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Innovative Pedagogies for Sustainable Environments and Education Mindsets in Higher Education

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Abstract

Sustainability is a concern of society today. Competent in sustainability and its implementation, graduates can effectively solve these problems. With the help of innovative pedagogies, higher education can mainstream sustainability in program and discipline curricula. Many teachers are already using innovative pedagogies for sustainability. Nevertheless, such wholesome curricula having content integrated with pedagogical innovations have not been proposed. Addressing sustainability effectively requires shifts in epistemic beliefs and transformations in learning environments. To engage and empower students as agents of change, the issue of education for sustainability, rather than about sustainability, is central (Winter et al., 2015). Education for sustainability prepares students for the future.

Keywords: *Innovative pedagogies, sustainable environments, education mindsets, higher education, sustainability competencies, epistemic beliefs, and transformative learning.*

1. Introduction

Most systems in place today are unsustainable and not feasible. While higher education sets students up for this challenge, many students are unaware (Winter et al, 2015). Individuals and institutions should accept the link between environmental and social systems. To reframe the world, higher education needs to integrate explicit sustainability competencies to produce minds who will redefine success. Innovations in learning goals,

pedagogies and educational environments have not brought about any significant change in the dominant mindset in higher education and society. More and more, work is surfacing that explains pedagogies that might cultivate the outlooks, knowledge, skills and attitudes needed to seize opportunities to address sustainability at all levels, and especially in higher education.

Education for Sustainability (EFS) within higher education aims at the transitions for a just and sustainable world. The capacity for instilling value, values, and ethics is termed ''sustainability competence'' by the UNECE. Educational pathways and opportunities are influenced by institution, system and mindset; pedagogies impact higher education institutional culture; disciplinary and interdisciplinary aspects impact cognitional, social and systemic learning. Shifting one's mindset involves the brain areas responsible for the macro and micro levels of thought, perception and socialisation. The research around mindset and epistemic belief, explanation of educational transitions, linking sustainability transformations with pedagogical innovations, and established theories provides policy-relevant, practice-oriented and conceptually rich frameworks for collaborative development of sustainable environments and innovative educational systems.

2. Theoretical Foundations

The demand of institutions and stakeholders to reform education in order to address unprecedented global social, environmental and economic crises, from local to global scales, has triggered the integration of sustainability into higher education (Winter et al., 2015). Sustainability as a subject matter is getting more focus in the education sector, particularly in universities. Sustainability education is a synonym for education for sustainability (EFS) as well as education about sustainability (EAS). EFS comprises a competencies framework that informs education at all levels, knowledge, skills, values and character of sustainable development and helps in the sustainability world. Sustainability issues are often taught through EAS, but this education doesn't have to take the form of a tool for self-growth or community change. The aim of the EFS at the post-secondary level is to prepare students, faculty, and administration to become agents of change in sustainability-related issues. A new generation of scholars possessing sustainability competencies, who are entering academic programmes within sustainability sciences or pursuing a career in sustainability or related fields, is beginning to emerge; however, many institutions are still resisting the inclusion of EFS in already crowded curricula.

2.1. Sustainability Education in Higher Education

In the Earth Summit in 1992 (held under the auspices of the United Nations), Education for Sustainability (EfS) in Higher Education (HE) took off significantly. According to Winter et al. (2015), EfS has emerged as an instrument of significant potential in the quest for a sustainable future, yet continues to be implemented at a much slower pace than required. Evaluations undertaken show progress in embedding EfS within HE, followed by the United Nations' SDGs, and yet, there is little evidence of transversality across programmes, nor of systematic monitoring, measuring and assessment of pedagogical practices at the curricular and co-curricular levels (Caetano & Carlos Felgueiras, 2018). Having no serious momentum and systematic shifts in the mindsets that would accompany an educational transformation of more HE institutions is a serious problem**.**

2.2. Mindset Shifts and the Role of Epistemic Beliefs

Environmental challenges require adjustments at two levels: individual and societal. This calls for shifts in mindsets and epistemic beliefs. Different ways of knowing can reconfigure interdisciplinary connections in collaboration to further sustainability. Environmental decision-making is influenced by profound states of awareness and ethical growth. Ecosystem management benefits from attention to local ecological knowledge and institutional dynamics. Critical thinking, conceptual change, and the social construction of knowledge are relevant educational strategies that promote competence and reflectivity on sustainability issues. Making use of system dynamics modelling in a participatory manner enhances engagement and scrutiny in environmental decision-making. As a result, changes in epistemic beliefs are crucial to adaptive learning and the sustainable transformation (Fazey, 2010).

