

Transdisciplinary Education for Sustainability

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Abstract

This paper is an exploration into the teaching and learning requirements within *Higher Education for Sustainable Development* (HESD). It provides an overview of why HESD is necessary, including recent high level United Nations policy directions for education, and broader societal sustainability goals. Because sustainable development is multi-faceted and interconnected (i.e. a wicked problem), high-level sustainable development policies at the international and national level offer goals, rather than concrete steps for achieving sustainability outcomes. This makes the creation of education programs, with clear learning outcomes for students, nebulous and presents a challenge for HESD program development. To address this Wiek, Withycombe, and Redman's (2011) assembled a list of *key sustainability competencies* which is widely used and cited by educators and researchers, and a recurring theme within general sustainability literature is the need to complement educational content with *transdisciplinary* approaches (i.e., partnerships with business, government and civil society actors) to impact change in real life. To help equip students to address societal transformation toward sustainability, transdisciplinary skills are also useful learning outcomes. However, the exploration of the intersection between transdisciplinary approaches and HESD has only recently started to gain attention in the literature. To understand the key educational outcomes of transdisciplinary approaches in HESD, this paper presents background on HESD followed by a literature survey. The literature survey reveals four key themes relevant to course development involving transdisciplinary approaches, including – *knowledge integration*, *applied cases*, *problem based learning* and *interpersonal skills /agency* – in combination these build student competencies to engage in societal activities related to sustainable development.

Key words: higher education, sustainable development, transdisciplinary

1. Introduction

The need to address societal 'un-sustainability' has been heralded globally at an unprecedented scale. This is evidenced by international agreements including the United Nations (UN) Agenda 2030 Sustainable Development Goals (SDGs) (2015), the Paris Climate Agreement (2015); and at the European level the 2019 European Commission announcement of one trillion Euro's to fund the European Green Deal with the goal of becoming the world's first carbon neutral continent by 2050. Unlike typical policy agendas, each of these agendas are aspirational – they are policy goals to transition to sustainable society, but they do not offer clear policy pathways to meeting these goals. Part of the difficulty is that sustainability is a *wicked problem*: wicked problems are multi-dimensional, path-dependent and unpredictable in nature (Rittel & Webber, 1973). Sustainability is about the way society is designed, and current societal design is unsustainable, requiring widespread transformation of social and economic systems to become sustainable (Bai et al., 2016; Rockstrom et al., 2009; Steffen et al., 2015). Because wicked problems have no clear solutions and represent complex and entwined challenges, interdisciplinary education and research fields are emerging to investigate potential societal futures and pathways for sustainable development (Bai et al., 2016; Falk & Gaffney, 2019; Future Earth & Australian Academy of Science, 2019).

Some recent literature argues that traditional university courses based upon long established disciplinary pathways are too narrow and too rigid to train the kind of population needed to effectively address the complex and intertwined challenges of sustainability (Bradbury et al., 2019; Sherman & Burns, 2015). Educational practices that are not cognizant of the interconnectedness of the 'wicked problems' facing humanity and the bio-geophysical reality socio-ecological systems, are destined to fail to meet future societal needs because of human dependence upon stable ecological conditions (Folke et al., 2011). Human impacts upon ecological systems are now so great that societal design must mitigate adverse impacts (Rockström, 2009; Steffen et al., 2015). Some literature even argues that the mainstream approach to learning, education and research is actively co-producing the very opposite sustainability (Bradbury et al., 2019; Wals & Jickling, 2002).

There is considerable debate and confusion around how to define *sustainable development* due to definitions deriving from different disciplines (Purvis 2019). Therefore, this paper takes the commonly used UN Brundtland (1987) report definition, that describes sustainable development as, ‘development that meets the needs of the present without compromising the ability of future generations to meet their own needs’.

The SDGs themselves cover many disciplines and topics, many requiring specific deep disciplinary knowledge. It is worth noting that ‘sustainable development is nested in a set of political, moral and epistemic assumptions that are not shared by all...there are also questions around the extent to which the university...can and should be held to such practical and immediate impacts on the world around’ (Chankseliani & Mccowan, 2021, p. 2). But for the purpose of this paper, I argue that universities as centres of learning and knowledge, do have an important role to play. Particularly in terms of the so called ‘third mission’ to contribute to the ‘social, economic and cultural development of the regions in which they operate, by transferring knowledge and technologies to industry and to society at large’ (Compagnucci & Spigarelli, 2020, p. 1). This paper is based upon the normative assumption that education can contribute to a more sustainable society and that this is indeed a desirable outcome of university education.

