of society in alignment with the objectives of ESD [24]. Today, although economic well-being remains an important educational outcome, there have been increasing calls for education to focus also towards global citizenship, social justice and sustainability [23]. The Aichi-Nagoya Declaration 2014 on ESD invites all education systems, from

preschool to higher education, to revisit and clarify their purpose, mission and goals and consider educating for a sustainable future.

ESD links with quality education in the sense that it has the potential to empower learners with the knowledge, skills and values needed to promote a sustainable society [23]. However, the concept of a sustainable society is contested [19]. Sustainability as an educational task has not been properly defined, is often considered too vague, distant or abstract, and as a result, sustainability learning outcomes often lack clarity. As no universal formula for sustainability exists, ESD has been interpreted in different ways around the world, and often according to context [14]. In some cases, prescriptive modes of ESD have prevailed—for instance, focusing on training people in how to live their lives more sustainably [14]. However, the uncertainty over which behaviours produce sustainable results has limited their effectiveness. As a result, more reflexive and transformative modes of ESD have emerged that tend to emphasize capacity-building and empowerment of learners to reach their own decisions over behavioural change [14]. The former rely mainly on instructional forms of teaching and knowledge transfer and the latter more on participation, self-determination, autonomous thinking and knowledge co-creation. As different societies have different boundaries for such processes and a corresponding view of democracy, the lack of global guidelines for ESD would not support educational systems enabling the transformational social change necessary for sustainability.

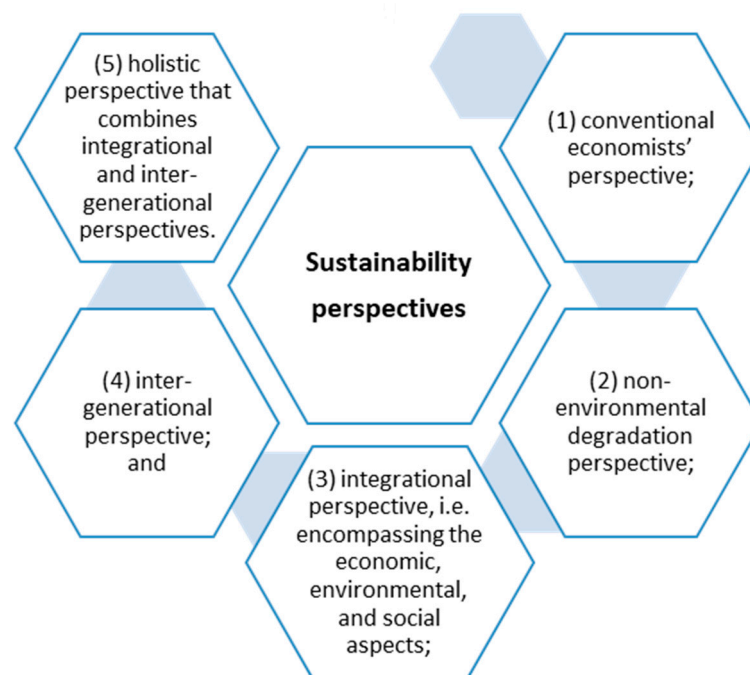
How sustainability is defined and understood, is critical to the design of appropriate educational pedagogies, their implementation, and their potential to deliver what they are designed for. We hypothesise that for assessments of effectiveness to be meaningful and comparable, we need a common conceptual understanding of what ESD aims to achieve, a reference base against which to assess educational outcomes. In this paper, we contextualise sustainability as a goal for Education, and develop a framework that connects the SDGs to educational learning outcomes. Using systems thinking and through a participatory approach, the framework allows education stakeholders and learners to work together to construct a common vision of sustainability, with sustainable development goals as end points. The process then leads to the selection of the competences required for such vision to realise, so that appropriate pedagogies and learning strategies can be developed, and progress towards delivering these competences as learning outcomes assessed.

## 2. Methodology

### *Sustainability As a Goal for Education: The Need for a Systems Approach*

In broad terms, sustainability is an attempt to reconcile growing concerns about a range of environmental issues with socio-economic objectives. The so-called three pillars of economic, social and environmental sustainability are not necessarily in alignment, and often create situations that are deemed complex and perplexing, with lack of clarity about the problems, and different interests creating tensions [25]. Sustainability, as seen from five different perspectives in published literature, is captured in Figure 1 [26]. The conventional economist perspective supports that sustainability is an end-point and can be achieved through efficient consumption [27]. In this view, sustainability is equated with economic growth and viability and the negative effects on the environment and society are not considered. The non-environmental degradation perspective is rooted in the *limits to growth* concept [28]. Economic development relies on natural resources and cannot continue indefinitely, as crossing environmental boundaries may cause ecosystem collapse. This view is eco-centric and excludes societal considerations such as poverty, unemployment, human rights and illiteracy from the aim of Sustainable Development. The integrational definition acknowledges that achieving it entails reconciliation of environmental, economic and social aspects [29] and is more complete than the previous two. However, it is mainly focused on present activities. The intergenerational definition stems from the Brundtland report [30] and considers the temporal scale of sustainability, the impact of current decisions on future generations, but nevertheless is abstract in how it bridges the three pillars of economy, environment and society. Lastly, the holistic perspective combines contextual (people,

planet, profit) with temporal considerations (short, medium and long-term) to provide a dynamic and evolving concept of sustainability [26].



**Figure 1.** Sustainability as seen from five different perspectives in published literature [26].

It is this plurality of definitions that has seen sustainability criticized as a “fuzzy” and vague concept, in terms of effectively communicating its meaning to a wide range of audiences [31]. Experts, for example, place more emphasis on the sociological role of how sustainability affects human-beings (social impact, unbalances, future uncertainty) and how problems of unsustainability can be solved (values, education and stakeholders), while students often see sustainability more as a scientific-technological subject—down to science to explain and technology to avoid and solve environmental problems [32]. Its complexity can further reduce its appeal to potential stakeholders, including educators and learners, often limiting policy-makers’ capacity to include it as the overarching goal of policies [33]. In practice, this raises the need to look at sustainability considering interactions between all its dimensions, its multiple scales and overall complexity [34], a task that most ESD initiatives have struggled or avoided to address in the past.

The SDGs introduced in 2015 as reference and universal guidepost for transitioning to Sustainable Development in the period 2015–2030, are aspirational, and according to the UN 2030 Agenda, are intended to be used as a set of interconnected goals and global targets. They provide a useful normative framework to understand sustainability, encompassing the vision of a Sustainable Society which is inclusive and takes into account social, environmental and economic capital and has the potential to attract public attention and influence public sentiment [33]. In this context, our societies and economies need to transform from the current unsustainable state onto a sustainable and resilient path, through an integrative approach that addresses all 17 SDGs, building on their synergies and benefits while alleviating their trade-offs [8]. This is what is often referred to as a systems perspective, with sustainability seen as a dynamic state that our society is constantly trying to define and reach. This, in turn, means that all 17 SDGs are important for achieving a sustainable society and they should not be seen in isolation. An isolated or reductionist view of the SDGs in policy formulation and application may result in excluding important positive feedback between targets that may enhance efforts and produce multiple benefits or disregarding negative feedback which will undermine efforts and cause policy resistance [8].

Systems thinking is widely recognised as an effective way to reframe the SDGs in order to highlight their integration and reflect on important directions towards building sustainable societies, compensating at the same time, for their shortcomings and limitations [35,36]. It offers the potential of a richer view on the relationship between Education and Sustainability, with ESD playing an active role in delivering the transformative changes required for society to move towards a sustainability state. Such transformation is an ambitious endeavour.