2.3. Innovative Pedagogical Theories and Frameworks

The theoretical basis of sustainability education refers to its values, goals and competences. It differentiates between education about sustainability and education for sustainability. There is a type of education that will provide knowledge about the state of the environment and a foundation for sustainable development. Another one enhances the ability to bring about change toward sustainability and the capacity to act. The theoretical underpinnings of the higher-education environment are suggested based on a systems approach, covering the entire socio-technical system.

Attitudes, beliefs and dispositions to learn can be influenced by sustainability

education. It is important that efforts to encourage a growth mindset because people may often have to deal with failure and frustration at various stages of a long-term engagement in sustainability. We hence link both growth and sustainability mindsets to individual agency, motivation and well-being. Unlike mindset change, epistemic-belief change specifically influences how learners interact with knowledge, expertise, information sources, and social relations. Higher education focuses on enabling students to acquire analytical and systems-thinking competencies in their area of specialisation. In addition, three drivers of student agency in higher-education institutions are social constructivism, disciplinary discourse and multiform articulation. When appropriately adapted to circumstances, these constructs could enhance agency and facilitate system intervention.

The educational approaches and frameworks that are responsible for sustainability learning and education are assessed, such as constructivism, experiential learning, systems thinking, and transformative learning. Theoretical and curricula related to the 'mindset' dimension and specifications for capabilities and competencies linked to the aim of sustainability education in higher education have been reported (Balsiger et al., 2017; Herodotou et al., 2019).

3. Pedagogical Innovations for Sustainability

Innovative pedagogy positively affects the transition to sustainability in higher education institutions by developing the learning, attitudes, values and competencies that encourage a desire for and commitment to sustainable living. Concepts for educational innovation are already well-established, widely disseminated, and in many cases well-researched about sustainability transitions. According to Winter et al. (2015), these can be classified into four wide categories according to their approaches to teaching, learning and assessment.

Experiential and place-based learning involves students working on real-world, rich in context issues and projects, often in collaboration with external partners, and conducted in groups or teams in an interdisciplinary context, co-evaluated with peers and stakeholders. Unlike other active pedagogical approaches, which focus exclusively on specific aspects, the sustainability transition is primarily one of its two foci. Another long-term focus of higher education is the provision of knowledge and skills that make you fit for work. This purpose has now been partially complemented by the goal of developing the individual will to act.

3.1. Experiential and Place-Based Learning

Experiential and place-based learning can be defined simply as learning by doing, with a primary focus on the physical location, social context, and community. There is a need to place higher education within an ecological framework that recognises the permeable boundaries between institutions of higher learning and the larger social-ecological systems surrounding them. Systems thinking emerges from complexity science, is very much relevant to sustainability issues, and represents a shift in thinking proposed to address contemporary societal challenges. It differs markedly from traditional linear, mechanistic forms of reductionist thinking dominant in higher education. Experiential learning represents a well-established theory, viewed as a formal theory of education, developmental psychology, and learning, which meets various sustainability and resilience pedagogical aims across multiple disciplines and levels of education. The theory is grounded in the "hand, head, and heart" areas of development or competencies and supports related pedagogies, such as landscape learning, place-based education, and education for sustainability (Winter et al., 2015). Because the emphasis is on wholeness rather than the separation of mind and body or cognitive and emotional development, people sometimes see it more holistically as "embodied learning" (Loynes & Towers, 2018). Combining these three frameworks is seen as a significant advance in sustainability education, enabling the inclusion of environmental, social, economic, and cultural dimensions, systems thinking, and greater alignment with values, ethics, global responsibility, and the 2030 Agenda.