The shortcomings of our current knowledge are reflected in the European Commission (EC) commitment to invest over €100 billion in research through Horizon Europe (2021–2030) to support universities and societal actors develop the pathways needed to advance the EC’s mandate to *both*, advance prosperity and economic growth, *and* a global transformation toward societal sustainability. To support this growing policy agenda is interest and investment in *Education for Sustainable Development* (ESD).

1.1 Education for Sustainable Development policy drivers

In 2005, the Millennium Development Goals (MDGs) were announced, initial uptake was slow, but commitment to action was reaffirmed at the UN World Summit in 2005. In parallel, the UN announced the Decade of Education for Sustainable Development (2005–2014). The 2005 UN definition for ESD is ‘the process of equipping students with the

knowledge and understanding, skills and attributes needed to work and live in a way that safeguards environmental, social and economic well-being, both in the present, and for future generations. The MDGs focussed upon developing nations, particularly the eradication of poverty, it was not until the 2015 announcement of Agenda 2030 with the SDGs aimed at all nations, that sustainable development and sustainability really became a major international societal agenda.

In the same year as the SDGs were announced, the UN announced a parallel ESD agenda – *Rethinking Education. Towards a global common good?* (2015). This position paper emphasised the need to educate *about* and *for* the sustainability goals.

But education is set at the national, regional or even institutional level. The *Swedish Higher Education Act* (1992:1434) Section 5 states ‘In the course of their operations, higher education institutions shall promote sustainable development to assure for present and future generations a sound and healthy environment, economic and social welfare, and justice’. Yet guidance on what and how to implement education for sustainable development across courses or institutions is left to each higher education institution to develop.

This education gap has also been highlighted at the international level, and some generic policy guidance has been produced, for example the UN guide ‘Accelerating Education for the SDGs in Universities: A Guide for Universities, Colleges, and Tertiary and Higher Education Institutions’ (SDSN, 2020), and ‘The Future Is Now: Science for Achieving Sustainable Development’ (Independent Group of Scientists appointed by the Secretary-General, 2019). Calls for greater agency from within the academic sector are coming from educational researchers, for example Wiek et al (2016) state that,

Large-scale educational transformation is needed to equip a new generation of professionals (not only sustainability professionals!) to address sustainability challenges through problem-solving approaches that integrate systems thinking, structured anticipation, value-laden deliberation, evidence-supported strategies, and strong collaboration across government, businesses, and civil society.

Yet despite this, sustainability education remains a niche subject, and there is a lack of clarity around *what* and *how* to teach in sustainability programs. Some of the key characteristics of education for sustainability are described in the next section.

1.2 Student Sustainability Competence Development

The problem-solving approaches required to equip this new generation of professionals to address sustainable development requires student-centred learning approaches. Student-centred learning approaches have a long history. In 1970, Freire outlined a radical student-centred learning approach in his book ‘Pedagogy of the Oppressed’. Freire’s model is critical and overtly political emphasising the power dynamic between teacher and student. His democratic model of teaching and learning can be described as a dialogical problem-posing pedagogy (Aubrey & Riley, 2019). This model is in direct contrast to the behaviourist approach which he refers negatively to as the ‘banking concept of education’, whereby the teacher holds the knowledge and transfers it to the student who is seen as an empty vessel (Aubrey & Riley, 2019). Freire rather seeks to cultivate the natural curiosity and critical thinking skills of the student through a dialogic process, defined by the student based upon the interests with the teacher having a directional roll to give clarity and help students become involved in the dialogic process (Aubrey & Riley, 2019). Freire’s approach sees the learner as an activist posing problems based upon their own life experiences.

Student-centred approaches based upon empowering the student as knowledge seeker, rather than simply a knowledge receiver, are transformational. *Transformative Learning Theory*, originated within the field of adult education (Mezirow, 1997), this approach has been identified as aligning with education for sustainability (Barth, 2015; Leal Filho et al., 2018). The development and nurturing of sustainability competencies requires more than information transmission (‘banking concept of education’); it requires a full bodied understanding of the sustainability challenge – which for many people – will invite the transformation of worldviews, paradigms, values and habits to ones that are more in alignment with a more sustainable world (Michel, Holland, Brunnquell, & Sterling, 2020; Papenfuss, Merritt, Manuel-Navarrete, Cloutier, & Eckard, 2019).