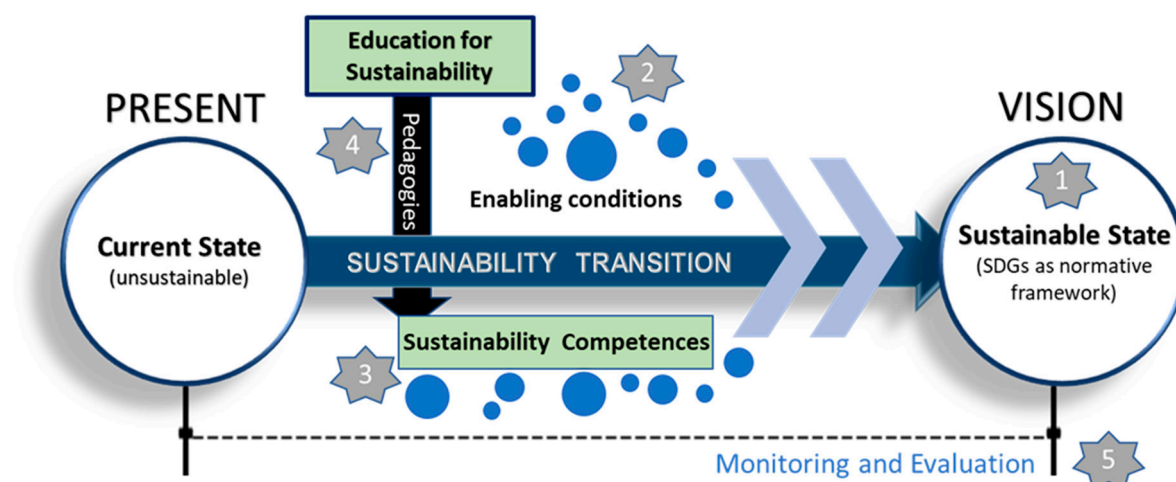
Systems thinking in this paper is used as an approach to look at the big picture of the role of education in enabling such transformation. It builds on the importance of aspirations in relation to human development and capability theory by facilitating understanding regarding, first, the way that aspirations (sustainability) are defined, secondly, the way they are connected to capabilities (competences) and thirdly, pedagogies, the processes by which capabilities become functioning. Contrary to overly simplistic political models that seek to deliver pre-defined version of sustainability, such an approach builds on its value as a metaphor or heuristic for a social ideal and allows ESD to embrace complexity and resist over-simplification.

We acknowledge that seeing sustainable development as an end state, visions of an ideal, sustainable future as influenced by history and culture could turn educational programmes into indoctrination for that kind of future, but here we assume that sustainable society as a system state can only emerge as the result of complex interactions between system parameters and conditions with education guiding the transformational process for society reaching such a dynamic state [37]. Building on the wide range of democratic pedagogies that have been discussed in the environmental education literature for over twenty years [38,39], the participatory and empowering nature of a systems approach, allows “educational aspirations” to be established by localized visions of the SDGs, and again not looking at them as a ‘product’ (i.e., fixed vision of sustainability) but as a way of thinking about the enabling factors and conditions necessary for sustainability to emerge. This approach is consistent with the holistic, ecological worldview that looks more to process than product, recognises the systemic view of change [40], and therefore allows for a more sustainable transformational process.

### 3. A Participatory Conceptual Framework for Sustainability Transformation through Education

Contextualizing the sustainability challenge through gap analysis from a systems perspective (Figure 2), the proposed framework aims to facilitate the process of sustainability transformation through education, and treats ESD as the means for bridging the gap between the current unsustainable state and a desired sustainable one. The process can accelerate the collaboration of all those involved in education and sustainability, allow educational institutions to develop a clear vision of what sustainability means to them and work towards transforming individuals, groups, organisations, communities and systems by developing the competencies needed to transition to a sustainable future [41,42]. The conceptual framework is based on the following systems thinking techniques: 1. Visioning, to generate a participatory vision of the sustainable state, 2. Back-casting, to identify the enabling conditions for the sustainable state, the kinds of competences the citizens need to develop to realise that state and the pedagogies that should be in place to aid the development of competences and 3. Monitor and evaluation indicators that will give information about the system state and the progress towards the sustainable state. In the following sections each part of the conceptual framework is explained in more detail.





**Figure 2.** Educational framework for sustainability transformation and main steps: (1) A participatory vision of sustainability, (2) enabling conditions for sustainability, (3) competences for sustainability transformation, (4) pedagogies and learning strategies for Education for Sustainable Development (ESD), and (5) monitoring and evaluation of ESD competences and distance from sustainable state. Adapted from [1].

### 3.1. A Participatory Vision of Sustainability

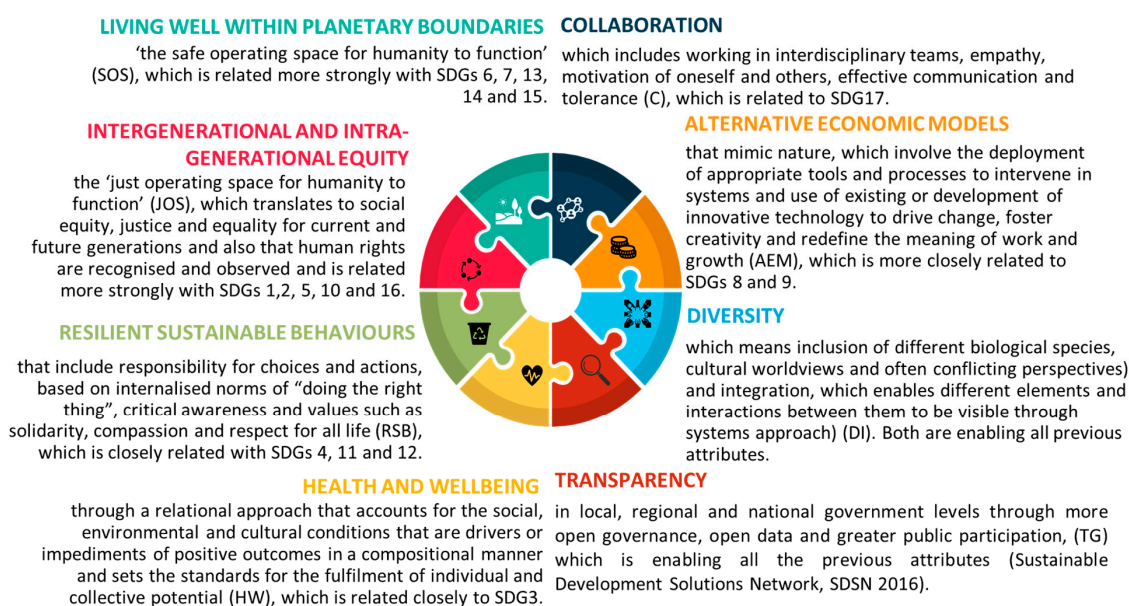
Sustainability does not translate to a fixed predefined version of a sustainable state, but a future that society will aspire to reach, a vision of a world transformed by the SDGs [43]. The implementation of the UN 2030 Global Agenda should be localised to address the needs and requirements of local communities [44]. Indeed, the localisation of the 2030 agenda, involving the engagement of local leaders, regional governing bodies and citizens in a process of participatory co-creation of community spaces, values, relationships and priorities, is considered increasingly central to the implementation of the SDGs [45]. This is an important process, as to achieve the systemic transformation towards sustainable development by 2030 and beyond requires collective action, coordination of multiple stakeholders and long-term planning of activities in the local level.