3.2. Cross-field research and systems thinking.

According to UNESCO(2019), the climate crisis and global sustainability challenges critically require new mindsets in education. Shifts of Mindset refer to an individual's epistemic beliefs of knowledge, knowing, learning and teaching. During the process of turning higher education institutions (HEIs) into sustainability laboratories, changes in mindsets towards sustainability have been evolving (Orr, 1992). These shifts can be influenced by socio-economic factors and diversity (e.g. gender, age) and flexible learning arrangements, but also inhibited by program priorities and pedagogical systems that encourage compliance and gated learning segments (Winter et al., 2015). Mindset-change initiatives can be supported by applying socio-constructivist theories, which engage students in social negotiations to construct, negotiate, and co-create sustainability literacy knowledge (Liu, Ziebell, & You, 2022). When students work together with each other, it stimulates conversations around the discipline and helps with formative peer

feedback and critique and the emergence of focus on sustainability-oriented mindsets (Liu et al., 2022).

3.3. Digital and Data-Driven Pedagogy for Sustainability

Any number of changes are taking place in education that include one of those on Sustainability. They are often grouped under the label "Education for Sustainability" (ES) also called Sustainability Education, or which is also described as "Education for Sustainable Development" (ESD). Various forms, pedagogies, modalities, and disciplines shape and influence how students think, engage with and act upon the world, as well as their relations with other people and issues, especially in a digital data-driven age. Technological society experiences parallel modifications at every layer of individual and institutional levels. The old breaks down into fragments to generate new variables. A cross-examination of the rise of anthropological analysis, inspired by the theoretical framework of Julian Steward's "cultural ecology or 'cultural' environment" and nearing realisation in the context of Marshall McLuhan's "global village" phenomenon, is a gradual shift in our society. This has resulted from the burgeoning accumulation and collation of data, buckets of gigabytes that both hit the ground and overtook the elite, across extreme depth and extraordinary breadth of topics. Education has long been regarded as an undertaking of giving bookish knowledge versus the imparting of reasoning and thinking, to make well-informed choices.

Data-driven pedagogy for Sustainability Education is experiencing rapid development. Numerous higher education institutions have already embraced various embodiment forms and phenomena while launching learner-centred, participatory, and data-minded courses relevant to sustainability at different pedagogical, implementation, and research levels. Due to individual action policies and commitments made by countries globally to tackle climate change, corporations and/or events are imposing sustainability restrictions on the establishment of new buildings and facilities; data-driven courses are considered a rapid and scalable way to address such issues.

GreenNet, the world's first web-based global computer network, was established in 1986 by computer scientist Peter T. A. Kane at the Massachusetts Institute of Technology. Simple seafloor pressure sensors allow time series data of density, temperature, and currents to be collected accurately. Tracking the changing status of specific geographical areas and their resident populations from the science side still carries great importance. Data of varied types and scales nevertheless remain untapped or

not widely known among many university students. Pedagogy for Sustainability Education, launched and sustained in varied historical contexts, is likewise scantily browsed or viewed among public archives and repositories. (T. Fiedler et al., 2021)

3.4. Participatory and Co-Design Methods with Stakeholders

Administrators and architects often use higher education institutions as land banks for infrastructural investment and upgrading. This practice raises questions of whose visions create these spaces, and whom they truly serve. Situating higher education within a neo-liberal economic worldview that constrains educational development as merely vocational training and knowledge production for economic competitiveness and growth, investigations were conducted through a participatory design to identify design visions for higher education at a campus level. This involved using participatory design and participatory action research to negotiate structures and processes that would allow targeted groups of users to engage collaboratively and concurrently in the design process, and then to design further cycles of user-led engagement. Users had stated that they did not want to arrive at a specific or defined design agenda for higher education, as they saw the agenda as too limiting to accommodate divergence, emergence, and eternity of thinking. It was thus decided to focus on investigating participants' broader design visions rather than any narrower agenda.