Within the field of Education for Sustainable Development, considerable research has been conducted over the past 20 years as to the learning outcomes needed to best equip students to tackle wicked sustainability problems that have one obvious solution. Amongst the most influential papers (Google Scholar citations to Dec 2020: 1557) related to education for sustainability is Wiek, Withycombe, and Redman's (2011) paper on *key sustainability competencies*. The paper summarises knowledge on sustainability education and presents the findings as key sustainability competencies i.e. 'functionally linked complexes of knowledge, skills and attitudes that enable successful task performance and problem solving with respect to real-world sustainability problems challenges, and opportunities' (Wiek, Withycombe, & Redman, 2011). They state that sustainability competencies can be differentiated from 'normal' competencies (e.g., critical thinking or basic communication skills) that graduates should acquire. The key sustainability competencies from this paper are summarised below:

- *Systems thinking* (the ability to analyse complex systems, across scales and disciplines while also considering feedback loops, delays etc.);
- *Strategic competence* (the ability to define and design and implement strategies for sustainability);
- *Anticipatory competence* (the ability to analyse evaluate and visualize future scenarios);
- *Normative competence* (the ability to map and apply sustainability values, principles and targets); and,
- *Interpersonal competence* (the ability to motivate enable and facilitate participatory and collaborative sustainability research and problem solving) (Wiek et al., 2011).

While all five competencies are important for students to acquire, greater *interpersonal competence* is essential. Interpersonal competence is a skill that enables a person to interact and facilitate knowledge integration between diverse actors. Interpersonal competencies emphasise the ability to motivate and work with others – not only peers, but also people from other disciplines, and non-academic sectors e.g. business and government – to offer more perspectives on complex problems (e.g. sustainability problems). Interpersonal competence has many parallels with *transdisciplinary approaches* to problem solving and

knowledge creation and speaks of the personal competence needed to make such collaborative approaches work.

1.3 Multidisciplinary and Transdisciplinarity education for sustainability

The first competency identified by Wiek, Withycombe, and Redman (2011) is systems thinking. Cross disciplinary approaches can help students learn to think in systems by connect the dots between types of knowledge, and potentially to learn together in constructivist ways (Renner, 1995).

Various cross-disciplinary modes exist including Multi-/Inter- and Transdisciplinary (MIT-disciplinary) modes. Multidisciplinary is the least sophisticated version, involving multiple disciplines or subject areas being brought together without necessarily relating strongly to each other, it is about representation of disciplines rather than building a shared narrative or systematically addressing a common problem (Dyer, 2003). Interdisciplinary approaches involve multiple disciplines but work towards the integration of subject fields, such that the combined response is greater than the sum of the various individual parts (Bruce, Lyall, Tait, & Williams, 2004; Dyer, 2003). Transdisciplinary approaches are interdisciplinary approaches that involve other sectors to go beyond conventional academic approaches, e.g. they may involve external stakeholders, or ‘problem owners’ who do not belong to academia but who can offer a unique perspective on the problem and co-creation of knowledge in real-world contexts (Lang et al., 2012; Lang, Wiek, & Wehrden, 2017).

‘Research practice, funding agencies and global science organizations suggest that research aimed at addressing sustainability challenges is most effective when ‘co-produced’ by academics and non-academics’ (Norström et al., 2020). Therefore, HESD should emphasizes for cross- and transdisciplinary multi-stakeholder co-creation of knowledge. Transdisciplinary approaches can achieve this through the creation of “knowledge production for social change which is based not only on the integration of knowledge from different disciplines” and sectors (Polk, 2014, p. 440). Sustainability challenges, by their nature, affect or engage a variety of stakeholders, with ‘no single actor has the capacity or power to fully grasp or address this complexity’ (Polk, 2015, p. 2).

Considering the Sustainable Development Goals, in some ways the most important is SDG17 which focuses on ‘partnerships for the goals’ – in essence it is about working together across sectors (e.g. academic, business and government) to find transdisciplinary solutions to link complex sustainability problems (i.e. integrating all SDGs) to work toward sustainable development. Certainly, transdisciplinary practices are seen to be of great importance in the literature on sustainable development for achieving sustainability. This connection has grown greatly over the last two decades, from less than 4 documents annually on the topic in the years preceding 1998. Growth was gradual until the last 15 years which has seen an explosion of literature with 795 documents on the topic published in 2020.