The need for the educational community to define collectively a sustainability vision of the future, “translating” what achieving the SDGs will mean, should be a participatory process with strong collaboration with local civil society, engaging learners, educators and stakeholders. Participation in the education sector has been found to increase synergies, establish positive learning environments and promote a culture of collaboration [46]. ESD can benefit from wider participation of stakeholders in a dialogue about the vision, mission and educational objectives of the institution, which can be an important driver for sustainability transformation [47]. Stakeholders that can be included in the visioning process could be internal to education such as students, professors, management, administration and service personnel; or external actors, such as local authorities, communities, indigenous populations, suppliers, businesses and citizen associations/movements [48]. Students, in particular, when they become engaged in shaping educational outcomes have been found to develop civic responsibility as a societal norm [49].

### 3.2. Enabling Conditions for Sustainability Transformation

“Generating a desirable future, and then looking backwards from that future to the present in order to strategize and to plan how it could be achieved”, often termed as back casting, is considered best practice in long-term planning for sustainability transitions [50]. Back casting, which is the methodology that binds all the steps of our framework, begins with a projection of the desired outcome(s), and works backwards to understand what is needed for their realisation. In an educational environment, this process could be used to relate educational outcomes to the enabling conditions

for the localised vision of sustainability to emerge. Example of enabling conditions for a vision of sustainability related to the SDGs is shown in Figure 3. This has been constructed by grouping the SDGs into major systemic attributes and enabling conditions. Those related to achieving *the safe operating space* refer to maintaining ecological integrity and not transgressing crucial planetary boundaries conditions [51]. Those related to achieving *the just operating space* [52] include the social foundation of justice, equity and equality for all, now and in the future (intergenerational dimension), under conditions empowering them to lead fulfilling lives. Finally, transparency, responsible governance, health and wellbeing, diversity, resilient sustainable behaviours, and partnerships between many actors of civic society that can lead to innovation, are also needed. A localised vision of the SDGs would also require an economy that is not short-sighted, if to ensure that humanity operates within the safe and just space and thus to promote natural and human wellbeing.



**Figure 3.** Examples of enabling conditions for a vision of sustainability related to the Sustainable Development Goals (SDGs).

Recent research [6] shows that four planetary boundaries have been crossed: climate change, loss of biosphere integrity, land-system change and altered biogeochemical cycles (phosphorus and nitrogen). Considering the uncertainty in earth system interactions, critical thresholds and tipping points, this increases the risk of compromising the ecological integrity of the earth which is the foundation of society and all economic activity [53]. Seen from the perspective of the hierarchy of needs, it offers a framework to explore drivers of behavioural motivation for people to enact the sustainability conditions [54]. If the Earth system reaches an inhospitable state for all life, this will adversely affect human wellbeing as the satisfaction of physiological needs such as food, water, sanitation, health, housing and energy will not be possible. Safety and security needs, such as employment, security of incomes and livelihoods of citizens, peace and non-violence, law and order, protection from the extreme effect of disasters and epidemics which are second tier needs will also be jeopardised [55]. This poses a serious threat in achieving a just society for current and future generations. Collaboration speaks to the feeling of belongingness, the third level in the hierarchy of needs that refers to developing meaningful relationships among people, institutions and nations to combat complex socio-ecological issues [55]. Status needs such as esteem, respect, confidence and achievement can only be enabled if there are adequate conditions that favour effective governance, transparency, diversity and an economic model that does not generate and sustain inequalities but allows the people and the planet to thrive [52]. The last level in the hierarchy of needs, self-actualisation, relates to transcendence, achieving the highest level of self-fulfilment which is based on fulfilling one’s potential. This level has

been shown to relate with advanced environmental sustainability which can be enabled when all other conditions including democratic participation, social equity, and transparent governance, technical and economic foundations have been satisfied [56]. Self-actualisation motivates resilient sustainable behaviours driven from an ethical point of acting with a civic sense to prioritise the common good and having the ability of moral judgement, value clarification and critical reflection on personal and collective values [57].

The interpretation of the SDGs to sustainability attributes can be used to distil values that are related to ecological system integrity, social justice, equity and equality, human rights and responsibility, empathy and solidarity, health and wellbeing [58]. Because “Sustainability is itself the emergent property of a conversation about what kind of world we collectively want to live in now and in the future” [59] its ethical framework requires a critical examination. The SDGs touch on the relationship between nature and humans and mainly propose an anthropocentric view of nature as instrument from which humanity derives resources and various services, however a moderate bio-centric view that recognises the inherent value of nature and prioritises the human-nature experience that contributes to quality of life and wellbeing, connection and empathy towards other beings and the context of development of cultural identity could also be appropriate [58]. This view would be beneficial for the change of paradigm required to address existential threats such as climate change, since ecological integrity can be severely compromised. This is directly related with satisfying human physiological and psychological needs. The change argued for is not one of simply changing behaviour; it is a change of process that is embedded in values [7]. The process relates the ultimate means, the base on which all life, the society and economy rely upon to satisfy the ultimate ends, the higher achievement possible for humanity which is self-actualisation [60]. However, there is a hidden danger, motivating sustainable behaviours on the basis on hope and fear relies on the view that humans can control a future fraught with uncertainty to avoid disastrous consequences [61]. This psychological vulnerability, especially in students, can be used as a governance tool to manipulate them towards specific actions and raises questions of power. The sustainability discourse is one with no right nor wrong answers, and requires people empowered to make critical decisions regarding individual and collective actions. Pragmatism advocates for value pluralism, as novel ethical situations and problem contexts can always emerge. These will require openness to perceive the conflicting value systems at play and humanistic inquiry to examine their nature and decide through democratic processes what action to take in the specific context [62].

### 3.3. Competences for Achieving Transformation

Having constructed a shared vision of what sustainability will look like, and established enabling conditions to realise it, the next task is to define the knowledge, skills, behaviours, and attitudes, collectively the competences that learners need to develop to realise such a state. This task is important, as the selection of sustainability competences will transform the curricula, pedagogies, educator training programmes and learning environments at the level of the education system [63]. The process should be taking into account all stakeholder views and contributions [64]. Such an approach can allow for more tailored strategies, relevant to the place, time and context of education and therefore result in a widely accepted selection of competences, increasing a feeling of ownership for stakeholders and learners [65]. The task is to define the knowledge, skills, values and attitudes that will empower learners to realise the sustainable state. A pre-set list of common, standard sustainability competencies can also be customized to that localised sustainability vision. A few authors have attempted to compile lists of sustainability competences [4,66–70], and examples of the ones prevailing in the current literature are summarised in Table 1.

Sustainability competences should not only include cognitive components, such as knowledge and understanding of environmental, social, economic and political systems and higher order thinking abilities such as reasoning and synthesising, but also social skills, values and emotions, collectively referred to as the affective domain of learning. Some examples of the former are open-mindedness,



intercultural understanding and empathy; and meta-cognitive abilities related to monitoring thinking and action processes that have been found to also influence behaviour [71,72]. Targeting the alignment between ‘what I learn’, ‘what I think’ and ‘what I do’ can enable a widespread change in mind-set and culture in educational organisations [73].

Sustainability competences should be complemented by strong disciplinary skills (e.g., in natural, social sciences, engineering and business). Working in inter-disciplinary or trans-disciplinary teams for sustainability problem-solving requires different views on the same challenges to be expressed and benefits from the integration of multiple perspectives to allow for innovative conceptualisations and creative approaches to emerge [71]. Furthermore, these competences should be underpinned by an ethical framework. Norms and values related to sustainability will make these competences have more coherent meaning for building a society where the SDGs are the norm. It has been argued that these competences could result in building unsustainable societies without the support of an ethical compass [74].