The purpose was also to foster deeper levels of participation by nurturing discussion on design education and design participation. The activity was named 'sandpit', chosen to evoke a playful attitude towards exploration. A sandpit as a physical space enables playing as a means of learning, exploration, discovery, and creativity. Sandpits of the educational design kind constitute a forum or an arena for idea exchange, such as participatory design. Educational design sandpits design desired interactions and share an emergent agenda among participants. Participants may be regarded as students, teachers, or anyone in between, engaging in a free and open discussion about spatial design in education. These broader participatory design principles were followed even when supporting the re-design of learning spaces in simple poster graphics, i.e., ideas were encouraged to travel without fixtures from a first poster to a second, then to a third, allowing conversation to remain unbroken as much as possible (Dupret & Chimirri, 2018).

4. Environmentally Sustainable Learning Environments

Enabling socially distributed, transdisciplinary knowledge production, ESD approaches equip higher education learners with environmental

sustainability competencies and attitudes necessary to undertake sustainability-oriented professional roles. Across many higher education institutions, sustainability-oriented educational strategies have been systematically deployed to address such systemic challenges (Winter et al., 2015). The degree to which higher education institutions concurrently embed and promote sustainability knowledge into their educational practices can vary widely from institution to institution. Two broad categories of educational pathways have been differentiated: educational frameworks that focus on the systemic embeddedness of sustainability knowledge within specialised disciplinary knowledge and situated practice, and ESD approaches that adopt an expansive, transdisciplinary perspective. ESD approaches enable socially distributed, transdisciplinary knowledge production across environmental-economy-society-technology systems, equipping higher education learners with the environmental sustainability competencies and attitudes necessary to undertake sustainability-oriented professional roles. The latter approaches are therefore particularly suited to addressing sustainability challenges characteristically faced by many contemporary higher education sustainability programmes.

4.1. Campus Design and Resource Stewardship

Learning environments shape student experiences through the design of facilities (Skapinker, 2017). Campuses comprise interaction-rich conditioned spaces, influencing well-being, awareness, engagement, and agency. Sustainable design impacts energy and water consumption, spatial quality, and ongoing resource stewardship (G Scholl & Betrabet Gulwadi, 2015). Universities embody resource-depleting production-consumption systems; the workplace-learning dichotomy mirrors individual behavioural dualism. Ideally, campuses reflect a transition towards a sustainable society, coaching students in venue design and resource accountability via a life-cycle approach. Attention to campus design and resource stewardship aligns educational objectives with sustainability principles.

Building orientation and foliage shading enhance lighting and thermal conditions, minimising energy demand. Well-insulated facilities further prevent air leaks and temperature shifts. A green roof covering a technology-intensive building cools it by 3 to 6 °C under summer peak conditions. A zero-energy academic space set for rapid assembly and rearrangement accommodates course re-configuration without major reconstruction. Converting the playground of a three-level school into

an experimental bioremediative wetland advises improvement of campus lands.

4.2. Hybrid and Flexible Learning Models

Given that higher education is linked worldwide to economic, social and environmental sustainability, it must better prepare graduates to deal with the sustainability issues of today. Different problems encountered within the education for sustainable development literature mostly arise due to an insufficient understanding of the interdisciplinary nature of sustainability problems. Additionally, other problems arise because there is a failure to support a systems thinking mindset that is required to deal with sustainability problems. In order to prepare graduates to contribute, sustainability education should be integrated more deeply with working on interdisciplinary collaboration, a systems thinking perspective, and continuity across formal and informal settings. "Systems thinking" holds that "problems" arise in the interrelationships among things, rather than in isolated parts. Thus, perspective and language must change. In stakeholder engagement, a landscape analysis specifies "who's in", "who's out", and "who's affected." Then you will need to examine what drives change. By using a systems approach, we can also better understand the feedback loops and delays between actions and consequences. On the other hand, traditional education tends to foster oversimplified aggregated representations of complexity. Systems approaches similarly help to better understand different worldviews and epistemologies as a source of social division and as an enabler of collaboration. In the context of engineering education, systems thinking assists with the integration of sustainability by raising questions about the interactions between technical, social, economic, cultural and political influences (Palmer et al. 2010) (Tucker and Morris 2012).