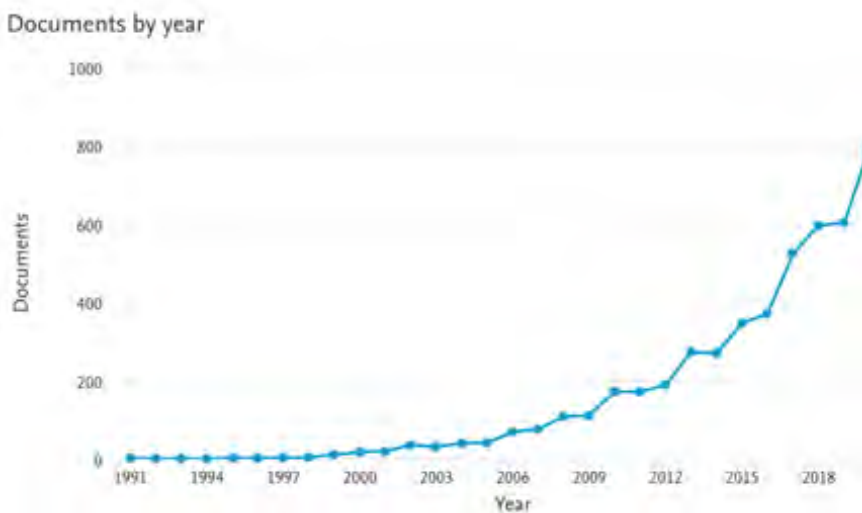


Figure 1: SCOPUS listed documents using the search string TITLE-ABS-KEY ("sustainable development" OR "sustainability") AND (transdisciplinary)

Figure 1 illustrates the rapid increase of interest in transdisciplinary practices in relation to sustainable development and sustainability. Interestingly, the uptake of this trend has been much slower in literature on HESD. This paper focuses on the literature that has been published to date and the key themes in the literature related to transdisciplinary practices and HESD.

2. Purpose, research question and methods

The purpose of this paper is to explore key themes of *transdisciplinary* related to *higher education for sustainable development* (HESD). The paper has two primary target audiences (i) educators who are tasked with teaching sustainability, and (ii) university executives and teaching and learning staff responsible for setting the direction for teaching within universities.

To explore this topic the paper asks the following research question: *What are the key themes of transdisciplinary that can be taught in HESD?*

To answer this question the paper explores the topic by using a selective *literature survey* (Fink, 2014). The literature survey inclusion terms are not exhaustive, the breadth of the field and the lack of consistent terminology makes a systematic literature review impractical with the time and resource limitations. Rather this paper seeks to offer a broad overview of peer reviewed academic articles. The review involved several steps including identifying relevant work, summarizing the evidence, and thematic analysis that categorizes key themes before finally interpreting the findings. These steps are transparent (explicitly stated search parameters) making the process reproducible and updatable. The methodology followed for this literature survey include:

Stage 1: Database search

SCOPUS is the largest abstract and citation database of peer reviewed literature, indexing 50 % more Social Science papers than the next largest database aggregator Web of Science (Manatos et al., 2017). Therefore, SCOPUS was the target database for this study. The bibliometric review, limited the search to English language, peer reviewed, articles by searching title, abstract and keywords using the following search string: TITLE-ABS-KEY (transdisciplinary AND "higher education" AND "sustainable development").

Stage 2: Article download and bibliographic analysis

The SCOPUS search identified 67 relevant papers. Bibliometric analysis was conducted using SCOPUS Analysis to provide graphs of (a) the year of publication and (b) country of origin.

Stage 3: Article refinement through exclusion and inclusion criteria

All papers identified in this search were downloaded, with the exception of a few inaccessible articles behind paywalls. The abstracts of all listed papers were manually checked for relevance, papers were excluded if they were either too narrow e.g., case studies about a specific course, or where transdisciplinary was only a minor component of the paper. Inclusion criteria were used for papers that emphasised generalisable principles most relevant to the research question on transdisciplinary processes and HESD. The 17 most relevant articles were read in full and content related to the research question noted.

Stage 4: Thematic analysis

Relevant content from the articles was reviewed for recurring themes which were identified and categorised. These are presented in tabular form in the results section. The discussion covers key findings on the origin of the content and the dominant themes. The dominant themes offering lessons for teachers in the field about how to apply transdisciplinary approaches in HESD curriculum to align student learning outcomes to the skills that the literature states are useful in transdisciplinary practice.

3. Results

3.1 Bibliometric analysis – year of publication

Despite sustainable development, higher education and transdisciplinary all being well documented topics, the literature survey reveals that little research has been conducted into the intersection between transdisciplinary approaches and HESD, and only recently has the relationship between the three themes emerged. The first such article was published in 2004 (See Figure 2). However, after 2016 the subject has gained more attention.