**Table 1.** Examples of competences for sustainability, based on a synthesis of viewpoints resulting from reviewing key publications in the literature.

<ul style="list-style-type: none"> <li>• <i>Systems thinking</i> is widely accepted as a competence for the learner to be able to understand complex systems, their elements and interactions between natural ecosystems forming our planet and socio-economic subsystems. Furthermore, it has to do with including multiple stakeholder perspectives and worldviews to produce a holistic conceptualisation of reality as an essential part of interdisciplinary collaboration [67,75].</li> <li>• <i>Future oriented thinking</i> (future thinking, anticipatory, foresighted thinking) is frequently included as a competence and relates to sustainability in the sense of taking into account future implications of current actions or considering future stakeholders’ wellbeing when planning and taking decisions [66,70,75].</li> <li>• <i>Collaboration</i> is included as a key competence in several studies [4,68], but in some cases captured in the form of effective communication, interpersonal skills for working with other people and inter-personal competences [69,70].</li> <li>• <i>Strategic thinking</i> also referred to as wise transformative social change and action competence [4,69,70] captures the ability to set goals and plan, implement and evaluate projects.</li> <li>• <i>Normative competence</i> refers to the ability to deal with norms, values and beliefs both of the individual and of society, regarding present and future generations and human and non-human actors [4,67,75,76].</li> <li>• <i>Modelling sustainable behaviour</i> hypothesises the presence of high-level norms that dictate action when dealing with trade-offs [69]. It is a <i>discursive competence</i>, having to do both with receiving and communicating value judgments in neutral manners and shows a relationship with normative competence.</li> </ul>	<ul style="list-style-type: none"> <li>• <i>Critical thinking</i> is explicitly mentioned in several studies and has to do with questioning personal and collective thinking and norms and the application of criteria to reach decisions which is reflected in wise decision making [4,69,75]. It has also been reported as competence in distanced reflection on individual and cultural models [77].</li> <li>• <i>Self-awareness</i> has to do with understanding of personal motivations, feelings and beliefs, and empathy towards others. It allows one to see the world by experiencing a deep emotional connection with reality and other people.</li> <li>• <i>Emotional intelligence</i> is included in elements such as taking into account other perspectives, multicultural understanding, responsibility, empathy, solidarity, self-awareness; if not explicitly mentioned [70].</li> <li>• The <i>ability to use media</i> has been reported as a competence [67] but does not feature in most frameworks. However, it could be seen as important, considering that in a globalised and interconnected world messages can be transferred very fast, reaching all communities around the world and enabling them to communicate, collaborate, participate and act together.</li> <li>• <i>Integrated problem-solving</i>, dealing with complex and ill-defined problems and drawing on all other competences to achieve optimal results [42] is increasingly recognised as an important competence [4,75].</li> <li>• <i>State of the planet knowledge</i> entails deep scientific understanding of natural phenomena and concepts and it is also worth mentioning as a sustainability competence [69].</li> </ul>
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Virtue, a quality that goes hand in hand with competence and shows a disposition to ‘do the right thing in the right situation’ should be cultivated in learners. Watching other people exhibiting the virtuous behaviour (role models), imitating their behaviour and reflecting on one’s behaviour have been shown to influence the development of virtue [74]. The discussion on values is by no means intended as indoctrination, whereby a set of “appropriate values” should be imposed on educational communities [77]. On the contrary, there is need for stakeholders to appreciate the diversity of value systems present in any discussion regarding implementing action or problem-solving for the SDGs and establish shared value systems, which will be negotiated and revised [74]. This ethical compass would need to address the complex and ever-changing discourse on the interface of socio-economic and ecological issues, requiring deep knowledge of the standards, ability to judge which standards are to be followed in wicked situations, reflection on the plurality of value systems and courage to materialise actions based on the decided standards [57]. The focus on learners’ values and moral competence is not meant to misdirect the discussion away from collective responsibility. Instead, it aims to highlight that individual actions can have significance; the choices students make, can have a direct link to the development of society [61]. This ultimately could prepare students becoming citizens of a democratic society. When personal norms, values and interests are open to discussion and criticism by a community of people; then they undergo a “peer-review” process that leads to their validation or abolishment. This can also lead to development of ethical inquiry as a competence in students [62].

### 3.4. Pedagogies for ESD

With sustainability competences defined as educational outcomes locally, appropriate pedagogies can now be designed. Pedagogies that engage head (cognitive domain), hands (psychomotor domain) and hearts (affective domain) are considered as the most relevant to enable learners develop sustainability competences [78] and act as important drivers for change. For example, pedagogies appropriate for developing sustainability competences, such as integrated problem-solving, systems thinking, normative, strategic and interpersonal competences, include project and problem-based learning, active learning, community service learning, critical emancipatory pedagogy, place-based environmental education, ecojustice and community learning and traditional ecological knowledge [79]. Examples of teaching techniques that can complement these pedagogies include, but are not limited to, case studies, mind and concept maps, life cycle and supply chain analysis, participatory action research and also the formation of interdisciplinary and jigsaw/interlinked teams [32,78–80]. Several emerging pedagogies review the educator—learner relationship and treat them, both, as partners in change or change—agents [81]. Moreover, they enable learners to experience authentic learning environments by working in inter and transdisciplinary teams to help communities overcome sustainability challenges with mutual benefits [82].

In this contextual framework, the role of the educator therefore becomes that of a facilitator oriented toward open-ended, collective problem solving, inspired by the visions of sustainability from the framework’s earlier stages. This not only contributes towards competences as learning outcomes, but also fosters creative and reflective interactions among the learners that may enable transformative learning and constitutes an important driver for change. The need for meaningful educator training programmes that will enable schoolteachers and university lecturers develop the knowledge, skills and confidence to embed these teaching techniques is of primary importance as underlined by the GAP on ESD [13]. Educators themselves need to develop and implement the processes that will allow their students to become empowered with sustainability competences [42].

### 3.5. Monitoring and Evaluation

While developing appropriate pedagogies and putting educational practices in place is imperative to the transformation process, there is a clear need for monitoring progress and evaluating effectiveness. Two major reviews of ESD practice [83,84] have revealed that the assessment of ESD outcomes is

the component of sustainability implementation that is lagging behind and so there is no valid justification as to whether the efforts put the last 20 years have been producing the desired change. The assessment of sustainability competence development will allow for reviewing, confirming or revising the implementation of the framework, ultimately building the evidence base for the impact of ESD in reducing the gap towards the desired sustainable state.

For example, the strength of sustainability competences developed in learners of universities has been shown positively correlated with contributions to sustainability [41]. Such curricula integrate the three dimensions of sustainability (environmental, social and economic), cross-cutting themes (e.g., governance, limits to growth, responsibility, holistic view, people as part of nature) and the appropriate pedagogies (e.g., Case studies: Presenting students with open-ended questions regarding complex real-world cases; community and social justice: students engage in activities that benefit the community and learn at the same time or address social justice issues; and environmental education related: linking scientific understanding of the ecology of a place with emotional motivation to care for the environment.). More specifically, the correlation was very strong for competences such as systems thinking; inter-disciplinary work; anticipatory thinking; justice, responsibility, and ethics; critical thinking and analysis; interpersonal relations and collaboration; empathy and change of perspective; communication and use of media; strategic action; personal involvement; assessment and evaluation; and tolerance for ambiguity and uncertainty. Thus, criteria and standards associated with sustainability competences' evaluation, collection of reliable data and use of standardised methods to compare values across scales and benchmarks are needed to assess them [85], and can now be easier developed, informed by the framework's previous steps.