4.3. Assessment Practices Aligned with Sustainability Goals

A mindset of sustainability entails reorienting human systems to live within planetary limits, while lunar-park-led by knowledge generation takes place. Hence, sustainability education in higher education must foster the competencies requisite for students to contribute towards a constellation of knowledge contributing to sustainability. Accordingly, higher education institutions everywhere have made ambitious commitments to sustainability as a guiding theme of their operations, facilities, and teaching and learning practices.

5. Cultivating Mindsets for Sustainable Action

The ability to think critically and reflectively emerges when students take

control of their learning, self-assess their thinking and evaluate the adequacy of their thinking through metacognition. This kind of exploration raises doubt, leading to hypothesis tests and further exploration (Winter et al., 2015). Moreover, researchers discovered that the values and type of values, including equity and justice, that a student is aware of are a vital attribute. Simultaneously, the notion of a global individual and sustainable transition is tied to a greater attention to these values in sustainability contexts.

A focus on values, ethics, and notions of global citizenship affects students' decisions to actively participate in the necessary transitions towards sustainable societies. Studies indicate that a framework in higher education that nurtures the deliberation of sustainability-related ethical issues can enhance students' understanding of the socio-political complexity of sustainability challenges. Embedded within such frameworks, topics about justice, equity, and planetary boundaries can help raise awareness of embedded value orientations and motivate the reconsideration of these values.

For the retention of students' motivation towards sustainability challenges on the globe and contribution to the sustainability transitions at the local level, community partnership and civic participation are both important. It is important to facilitate relevance and reciprocity in student engagement with partners. As part of a broader consumption and production community, facilities recognised that academic institutions depend on the surrounding society for water, energy, and food. In this sense, while the off-campus functioning ensures the on-campus functioning, opportunities for service-learning through community engagement in higher education contribute to sustainability transitions. Students should engage in social and community activities that help them become active participants in social life and fulfil obligations related to their own society and institution.

5.1. Critical Thinking and Reflexivity

Higher education institutions have been called to strengthen teaching and learning approaches aimed at fostering students' critical awareness of interdependence among the social, environmental, economic, and cultural dimensions of sustainability. Critical thinking represents the ability to analyse complex issues to make informed judgements and to solve problems through rational discourse. Arguably, critical thinking is a key competence for achieving sustainability because the numerous paradoxes and contradictions associated with the different dimensions of sustainability require individuals to read through the lines of various proposals and initiatives concerning a transition towards more sustainable

societies. Reflexivity—a meta-competence in critical thinking—is the ability to articulate the reasoning that underpins students' conclusions. Developing reflexivity allows for questioning ownership of the perspectives they bring to their reasoning, opening up the possibility for exploring the plurality of perspectives that shape the sustainability discourse. (Sommier et al., 2022) To help students develop reflexivity, they are invited to keep a "doubting notebook" in which they write down why they doubt a particular statement, policy, or procedure relative to sustainability and/or constraining what they put forward as solutions to sustainability-related issues. Such a habit serves to trace the reasoning behind each doubt or proposal and subsequently prompts students to explore alternative positions. (Danvers, 2019)

5.2. Values, Ethics, and Global Responsibility

A sustainable future means being able to live as a global citizen, caring for the environment and society. According to Sund & Pashby (2018), through education in ethics, one can develop this capacity. Global awareness in education is not simply exposing students to wider geographic and cultural issues. According to del Baldo & Baldarelli (2017), information about issues of justice and equity, limits of planetary boundaries, and systemic inequalities in education is vital.