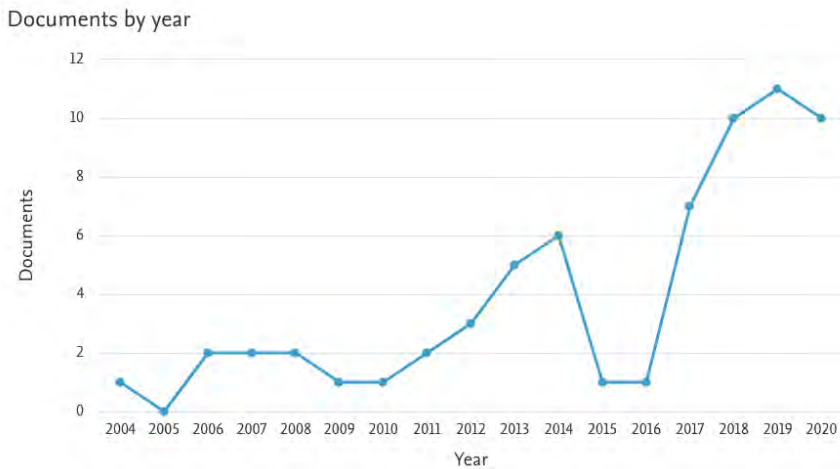


Figure 2. SCOPUS listed publications by year using the search string: TITLE-ABS-KEY (transdisciplinary AND "higher education" AND "sustainable development")

3.2 Bibliometric analysis – country and author

Figure 3 shows that the majority of literature is coming out of Germany. Indeed, Germany is a leader in transdisciplinary writing for sustainability and notably, Leuphana university is well represented. Leuphana university has a HESD research and education mandate and it is one of the few universities in the world to have a faculty of sustainability; and it counts UNESCO-Chair for 'Higher Education for Sustainable Development' (since 2005) Prof. Gerd Michelsen amongst its faculty. Leuphana university is also a centre for research on transdisciplinary research, so it is no surprise that eight (12 %) of the 67 documents are affiliated to Leuphana University. Michelsen (2013, p. 1510) himself links transdisciplinary approaches to education to "a background of the Bologna process and the 2005 Bergen Declaration announced by ministers of education (Bergen Communiqué' 2005), which together set the goal of making aspects of sustainability an integral part of all bachelor's and master's programmes ... (and) how complex problems can be worked on in an inter- and transdisciplinary manner". Table 1 summarises the key characteristics of transdisciplinary education for sustainability, and the discussion section elaborates on these themes.

Documents by country or territory

Compare the document counts for up to 15 countries/territories.

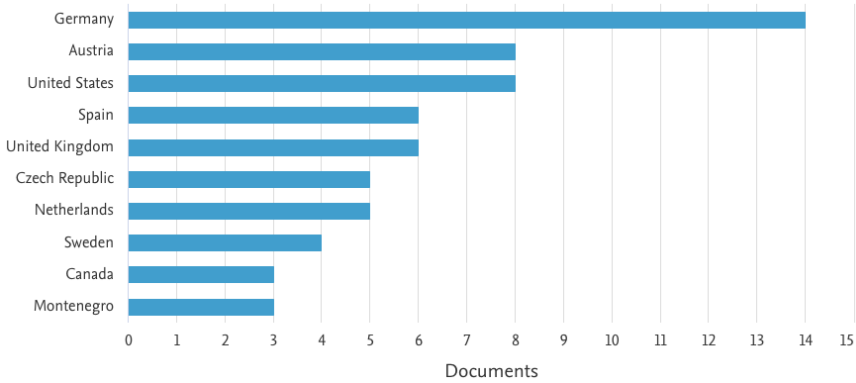


Figure 3. SCOPUS listed document origin by country or territory using the search string: TITLE-ABS-KEY (transdisciplinary AND "higher education" AND "sustainable development")

Table 1. Summary of themes plotted against literature.