Monitoring will allow stakeholders to become actively involved in the process of transition, identify possible gaps in action plans, issues with the pedagogies used, the competences targeted or even their vision of sustainability. These offer opportunities for improvement, encourage accountability and allow for meaningful changes in a process that needs to be adaptive and dynamic [86]. Evaluation can elucidate the development of competences related to sustainability in learners, redefine the relationship between learners and educators and provide evidence of transformational change [87]. Benchmarking, for example, can break through resistance to change by demonstrating the success of practices, increase accountability, as well as enhance institutional reputation [86]. The framework proposed allows for the development of evaluation tools that can support educational institutions to monitor and manage their progress towards sustainable development.

For this, the use of indicators across four categories (integral sustainability, the socio-cultural, the environmental and the economic dimensions) each with its own key items for assessing SDG integration in the curriculum has been suggested [88]. The biggest gaps in the university curricula were found to be in relation to the ethical foundation of sustainability; associated with human rights, dignity and gender issues as well as poverty reduction and climate change mitigation. The use of rubrics for assessing sustainability competences, developed during problem-oriented programmes, has also been suggested [89]. Appropriate models and tools for their measurement have been also developed by operationalising the cognitive, affective and behavioural dimensions of ESD in secondary education in Germany [90]. A similar study proposed a heuristic model for measuring systems thinking competence and pedagogical capacity in student teachers participating in case studies of non-sustainable patterns of global change [91]. The development of ESD indicators regarding the implementation of the GAP has been proposed by others [92]. Measuring the ESD relevance of teacher training programmes in Germany, results demonstrated that student competences can be measured in a reliable way. However, more indicators need to be developed and tested, the effect of socio-demographic factors on the development of competences clarified and data from other levels of education and geographies obtained to have a complete picture.

#### 4. Discussion

Addressing the need to contextualize the role of ESD, the framework developed allows both educators and learners to see the bigger picture and understand the role of education in sustainable development. Its steps should be considered conceptual, as greater specificity will be highly dependent on context, institutional capacity, problem, timeframe and resources available to the educational redesign process. However, strategy and principles should be transferrable despite the contextual variance inherent in large scale systems. It is important to note that experimentation and innovation are important components of every social transition and so involved stakeholders should be encouraged to try new approaches, structures and actions to realise their vision [93]. Reflexive praxis is crucial for providing insights into possible pathways for action, desirable solutions in terms of pedagogies, educational environments and learning methodologies and also combating challenges and barriers that emerge on the way [94]. Lastly, adaptation, flexibility and openness to change are desirable in any organisational change plan to cope with uncertainty of outcomes. The team of change-agents should recognise their ignorance about how the future will unfold, but at the same time establish methods for data collection and analysis available to all and establish check-points through the process of transition to reflect on actions/strategies and modify them [2].

To address issues of power and individual versus collective responsibility, we envisage the implementation of the framework through a mixed approach: bottom-up and top-down. This will allow, on the one hand, the building of communities within formal education organisations, such as Universities or schools, to act as niche-points of innovation and change-makers that will initiate, implement, institutionalise and share effective practices [95]. On the other hand, implementation of this framework at the level of the educational system will favour the alignment of those niche initiatives by enabling transformational change in the current educational policy landscape moving from the macro to the micro level [96]. The implementation process can be facilitated by establishing a group of sustainability change-agents/champions within the educational institution (with members from all crucial stakeholder groups identified earlier), who will bear the responsibility of bringing all the stakeholders together to decide on common visions, competences and teaching- learning strategies. Further, they will develop a platform for frequent communication of the plan development, tackle challenges, monitor and evaluate progress in a transparent and inclusive way [84,97].

The application of the framework will provide benefits as part of a whole-institution approach (that targets education, research, operations, administration, community relationships) in formal education settings (e.g., Higher Education institutions, primary and secondary schools, educator training organisations), where the learning and training environments are aligned to the sustainability vision, and where institutional changes are taking place to facilitate the sustainability transformation. Educational organisations often suffer from inertia, as established beliefs of how they should function, how teaching and learning should be practised, and what kind of relationships with the wider community they should seek to develop; can be very powerful and persistent [98]. Several barriers to the sustainability transformation of educational institutions have been identified [50,99,100]. These are often associated with the internal structure of the institution, administrative, educational, research, and operations-related; including the type of Institution, private or public; and its culture. The latter refers to issues with interdisciplinarity, bureaucracy, competition, lack of collaboration and incentives to cooperate, overcrowded curriculum, and academic silos. In addition, external factors, such as governance issues, inappropriate regulations, and lack or delays in enforcement, topped by lack of pressure from society and low priority given to the task may prevent institutional integration of sustainability. For example, agreements or programmes not implemented properly, the absence of sustainability criteria in quality assurance certification programmes and ranking systems, and overall lack of sustainability aims have also been identified as impediments [48]. Lack of training and information, negative perceptions about sustainability, lack of leadership, perceived high cost, lack of interest, and resistance because of work overload among others have been shown to hamper progress with both the academic community and external stakeholders, with lack of resources (allocated

budget and dedicated personnel) making things even worse. Proactive educational organisations can transform these barriers to opportunities for redesigning curricula and pedagogies geared to achieving the SDGs [88]. For example, problem-based and active teaching and learning practices; teachers as facilitators of knowledge; interdisciplinary collaboration; flexible management; certification for sustainability; professors and students acting as change agents; alignment with internal and external community needs; engagement in dialogue; transparency of governance; policies on how to integrate sustainability in mission, vision and action plans were amongst the opportunities identified [48]. In that direction, the framework developed here makes it easier for these opportunities to be identified, and for whole institution approaches to be developed and aligned to sustainable development. Its application can facilitate both the recognition of the importance of the SDGs and of the appropriate design of the curriculum as the means to achieve them [88]. The framework therefore allows education to play a clear and critical role in capacity-building for sustainability, the process of empowering learners (society) to develop the competences needed for sustainability to emerge [42].

## 5. Conclusions

In this work, our aim was to redefine the role of ESD in the era of the SDGs from a systems perspective. Therefore, education's transformative potential to facilitate the transition to sustainability was recognised. We developed a participatory framework that allows education practitioners and stakeholders together with communities of learners to decide on common visions for sustainability. Although the SDGs are a global framework, localising them in terms of educational outcomes helps the realisation of both community vision and of global priorities. Constructing a common vision of sustainability guided by the SDGs, can help educators and learners identify constraints and enabling conditions, work together to select the competences needed, develop appropriate curricula and pedagogies, pursue the many facets of a whole-institution approach and evaluate progress towards sustainability as a well-defined goal. The proposed framework offers the opportunity of rethinking education as a systemic tool for transformative social change. Nelson Mandela stated in 2003, that "education is the most powerful weapon we can use to change the world" [101], and today the need for the world to change is more urgent and greater than ever. The road to sustainability is paved by education, and unless we invest on it, we might never get there.