5.3. Civic Engagement and Community Partnerships

Civic engagement offers another avenue for partnering with students and the wider community. When we engage with local, Indigenous and global communities, we can understand local realms of reality and their interconnection. Community-oriented partnerships allow students to create a solution in a more specified context, thus widening the social and community impact (Mason O'Connor et al, 2011). Through these joint efforts, on the one hand, pedagogical goals involve developing competencies relevant to employability and the ability to solve problems. Local problems and civic engagement are equally addressed. As a result, curriculum innovations may be developed from the real needs, interests, and career aspirations of the students through various educational interventions (D. James et al., 2011).

Community-based projects that are collaborative in nature are more service learning compatible. Their emphasis on social justice and tackling systemic or root causes of issues differentiates them from conventional internship or co-op models. Generally, these latter things focus on discipline-specific skills, experience and workplace readiness.

6. Implementation Strategies in Higher Education Institutions

An examination of implementation strategies within higher education institutions to embed education for sustainable development through curriculum internationalisation, formal and informal learning, and on-campus initiatives. Theories of transformative learning, developing critical reflection, and strengthening outcomes in the affective domain will enhance education for sustainability. According to Winter et al. (2015), the engagement of lecturers' beliefs and promotion of deep ecology, as well as the inclusion of sustainability within institutional policies and practices, will lead to sustainable graduates.

Societal transformations for sustainable futures depend heavily on the education and competencies that higher gain during their studies. Curricula explicitly focused on sustainability are, however, often perceived as a burden, and conventional strategies to facilitate a transition towards sustainability frequently engage uncritically with the existing disciplinary arrangement of curricula in higher education. As the concept of sustainable development gained traction through worldwide conferences and reports, it permeated through the United Nations to institutions of higher learning throughout the world, like the United Nations Educational, Scientific and Cultural Organisation (UNESCO) and the United Nations Environment Programme (UNEP), with the advent of the decade (2005-2014) of education for sustainable development.

Another report with some historical prevalence came out through the International Association of Universities, Launay (2012), indicating that in the Australian context, the cognisance of sustainability is merely a decade older than that suggested by the previous two reports. Additionally, the Universities Australia (as cited in Winter et al., 2015) suggests that developing capacities and global alumni graduates' competencies is a considerable extended set, with sustainability as the pivot. Confronted with the wide spectrum considered comprehensively in sustainability, ecosystem sustainability, social sustainability, and economic sustainability are the three main areas upon which higher education focuses as a prerequisite for enabling students to continuously learn, unlearn, relearn, innovate, and invent new competencies with the significant accumulation of complexity and uncertainty in the world.

6.1. Strategic Planning and Policy Alignment

The processes of institutional transformation relate to the embedding of sustainability in higher education. An effective way to engage students' awareness and achieve an informal

learner shift towards sustainability-oriented mindsets is by driving a strategic approach, causing the implementation of sustainability pedagogy across disciplines (Winter et al., 2015). For effective higher education pedagogy for sustainability literacy in Europe and North America, system-wide theoretical institutional strategic planning process synchronisation must include the how, what, why and when of sustainability education. Institutions must implement pedagogic practices aimed at raising awareness of environmental sustainability challenges and sustainability-related skills through curriculum and extracurricular activities. Tools for mapping the curriculum need to be generated by the institutions about planning, change and implementation of sustainability-oriented topics in pedagogy pertaining to all disciplines. It essentially restricts the coordination of sustainable education design in the highly decentralised institutional context of Europe and North America (Filho et al. 2019).

Achieving sustainability-oriented education awareness requires a precise articulation of institutional documents aligned to support four interconnected sustainability skills. These skills include ecology literacy (awareness of interdependencies with the natural environment); climate literacy (understanding of how climate change affects earth systems); social-justice literacy (knowledge of inequities; recognition of racial, gender, economic; and other academic injustices); and sustainable-living literacy (ability to demystify lifestyle decision choices) in higher education system, culture, design, and operation at hierarchical levels. Integration and adoption of the proposed skills can transform rigid and overloaded curricula imposed from the top down within the formally defined curriculum, fostering instead informal and flexible learner-state initiatives capable of emergence from the ground up.