Paper	Transdisciplinary characteristic			
	Knowledge integration	Applied cases/ cross sectoral partnerships /in real life	Problem based learning	Inter-personal skills/ agency
(Steiner & Posch, 2006)	•	•	•	
(Adomssent, Godemann, & Michelsen, 2007)	•	•	•	
(Sipos, Battisti, & Grimm, 2007)	•			

(Giesenbauer & Müller-Christ, 2020)	•	•			
(Galvão, Faria, Viegas, Branco, & Goulao, 2020)	•	•	•		
(Probst et al., 2019)					•
(Sonetti, Brown, & Naboni, 2019)	•				
(Mokiy, 2019)	•				
(Sahakian & Seyfang, 2018)	•	•			
(Michelsen, 2013)	•				
(Hensley, 2018)		•	•	•	
(Avery & Nordén, 2016)	•				
§(Barth, Adomßent, Fischer, Richter, & Rieckmann, 2014)	•	•			•
(Wals, 2014)	•			•	
(Lozano, Lozano, Mulder, Huisingh, & Waas, 2013)	•	•			
(Missimer & Connell, 2012a)	•				
(Correia, Xavier do Valle, Dazzani, & Infante-Malachias, 2010)	•				

4. Discussion

4.1 Transdisciplinarity in HESD: an emerging field

Figure 1 illustrates the rapid growth in literature on transdisciplinary and sustainable development. Publication rates accelerate after 2015, coinciding with several sustainability related policy announcements e.g. Sustainable Development Goals (SDGs) (2015), the Paris Climate Agreement (2015); Paris Agreement (2015) and the New Urban Agenda (2016). This can also be observed in Figure 2 showing the intersection between transdisciplinarity and HESD but the volume of papers is significantly less, the literature indicates that in part this could be attributed to an inherent conservatism in most universities (Adomson et al., 2007; Barth & Michelsen, 2013; Michelsen, 2013; Moki, 2019; Wals & Jickling, 2002).

Working across sectors in transdisciplinary approaches tends to be more common in large complex consulting or government organisations than in universities, yet this is exactly the type of education required to tackle the wicked sustainability problems.

Some authors even state that often higher education institutions lack holistic visions and incentives leading to anti-transdisciplinary attitudes and a tendency for academics and departments to focus on siloed approaches in teaching and researching activities (Sonetti et al., 2019). What is essentially seen as "lack of strategic boundary-crossing thinking" (Avery & Nordén, 2016, p. 670). Transdisciplinary approaches can help overcome academic fragmentation and mono-disciplinarity (Lozano et al., 2013).

A detailed report from the Russian Federation states that by its nature transdisciplinary approaches present an opportunity to use this concept for the education of (specialist) generalists in higher education (Moki, 2019). The logic for *specialist generalists* is because "different scientific disciplines, make necessary conclusions, and suggest optimal solutions for complex multifactor problems. Therefore, generalists should be considered as an important move towards the solution of complex multifactor problems of modern society". Michelsen (2013) differs slightly by suggesting that transdisciplinary discursive competence, should be firmly rooted in disciplinary competence.

4.2 Knowledge integration

Transdisciplinary approaches focus on what Wiek, Withycombe, and Redman (2011) refer to as ‘systems thinking’ competence – the need for holistic, multidisciplinary ways of thinking. These go beyond the ability of any one person and require collaboration across disciplines and sectors. Indeed, SDG17 focuses on ‘partnerships for the goals’ – in essence it is about working together across sectors (e.g. academic, business and government) to find transdisciplinary solutions to complex sustainability problems to address sustainable development.

Within universities, transdisciplinary content of sustainability programs that includes ecological and social science components as well as working with societal actors can be difficult to position within traditional, narrow discipline-based faculties, schools, and departments. But transdisciplinary approaches are valid, as they seek ‘knowledge integration’ whereby a range of disciplinary perspectives, theories, and methods, allow for new knowledge structures to be built up (Adomssent et al., 2007). Therein lies the challenge. Knowledge integration increases complexity, “the challenge of transdisciplinary processes lies in overcoming a high degree of complexity. The issues to be resolved generally cut across disciplinary paths to a solution ... Complex problem situations encompass factors which are not necessarily predictable, which give rise to uncertainty, and which may lead to some of the sub-objectives finding themselves in a contradictory relationship with one another” (Adomssent et al., 2007, p. 394). The transdisciplinary approach is a way of expanding the scientific worldview, which consists of examining an object outside any single scientific discipline (Mokiy, 2019). Similarly, Sipos, Battisti & Grimm (2007) discuss the notion of ‘transformative sustainability learning’ involving a transdisciplinary curriculum that integrates knowledge from numerous distinct disciplines, embedding streams of knowledge into one another and integrating them in new ways (Sipos et al., 2007). Similarly, Tasdemir & Gazo (2020) suggest sustainability curricula in higher education institutions needs to be holistic, synergistic, balanced and transdisciplinary. Transdisciplinary approaches are “based on the philosophic principles of unicentrism. In a broad sense, unicentrism is a position in philosophy and in science that is based on the problem of the correlation between the single and its fragments” (Mokiy, 2019, p. 61). Hensley (2018, p. 608) when discussing transdisciplinary approaches emphasises transformation – “sense of self, which is necessary for each citizen-student to

develop a rich sense of purpose for his life ... (rather than simply) training students for future jobs.”