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## References

1. Voulvoulis, N.; Burgman, M.A. The contrasting roles of science and technology in environmental challenges. *Crit. Rev. Environ. Sci. Technol.* **2019**, *49*, 1079–10106. [[CrossRef](#)]
2. Dovers, S.R.; Handmer, J.W. Sustainability and change. *Glob. Environ. Chang.* **1992**, *2*, 262–276. [[CrossRef](#)]
3. De Pauw, J.B.; Gericke, N.; Olsson, D.; Berglund, T. The effectiveness of education for sustainable development. *Sustainability* **2015**, *7*, 15693–15717. [[CrossRef](#)]
4. Steffen, W.; Richardson, K.; Rockström, J.; Cornell, S.E.; Fetzer, I.; Bennett, E.M.; Biggs, R.; Carpenter, S.R.; De Vries, W.; De Wit, C.A.; et al. Planetary boundaries: Guiding human development on a changing planet. *Science* **2015**, *347*, 1259855. [[CrossRef](#)] [[PubMed](#)]
5. UNESCO. *Education for Sustainable Development Goals. The Global Education 2030 Agenda*; UNESCO: Paris, France, 2017.
6. Scoones, I.; Stirling, A.; Abrol, D.; Atela, J.; Charli-Joseph, L.; Eakin, H.; Ely, A.; Olsson, P.; Pereira, L.; Priya, R.; et al. *Transformations to Sustainability*; Steps Working Paper 104; Steps Centre: Sussex, UK, 2018; pp. 618–622.



7. UNFCCC. *Adoption of the Paris Agreement*; UN: New York, NY, USA, 2015.
8. IIASA. *Transformations to Achieve the Sustainable Development Goals*; IIASA: Laxenburg, Austria, 2018; pp. 1–157.
9. Trevors, J.T.; Saier, M.H. Education for humanity. *Water Air Soil Pollut.* **2010**, *206*, 1–2. [CrossRef]
10. Cortese, A.D. The critical role of higher education in creating a sustainable future need for a new human perspective envisioning a sustainable future. *Plan. High. Educ.* **2003**, *31*, 15–22.
11. Rauch, F.; Steiner, R. Competences for education for sustainable development in teacher education. *Cent. Educ. Policy Stud. J.* **2013**, *3*, 9–24.
12. Wals, A.E.J. *Beyond unreasonable doubt—Education and Learning for Socio-Ecological Sustainability in the Anthropocene. Inaugural Address Held Upon Accepting the Personal Chair of Transformative Learning for Socio-Ecological Sustainability*; Wageningen University: Wageningen, The Netherlands, 2015.
13. UNESCO. *Roadmap for Implementing the Global Action Programme on Education for Sustainable Development*; UNESCO: Paris, France, 2014.
14. UNESCO. *Shaping the Education of Tomorrow*; 2012 Report on the UN Decade of Education for Sustainable Development, Abridged; UNESCO: Paris, France, 2012; p. 89.
15. Mckeown, R. ESD Toolkit Version 2. 2002, pp. 1–142. Available online: [http://www.esdtoolkit.org/esd\\_toolkit\\_v2.pdf](http://www.esdtoolkit.org/esd_toolkit_v2.pdf) (accessed on 29 October 2019).
16. Scott, W. Education for sustainable development (ESD): A critical review of concept, potential and risk. In *Schooling for Sustainable Development in Europe: Concepts, Policies and Educational Experiences at the End of the UN Decade of Education for Sustainable Development*; Springer International Publishing: Cham, Switzerland, 2015.
17. Thomas, I. Sustainability in tertiary curricula: What is stopping it happening? *Int. J. Sustain. High. Educ.* **2004**, *5*, 33–47. [CrossRef]
18. Lourdel, N.; Martin, J.; Béreard, O. Overcoming obstacles to understanding sustainable development—An approach based on personal experiences. In *Proceedings of the EESD06—Engineering Education in Sustainable Development*, Lyon, France, 4–6 October 2006.
19. Seatter, C.S.; Ceulemans, K. Teaching sustainability in higher education: Pedagogical styles that make a difference. *Can. J. High. Educ.* **2017**, *47*, 47–70.
20. Carew, A.L.; Mitchell, C.A. Teaching sustainability as a contested concept: Capitalizing on variation in engineering educators' conceptions of environmental, social and economic sustainability. *J. Clean. Prod.* **2008**, *16*, 105–115. [CrossRef]
21. Blumstein, D.T.; Saylan, C. The failure of environmental education (and how we can fix it). *PLoS Biol.* **2011**, *5*, e120. [CrossRef] [PubMed]
22. UNESCO. *Global Monitoring Report 2013/4: Teaching and Learning: Achieving Quality for All*; UNESCO: Paris, France, 2014.
23. Laurie, R.; Nonoyama-Tarumi, Y.; Mckeown, R.; Hopkins, C. Contributions of education for sustainable development (ESD) to quality education: A synthesis of research. *J. Educ. Sustain. Dev.* **2016**, *10*, 226–242. [CrossRef]
24. Mochizuki, Y. Rethinking schooling for the 21st century: UNESCO-MGIEP's contribution to SDG 4.7. *Sustain. J. Rec.* **2019**, *12*, 88–92. [CrossRef]
25. Niles, D.; Tachimoto, N. Science and the experience of nature. *Nat. Sustain.* **2018**, *1*, 540–543. [CrossRef]
26. Lozano, R. Envisioning sustainability three-dimensionally. *J. Clean Prod.* **2008**, *16*, 1838–1846. [CrossRef]
27. Stavins, R.N.; Wagner, A.F.; Wagner, G. Interpreting sustainability in economic terms: Dynamic efficiency plus intergenerational equity. *Econ. Lett.* **2003**, *79*, 339–343. [CrossRef]
28. Meadows, D.H.; Goldsmith, E.I.; Meadows, D. The limits to growth: A report to The Club of Rome. *N. Y.* **1972**, *102*, 27.
29. Elkington, J. Enter the triple bottom line. In *The Triple Bottom Line: Does it All Add Up?* Earthscan: London, UK, 2013; pp. 23–38.
30. WCED. Our Common Future (The Brundtland Report). *Med. War* **1987**, *4*, 17–25.
31. Eernstman, N.; Wals, A.E.J. Locative meaning-making: An arts-based approach to learning for sustainable development. *Sustainability* **2013**, *5*, 1645–1660. [CrossRef]