6.2. Faculty Development and Support Systems

Faculty development and support systems are essential for promoting sustainable development in higher education (Winter et al., 2015). Institutional studies examine lecturers' beliefs and attitudes about sustainability and transformative learning. Theories of action belonging to an international family of curriculum-wide approaches aim to embed education for sustainable development in undergraduate programmes. Research highlights the importance of fostering uncommonly encountered affective learning outcomes and transformative perspectives among students. Key references include comprehensive frameworks of pedagogical action for teaching and learning for sustainability, critical ethnographic research tracking the diffusion of pedagogical innovations

over time, and a detailed set of guidelines for curriculum internationalisation developed to support faculty in these initiatives.

6.3. Curriculum Integration and Assessment Alignment

A curriculum that is well-aligned combines learning outcomes with teaching strategies and assessment practices. A mapping exercise identifies the alignment of an existing program's learning outcomes with sustainability-related outcomes. Next, there is an iterative process that will capture the collaborative determination of appropriate curricular and co-curricular educational strategies to foster the achievement of those outcomes (Albareda Tiana et al., 2019).

Since the competency framework offers program outcomes that include sustainability competencies, it provides a common reference point for mapping existing program learning outcomes and curricular strategies in the context of curriculum renewal decisions. Establishing a common understanding of sustainability and the overall aim for ambitious global citizenship educational strategies promotes a collective effort to implement sustainability competencies across programs while allowing for specific program nuances.

6.4. Equity, Inclusion, and Access in Sustainable Education

Education for sustainability supports learner agency. It helps learners critically reflect on and investigate their professional and personal values, priorities and relationships. It also deals with the assumptions, data, and arguments that inform their thinking, patterns of systemic change and the drivers of their professional and personal action or inaction. Students form a professional identity and learn the value of life-long learning. These identity-related actions and behaviours show the extent to which professionals think and act sustainably. Also, they are related to identity. Through a student's sustainability orientation, the relationship between sustainability education and sustainability-related action can thus be described.

Research on the evolution of people's thinking about sustainability shows that as individuals acquire greater understanding about the issues, moving from a technical focus through a focus on systems and equity, their commitment to sustainability-related actions increases. Periods of rapid learning about the issues can play a catalytic role in advancing that journey. It is speculated that before graduation, university students who have learnt a great deal about sustainability may be considerably more likely than those who have acquired little insight to take ongoing action; early focus on these concepts can be expected to promote such understanding; and that

engagement in certain types of sustainability-linked decisions undertaken early in one's career can reinforce initial interest in the area. (Winter et al., 2015)

7. Evaluation and Evidence of Effectiveness

Multiple objectives are addressed:

(a) to support pre-service teachers and future educational leaders in becoming critical scholars by reflecting on attitudinal and pedagogical aspects;

(b) to develop critical learning activities in substitution of traditional lecture methods;

(c) to stimulate sustainable values disregarding the content of the course; and

(d) to monitor or assess progress in teachers adopting a sustainability paradigm towards professionalism.

To design and assess these activities, a reflective self-evaluation tool has been developed for analysing the learning experiences that have contributed more significantly in promoting such values across different teaching settings (J. Pace, 2010).

7.1. Metrics, Indicators, and Methodologies

A study of pedagogical approaches in higher education institutions for sustainability education identifies sustainability-related competences and leading change in universities as major challenges. A set of corresponding indicators and methodologies specified for assessing sustainability and transformative learning maps to the pedagogical levels and conditions. A research project at one university promotes incorporating sustainability into university classrooms and learner competencies to support sustainable consumption, while enabling students to conceptualise the processes and challenges of changing universities through another project with a service-learning approach. Values, agency, motivation, and transformative learning for sustainability are additional key competencies articulated for institutional change. Tools that support sustainability education include ecological-footprint calculators that facilitate the evaluation of behaviour-impact links, as well as monitor decisions and impacts. Monitoring the development of key competencies as well as related student skills and performance is essential for advancing competency-based education. In general terms, the indicators, induction and metrics contribute to measuring the embedding of sustainability in a specific area of university education and tracking progress in the acquisition of sustainable development competencies (Albareda Tiana et al., 2019).