4.3 Applied cases

Steiner and Posch (2006) note that transdisciplinary education for sustainable development initiates learning not only at the student level but also at the level of the teachers and practitioners involved. It is not as they say a subject-object relation in the sense that the subject academic teacher/researcher teaches about or does research on the societal actors as an object. It is rather a subject-subject relation, focusing on the intense interaction between academia and practitioners” (Steiner & Posch, 2006, p. 879). Closely related to this is the action-oriented part of transdisciplinarity aimed at real world problem solving that some call a ”transformative learning goal” aiming to integrating both practical and scientific knowledge in learning programs (e.g., Sahakian & Seyfang, 2018).

Novel ways of working between disciplines and with societal actors are revealed in the literature review to help build skills within individuals to help generate inter-disciplinary understanding. Much of this relates to what Wiek, Withycombe, and Redman (2011) refer to as interpersonal competencies, i.e., the ability to motivate enable and facilitate participatory and collaborative sustainability research and problem solving. Galvão et al. (2020) describe interpersonal skills facilitated by teaching staff to promote transdisciplinary learning outcomes: ”the use of information and communication technologies with professors monitoring and supervising through discussions and debates that promote interdisciplinary thinking and, ultimately, transformative and transdisciplinary learning outcomes” (Galvão et al., 2020).

Probst et al (2019) conducted surveys with students to show that transformative university learning experiences can contribute to sustainability attitudes, skills, and agency, the findings support the case for transdisciplinary course designs rooted in real-world sustainability challenges. A review of sustainability courses by Sahakian & Seyfang (2018) revealed trends towards transdisciplinarity in teaching.

There is a growing need of the society in specialists that are able to actively use the trans-disciplinary approach and systems transdisciplinary approach for solution of complex multifactor problems of nature and society (Mokiy, 2019).

4.4 Problem based learning

Sipos (2007, p. 76) is the most explicit of the authors who mention problem based learning, stating that it involves, ‘a framework for learning that is focused, experiential and organized around investigation of real-world problems. Authentic experiences foster active learning, support knowledge construction and integrate school learning and real life.’ Problem based learning is a method that sits between *applied cases*, and *agency*.

4.5 Agency

According to Probst et al. (2019) transformative university learning experiences can contribute to sustainability attitudes, skills, and agency. The findings support the case for transdisciplinary course designs rooted in real-world sustainability challenges. To achieve this Probst et al (2019) go on to list the following learning objectives for students: (1) developing perception that it is possible to influence sustainable development outcomes (2) engagement in voluntary work (3) development of professional skills.

Hensley (Hensley, 2018, p. 661) concurs on the importance of developing student agency, ‘In the framework of sustainable education, teachers are encouraged to develop and endorse student agency to promote self-realization and prevent estrangement’.

When considered against the national and international goals for sustainability, ultimately to achieve these goals it is necessary to train graduates as ‘change agents’ to transform existing dominant (but unsustainable) systems into sustainable systems.

4.6 Summary of the literature survey

The literature surveyed in this paper indicates that teachers and universities wishing to create the learning conditions for students to address complex and wicked sustainability problems should, in support of developing the *key sustainability competencies* (Wiek et al., 2011), in-

clude course content involving *transdisciplinary approaches*. This approach can help with the development of *interpersonal competence* to engage with people from diverse backgrounds, values, and disciplinary knowledge.

Educators wishing to create transdisciplinary conditions within a higher education program should consider:

1. *Knowledge integration* – by including diverse knowledge sets from multiple disciplinary backgrounds (Adomssent et al., 2007; Avery & Nordén, 2016; Barth et al., 2014; Correia et al., 2010; Galvão et al., 2020; Giesenbauer & Müller-Christ, 2020; Hensley, 2018; Lozano et al., 2013; Michelsen, 2013; Missimer & Connell, 2012b; Moki, 2019; Sahakian & Seyfang, 2018; Sipos et al., 2007; Sonetti et al., 2019; Steiner & Posch, 2006; Wals, 2014)
2. *Applied cases* – course work should involve cross sectoral partnerships ‘in real life’. The more complex the case the better as this requires great engagement with wider knowledge fields and greater integration of ideas (Adomssent et al., 2007; Barth et al., 2014; Galvão et al., 2020; Giesenbauer & Müller-Christ, 2020; Hensley, 2018; Lozano et al., 2013; Sahakian & Seyfang, 2018; Steiner & Posch, 2006)
3. *Problem based learning* – cases should present a challenge with no clear solution requiring a systems analysis and application of diverse knowledge (Adomssent et al., 2007; Galvão et al., 2020; Hensley, 2018; Steiner & Posch, 2006; Wals, 2014)
4. *Interpersonal skills / agency* – learning exercises may be facilitated by teaching staff, peers and cross sectoral contacts ‘in real life’, which means the students have to navigate different values, personalities and other unknowns within a wide group of people (Barth et al., 2014; Hensley, 2018; Probst et al., 2019). This exposes students to new ways of thinking and develops important interpersonal skills which in turn increases graduate’s agency. At its essence this is about working with, and influencing others to bring about change for sustainability

as described by numerous high level national and international policy goals.

The overwhelming consensus on transdisciplinary educational approaches is the importance of *knowledge integration* – synthesising fragmented disciplinary knowledge into new meaning to address complex challenges that cannot be solved through single disciplinary lens. The other themes are largely supporting ways of achieving knowledge integration.

4.7 Future Research

Transdisciplinary learning and research will increasingly be needed for tackling societal issues and higher education institutions (HEI) should consider new organisational approaches (i.e., in contrast to traditional disciplinary educational silos), e.g., ‘multi-dimensional and networked organisational models’ (Giesenbauer & Müller-Christ, 2020) to promote greater disciplinary and societal integration. Indeed, Giesenbauer & Müller-Christ (2020) go on to recommend that HEI should practice self-reflection, open up to societal discourse and change if appropriate.

Future research could investigate turning a reflexive lens upon the university itself, through such processes as departmental audits to look for opportunities to embed sustainability learning, and similarly, to identify ‘unsustainable’ learning content with a view to phase this out. Transdisciplinary philosophy to the level of educating for sustainability, new forms of university teaching are required that also call for a reorientation of existing structures. Therefore, the behaviour and role definitions of students, teachers, and researchers also must change. To attain that goal, students must be educated differently, as do the teachers and researchers themselves in order to have the needed, and in some cases new, competences for educating for sustainable development” (Steiner & Posch, 2006, p. 888).

Precedents do exist and such approaches have been incorporated in more progressive universities such as Leuphana University in Lüneburg, Germany, where transdisciplinary content is required by the university’s upper management, and delivery is through the Faculty of Sustainability. This they call the “Lüneburg Approach” by establishing an intermediate level of collaboration between sustainability activists within universities and in higher education policy and administration

(Adomssent et al., 2007). Given the unusual emphasis on sustainability education and transdisciplinary practice, it is not surprising that the bulk of the papers revealed in the SCOPUS search originate from Leuphana university.

5. Conclusions

Some argue that traditional university courses based upon long established disciplinary pathways can be too narrow and too rigid to train the kind of graduates needed to effectively address the complex and intertwined challenges of sustainability. The literature survey reveals key sustainability competencies as well as transdisciplinary approaches and methods that can help overcome this. *Key sustainability competencies* to support education for sustainability as described by Wiek, Withycombe and Redman 2011 are widely used by educators and cited in the research. Further to this, transdisciplinary approaches can help train students in ways to overcome knowledge shortcomings by applying interpersonal skills to engage with people from outside their formal disciplinary training – but the challenge is how to teach these skills.

The literature shows four key approaches can help students foster transdisciplinary skills. The four themes identified in the literature survey include: *Knowledge integration* (diverse knowledge sets from multiple disciplinary backgrounds), *Applied cases* (cross sectoral partnerships ‘in real life’), *problem based learning* (systems analysis and application of diverse knowledge) and *Interpersonal skills /agency* (working with, and influencing others to bring about change).

As the ever increasing urgency to adapt to the climate and sustainability emergency continues to grow, the need to develop student’s capacity to facilitate transdisciplinary processes as part of their learning experience will also grow. This paper highlights current best practice as identified in the literature to help teachers support students to develop skills to improve their *agency* to effect change in real life. It is the combination of *key sustainability competencies* with *agency* that ultimately achieves the *educational goal* of creating graduates with the skills to meet the broader societal need *to meet multiple sustainability policy and societal goals* – in other words, learning to create transformational impact towards sustainability.

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