32. Segalàs, J.; Mulder, K.F.; Ferrer-Balas, D. What do EESD “experts” think sustainability is? Which pedagogy is suitable to learn it? Results from interviews and Cmaps analysis gathered at EESD 2008. *Int. J. Sustain. High. Educ.* **2012**, *13*, 293–304. [CrossRef]
33. Hák, T.; Janoušková, S.; Moldan, B.; Dahl, A.L. Closing the sustainability gap: 30 years after “Our Common Future” society lacks meaningful stories and relevant indicators to make the right decisions and build public support. *Ecol. Indic.* **2018**, *87*, 193–195. [CrossRef]
34. Zachary, D.S. On the sustainability of an activity. *Sci. Rep.* **2014**, *4*, 5215. [CrossRef] [PubMed]
35. Lim, M.M.L.; Søgaard Jørgensen, P.; Wyborn, C.A. Reframing the sustainable development goals to achieve sustainable development in the anthropocene—A systems approach. *Ecol. Soc.* **2018**, *23*. [CrossRef]
36. Zhang, Q.; Prouty, C.; Zimmerman, J.B.; Mihelcic, J.R. More than Target 6.3: A Systems Approach to Rethinking Sustainable Development Goals in a Resource-Scarce World. *Engineering* **2016**, *2*, 481–489. [CrossRef]
37. Palmberg, I.; Hofman-Bergholm, M.; Jeronen, E.; Yli-Panula, E. Systems thinking for understanding sustainability? Nordic student teachers’ views on the relationship between species identification, biodiversity and sustainable development. *Educ. Sci.* **2017**, *7*, 72. [CrossRef]
38. Huckle, J. Education for sustainability: Assessing pathways to the future. *Aust. J. Environ. Educ.* **1991**, *7*, 49–69. [CrossRef]
39. Fien, J. *Environmental Education: A pathway to Sustainability*; Deakin University Press: Geelong, Australia, 1993.
40. Fien, J.; Tilbury, D. The global challenge of sustainability. In *Education and Sustainability: Responding to the Global Challenge*; Tilbury, D., Stevenson, R., Fine, J., Schreuder, D., Eds.; IUCN: Gland, Switzerland, 2002.
41. Lozano, R.; Barreiro-Gen, M.; Lozano, F.J.; Sammalisto, K. Teaching sustainability in European higher education institutions: Assessing the connections between competences and pedagogical approaches. *Sustainability* **2019**, *11*, 1602. [CrossRef]
42. UNESCO. Issues and Trends in Education for Sustainable Development. Available online: <https://unesdoc.unesco.org/ark:/48223/pf0000261445> (accessed on 29 October 2019).
43. Glasser, H. Toward robust foundations for sustainable well-being societies: Learning to change by changing how we learn. In *Sustainability, Human Well-Being, and the Future of Education*; Springer: Berlin, Germany, 2018.
44. UCLG. Towards the Localization of the SDGs. Available online: [https://www.uclg.org/sites/default/files/towards\\_the\\_localization\\_of\\_the\\_sdgs.pdf](https://www.uclg.org/sites/default/files/towards_the_localization_of_the_sdgs.pdf) (accessed on 29 October 2019).
45. Boix-Mansilla, V.; Jackson, A. Educating for Global Competence: Preparing Our Youth to Engage the World. Council of Chief State School Officers’ EdSteps Initiative & Asia Society Partnership for Global Learning. 2013. Available online: <https://asiasociety.org/files/book-globalcompetence.pdf> (accessed on 29 October 2019).
46. Lidstone, L.; Wright, T.; Sherren, K. An analysis of Canadian STARS-rated higher education sustainability policies. *Environ. Dev. Sustain.* **2015**, *17*, 259–278. [CrossRef]
47. Bullock, C.; Hitzhusen, G. Participatory development of key sustainability concepts for dialogue and curricula at The Ohio State University. *Sustainability* **2015**, *7*, 14063–14091. [CrossRef]
48. Blanco-Portela, N.; Benayas, J.; Perterra, L.R.; Lozano, R. Towards the integration of sustainability in Higher Education Institutions: A review of drivers of and barriers to organisational change and their comparison against those found of companies. *J. Clean. Prod.* **2017**, *166*, 563–578. [CrossRef]
49. Frisk, E.; Larson, K. Educating for sustainability: Competencies & practices for transformative action. *J. Sustain. Educ.* **2011**, *2*, 1–20.
50. Holmberg, J.; Larsson, J. A sustainability lighthouse-supporting transition leadership and conversations on desirable futures. *Sustainability* **2018**, *10*, 3842. [CrossRef]
51. Rockström, J.; Steffen, W.; Noone, K.; Persson, Å.; Chapin, F.S.; Lambin, E.F.; Lenton, T.M.; Scheffer, M.; Folke, C.; Schellnhuber, H.J.; et al. A safe operating space for humanity. *Nature* **2009**, *461*, 472. [CrossRef] [PubMed]
52. Raworth, K. A safe and just space for humanity—Can we live inside the doughnut? Why the world needs planetary and social boundaries. *Oxfam Policy Pract. Clim. Chang. Resil.* **2012**, *8*, 1–26. Available online: <http://blogs.oxfam.org/en/blog/12-02-13-can-we-live-inside-doughnut-why-world-needs-planetary-and-social-boundaries> (accessed on 29 October 2019).

53. Dearing, J.A.; Wang, R.; Zhang, K.; Dyke, J.G.; Haberl, H.; Hossain, M.S.; Langdon, P.G.; Lenton, T.M.; Raworth, K.; Brown, S.; et al. Safe and just operating spaces for regional social-ecological systems. *Glob. Environ. Chang.* **2014**, *28*, 227–238. [CrossRef]
54. Maslow, A.H. A theory of human motivation. *Psychol. Rev.* **1943**, *50*, 370–396. [CrossRef]
55. Yawson, D.O.; Armah, F.A.; Pappoe, A.N.M. Enabling sustainability: Hierarchical need-based framework for promoting sustainable data infrastructure in developing countries. *Sustainability* **2009**, *1*, 946–959. [CrossRef]
56. Walsh, P. A policy framework for sustainability in developing countries: Applying value chain theory to a society's hierarchy of needs. *WIT Trans. Ecol. Environ.* **2011**, *150*, 663–674.
57. Schank, C.; Rieckmann, M. Socio-economically substantiated education for sustainable development: development of competencies and value orientations between individual responsibility and structural transformation. *J. Educ. Sustain. Dev.* **2019**, *13*, 67–91. [CrossRef]
58. Keitsch, M. Structuring ethical interpretations of the sustainable development goals—Concepts, implications and progress. *Sustainability* **2018**, *10*, 829. [CrossRef]
59. Wallace, A. Between facts and norms: Contributions to a discourse theory of law and democracy. Jürgen Habermas. *Ethics* **2002**, *108*, 3.
60. Meadows, D. Indicators and Information Systems for Sustainable Development. Available online: [http://www.biomimicryguild.com/alumni/documents/download/Indicators\\_and\\_information\\_systems\\_for\\_sustainable\\_development.pdf](http://www.biomimicryguild.com/alumni/documents/download/Indicators_and_information_systems_for_sustainable_development.pdf) (accessed on 29 October 2019).
61. Dahlbeck, J. Hope and fear in education for sustainable development. *Crit. Stud. Educ.* **2014**, *55*, 154–169. [CrossRef]
62. Minteer, B. *Refounding Environmental Ethics: Pragmatism, Principle, and Practice*; Temple University Press: Philadelphia, PA, USA, 2011.
63. Carm, E. Rethinking education for all. *Sustainability* **2013**, *5*, 3447–3472. [CrossRef]
64. Kjaer, L.L.; Pigosso, D.C.A.; Niero, M.; Bech, N.M.; McAloone, T.C. Product/service-systems for a circular economy: The route to decoupling economic growth from resource consumption? *J. Ind. Ecol.* **2019**, *23*, 22–35. [CrossRef]
65. Kirkman, R.; Voulvoulis, N. The role of public communication in decision making for waste management infrastructure. *J. Environ. Manag.* **2017**, *203*, 640–647. [CrossRef] [PubMed]
66. De Haan, G. The BLK '21' programme in Germany: A 'Gestaltungskompetenz'-based model for education for sustainable development. *Environ. Educ. Res.* **2006**, *12*, 19–32. Available online: <http://www.tandfonlin.com/doi/abs/10.1080/13504620500526362> (accessed on 29 October 2019). [CrossRef]
67. Rieckmann, M. Future-oriented higher education: Which key competencies should be fostered through university teaching and learning? *Futures* **2012**, *44*, 127–135. [CrossRef]
68. Wiek, A.; Withycombe, L.; Redman, C.; Mills, S.B. Moving forward on competence in sustainability research and problem solving. *Environment* **2011**, *53*, 3–12. [CrossRef]
69. Glasser, H.; Hirsch, J. Toward the development of robust learning for sustainability core competencies. *Sustain. J. Rec.* **2016**, *9*, 121–134. [CrossRef]
70. Lambrechts, W.; Mulà, I.; Ceulemans, K.; Molderez, I.; Gaeremynck, V. The integration of competences for sustainable development in higher education: An analysis of bachelor programs in management. *J. Clean. Prod.* **2013**, *48*, 65–73. [CrossRef]
71. Barth, M.; Godemann, J.; Rieckmann, M.; Stoltenberg, U. Developing key competencies for sustainable development in higher education. *Int. J. Sustain. High. Educ.* **2007**, *8*, 416–430. [CrossRef]
72. Faham, E.; Rezvanfar, A.; Mohammadi, S.H.M.; Nohooji, M.R. Using system dynamics to develop education for sustainable development in higher education with the emphasis on the sustainability competencies of students. *Technol. Soc. Chang.* **2017**, *123*, 307–326. [CrossRef]
73. Lozano, R. Are companies planning their organisational changes for corporate sustainability? An analysis of three case studies on resistance to change and their strategies to overcome it. *Corp. Soc. Responsib Environ. Manag.* **2013**, *20*, 275–295. [CrossRef]
74. Blok, V.; Gremmen, B.; Wesselink, R. Dealing with the wicked problem of sustainability in advance. *Bus. Prof. Ethics J.* **2016**. [CrossRef]
75. Wiek, A.; Bernstein, M.; Foley, R.; Cohen, M.; Forrest, N.; Kuzdas, C.; Kay, B.; Withycombe Keeler, L. Operationalizing competencies in higher education for sustainable development. In *Handbook of Higher Education for Sustainable Development*; Routledge: London, UK, 2016; pp. 241–260.