7.2. Longitudinal Impact and Scalability

Sustainability-related competencies can be expected to develop over extended projects or programs and participation in learning-focused networks. Distinguishing between short-term and longitudinal changes is necessary, as immediate effects may not always be sustainable, while longer-lived transformations might not always yield large initial changes. Projects with limited timelines may still influence institutional development or faculty cultures.

The problem of time arises because many educational innovations are designed as one-off events. Innovative implementations targeted at sustainability in higher education expose the compositional challenge of unpacking implementations into transferable components while preserving the core underpinning intent. The terminology associated with educational interventions appears already well developed, yet unfamiliar nomenclatures evolve to further support transfer across disciplines. (Winter et al., 2015)

7.3. Challenges, Limitations, and Ethical Considerations

Mixing the desired outcome of education with the sustainability outcome may cause institutions to focus early on the environment. Problems faced by students, such as anxiety and lack of resources, are rarely included in assessments. This restrictiveness neglects wider learning environments and closes off learning opportunities, making it more difficult to innovate pedagogies and mindsets within higher education (Leal Filho et al., 2017).

8. Case Studies and Comparative Perspectives

Universities are improving courses to implement sustainability competencies in students. Rethinking Educators' Role: The emergence of these programmes leads HEIs to rethink the role of educators and how education is structured. A review of case studies across educational contexts sheds light on the potential transferability of these alternative pedagogical frameworks to other curricular spaces and the need to know other institutional contexts and constraints.

Collaborative education for sustainable development (ESD) initiatives that work together to design sustainability education become a strategy for sustainability. The collaborations of several organisations create general curricular maps that connect major domains of sustainability theory and develop their own policies within legal regimes for ESD. There is debate about whether earthquake-proofing high-rise buildings is sufficient to guarantee people's safety, but the fact remains that high-rises are safe, and buildings are

safe, whatever the earthquake rating. (Sommier et al., 2022).

8.1. Case Studies of Innovative Programs

An increasing number of higher education organisations are now reacting to climate change, escalating biodiversity loss, and growing social inequities through the development of programs that foster sustainability-oriented mindsets. The acquisition of disciplinary expertise and the potential to critically reflect on epistemic beliefs, values, ethics and worldviews that promote engagement in sustainable solutions. The following case studies outline a number of initiatives that aim to implement innovative programs for sustainability-oriented mindsets to help leaders in higher education make informed decisions. Each case study provides information on the initiative (objective, strategy, outcome and challenges, etc.) as well as the context, along with principles, factors and patterns which might help enhance transference of these initiatives to other settings.

8.2. Cross-Institutional Innovations and Collaboration

Higher education is generally supposed to promote values like inclusion, equity and social justice. However, the diverse roles of universities, polytechnics and other institutions limit the predictability and generalizability (Mehling & Kolleck, 2019). Policy, governance and organisational support required to nurture interdisciplinary collaboration can be explored through models. A Malmö programme saw cross-sector collaboration generate new solutions for sustainable urban development, while at four institutions in Fribourg, Switzerland, an International Sustainability Teaching Network (online only) augmented existing courses (Sommier et al 2022).

9. Conclusion

Sommier et al. (2022) argue that to ensure the sustainability of higher education, it is necessary to change the pedagogies and the enabling environments that support learning activities and enable sustainable action. The world needs a bigger mindset shift at the societal level to enable the sustainable actions, socio-ecological transformations necessary to revive a sense of community and well-being today and in the future (Winter et al., 2015). Education for sustainability seeks to support sustainability-enhancing reforms in various social sectors. Employing a socio-ecological lens, and not just planetary protection, this agenda calls for actions that will enhance community well-being. These include equity (including gender equity), resilience, inclusion, social cohesion, fair distribution of resources, inter- and intra-generational responsibilities, international peace and democracy. Education is crucial for enhancing understanding and enhancing actions

contributing to the sustainability agenda; however, the European Commission (2020) indicates that sustainability education is nevertheless not sufficiently available within higher-education systems, which have been assessed to date.

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