76. De Haan, G. Gestaltungskompetenz als Kompetenzkonzept der Bildung für nachhaltige Entwicklung. In *Kompetenzen der Bildung für nachhaltige Entwicklung*; Springer: Berlin, Germany, 2008.
77. Komarsinski, A.; Ishimura, G. Critical thinking and normative competencies for sustainability science education. *J. High. Educ. Lifelong Learn.* **2017**, *24*, 21–37.
78. Sipos, Y.; Battisti, B.; Grimm, K. Achieving transformative sustainability learning: Engaging head, hands and heart. *Int. J. Sustain. High. Educ.* **2008**, *9*, 68–86. [[CrossRef](#)]
79. Lozano, R.; Merrill, M.Y.; Sammalisto, K.; Ceulemans, K.; Lozano, F.J. Connecting competences and pedagogical approaches for sustainable development in higher education: A literature review and framework proposal. *Sustainability* **2017**, *9*, 1889. [[CrossRef](#)]
80. Blake, J.; Sterling, S.; Goodson, I. Transformative learning for a sustainable future: An exploration of pedagogies for change at an alternative college. *Sustainability* **2013**, *5*, 5347–5372. [[CrossRef](#)]
81. Van Poeck, K.; Læssøe, J.; Block, T. An exploration of sustainability change agents as facilitators of nonformal learning: Mapping a moving and intertwined landscape. *Ecol. Soc.* **2017**, *22*. [[CrossRef](#)]
82. Leal Filho, W.; Shiel, C.; Paço, A. Implementing and operationalising integrative approaches to sustainability in higher education: The role of project-oriented learning. *J. Clean. Prod.* **2016**, *133*, 126–135. [[CrossRef](#)]
83. Karatzoglou, B. An in-depth literature review of the evolving roles and contributions of universities to education for sustainable development. *J. Clean. Prod.* **2013**, *49*, 44–53. [[CrossRef](#)]
84. Lozano, R.; Ceulemans, K.; Alonso-Almeida, M.; Huisinigh, D.; Lozano, F.J.; Waas, T.; Lambrechts, W.; Lukman, R.; Hugé, J. A review of commitment and implementation of sustainable development in higher education: Results from a worldwide survey. *J. Clean. Prod.* **2015**, *108*, 1–18. [[CrossRef](#)]
85. Sala, S.; Ciuffo, B.; Nijkamp, P. A systemic framework for sustainability assessment. *Ecol. Econ.* **2015**, *119*, 314–325. [[CrossRef](#)]
86. Soland, J.; Hamilton, L.S.; Stecher, B.M. Measuring 21st Century Competencies. In *Global Cities Education Network Report*; Asia Society: Washington, DC, USA, 2013; 68p.
87. Yoko, S. 2013 Asia-Pacific Education Research Institutes Network (ERI-Net) Regional Study on Transversal Competencies in Education Policy & Practice (Phase I). *Regional Synthesis Report*; UNESCO Bangkok: Bangkok, Thailand, 2015.
88. Albareda-Tiana, S.; Vidal-Raméntol, S.; Fernández-Morilla, M. Implementing the sustainable development goals at University level. *Int. J. Sustain. High. Educ.* **2018**, *19*, 473–497. [[CrossRef](#)]
89. Albareda-Tiana, S.; Vidal-Raméntol, S.; Pujol-Valls, M.; Fernández-Morilla, M. Holistic approaches to develop sustainability and research competencies in pre-service teacher training. *Sustainability* **2018**, *10*, 3698. [[CrossRef](#)]
90. Waltner, E.M.; Riess, W.; Mischo, C. Development and validation of an instrument for measuring student sustainability competencies. *Sustainability* **2019**, *11*, 1717. [[CrossRef](#)]
91. Schuler, S.; Fanta, D.; Rosenkraenzer, F.; Riess, W. Systems thinking within the scope of education for sustainable development (ESD)—A heuristic competence model as a basis for (science) teacher education. *J. Geogr. High. Educ.* **2017**, *42*, 192–204. [[CrossRef](#)]
92. Waltner, E.M.; Riess, W.; Brock, A. Development of an ESD indicator for teacher training and the national monitoring for ESD implementation in Germany. *Sustainability* **2018**, *10*, 2508. [[CrossRef](#)]
93. Loorbach, D. Transition management for sustainable development: A prescriptive, complexity-based governance framework. *Governance* **2010**, *23*, 161–183. [[CrossRef](#)]
94. Gokool-Ramdoo, S.; Rumjaun, A.B. Education for sustainable development: Connecting the dots for sustainability. *J. Learn. Dev.* **2016**, *4*, 1.
95. Lozano, R. A tool for a Graphical Assessment of Sustainability in Universities (GASU). *J. Clean. Prod.* **2006**, *14*, 963–972. [[CrossRef](#)]
96. Kapitulkínová, D.; AtKisson, A.; Perdue, J.; Will, M. Towards integrated sustainability in higher education—Mapping the use of the Accelerator toolset in all dimensions of university practice. *J. Clean Prod.* **2018**, *172*, 4367–4382. [[CrossRef](#)]
97. Liebhart, M.; Lorenzo, L.G. Between planned and emergent change: Decision maker's perceptions of managing change in organisations. *Int. J. Knowledge Cult. Chang. Manag.* **2010**, *10*, 147–162.
98. Sterling, S.; Witham, H. Pushing the boundaries: The work of the Higher Education Academy's ESD Project. *Environ. Educ. Res.* **2008**, *14*, 399–412. [[CrossRef](#)]

99. Senge, P.M. *The Fifth Discipline, the Art and Practice of the Learning Organization*; Doubleday/Currency: New York, NY, USA, 1991.
100. Lozano, R. Incorporation and institutionalization of SD into universities: Breaking through barriers to change. *J. Clean Prod.* **2006**, *14*, 787–796. [[CrossRef](#)]
101. Mandela, N. Lighting your way to a better future, Speech delivered by Mr N R Mandela at launch of Mindset Network, Planetarium, University of the Witwatersrand Johannesburg South Africa. 2003. Available online: [http://db.nelsonmandela.org/speeches/pub\\_view.asp?pg=item&ItemID=NMS909](http://db.nelsonmandela.org/speeches/pub_view.asp?pg=item&ItemID=NMS909) (accessed on 29 October 2019).



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