sustainability

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Mapping Students' Development in Response to Sustainability Education: A Conceptual Model

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Received: 14 June 2019; Accepted: 7 August 2019; Published: 9 August 2019

Abstract: Target 4.7 of the Sustainable Development Goals requires that, by 2030, all learners acquire the knowledge and skills needed to promote sustainable development. This not only demands an interdisciplinary approach, but also that this approach must seek to be transformative, with change for sustainability as an explicit outcome in addition to subject knowledge. Many have argued that the complex or 'wicked' nature of sustainability challenges indicates the need for a learning experience that emphasizes active, reflective learning across-and between-discipline areas. In this paper we develop a conceptual model of sustainability learning for higher education that can potentially address the distinctiveness of sustainability education and monitor students' progression as learners. Our conceptual model of sustainability learning, has been developed on a university Master's program in Sustainability and integrates continua of pedagogy and disciplinarity into a three-dimensional space. Learners can be represented as different loci within this space at different points in their development. This potentially allows a 'learning journey' to be plotted. We propose that the model can also be used more widely as a tool to visualize learning progression within other university programs, providing an opportunity for both learners and curriculum designers to reflect on progress.

Keywords: sustainability education; interdisciplinarity; learning journey; learning progression; sustainable development goals

1. Introduction

In order to address the complex or 'wicked' nature of sustainability challenges and prepare students to contribute to a more sustainable future, sustainability education involves students in learning which is both interdisciplinary, a necessary pre-condition for a sustainable future [1], and of a profoundly personal nature, addressing values and behavior that are the essential in underpinning sustainable behavior [2]. Crucially, this learning is constructivist in style, and co-created by students, using their and their peers' prior knowledge and experience, as well as the formal curriculum [3].

As a subject within higher education, sustainability education therefore places complex demands on learning and teaching [4,5]. This article is based on our consideration of learners' experience of a one-year (for full-time study) taught Master's degree in Sustainability which has the explicit aim of facilitating the development of students as agents of change for sustainability. The MSc program is delivered by Anglia Ruskin University in the UK, in a partnership with Eden Project, an educational charity. The program takes a broad approach to the study of sustainability, aiming to develop students as innovators and systems thinkers rather than to give them in-depth knowledge of specific sustainability topics. Students are encouraged to develop a personal approach to the program, constructing their own learning journey. Because of this, it is highly desirable that students become autonomous learners who can integrate a wide range of subject content with their own experience to build their personal learning.

There is a large and growing literature devoted to describing the type of education which is consistent with sustainability learning [6], with many authors continuing to call for a transformation both of, and in, education [7]. Such transformation becomes more urgent as sustainability itself becomes a diminishing prospect [8]. This may be due, at least in part, to the lack of attention paid to the practical aspects of this transition, including how we can overcome institutional inertia, entrenched disciplinary traditions and the fiercely protectionist stance of of those who consider this to be an affront to academic freedom [9,10]. Administrative constraints are often overlooked but are an increasingly important part of universities' economic sustainability. However, we see individual case studies and examples of how sustainability is becoming part of existing structures and processes, how curricular content and pedagogy are being stretched and adapted, reformed and repurposed [6–8,11].

Programs, such as our taught Master's, that attempt to cover sustainability as a whole rather than sustainability in a specific context such as economics, social policy or the built environment, need to prepare students to operate in a space that transcends conventional subject boundaries and to address so-called 'messy' or 'wicked' problems. They also need to be able to recognize uncertainties and unknowns, and to build connections between different parts of a problem, rather than approaching them in a deductive, reductionist and compartmentalized manner. We do this by stimulating students to become systems thinkers and, through a largely emancipatory process [12], to place an emphasis on learning over teaching, encouraging what Vare and Scott [13] refer to as 'open-ended' learning (their 'ESD II') rather than on 'problem solving' or specified alternative futures (or their 'ESD I').

In this paper we introduce a visual framework for considering the pedagogy of such sustainability education in relation to this complexity. We then postulate how this space can be used to represent students' learning in relation to pedagogy and content, and suggest that this framework can be used as a developmental tool.

In considering the learning objectives for education to support the Sustainable Development Goals, UNESCO [5] (p. 7) highlighted 'learning content and outcomes, pedagogy and the learning environment'. For this paper, we have interpreted this as three specific areas or dimensions that allow us to characterize learning:

- *Learning content*: Specifically, the need for students and teaching staff to work across and between a range of academic disciplines, and to bring these together in a systems approach to address the complexity of global sustainability challenges.
- *Pedagogy and the learning environment—the ways that learners learn*: Sustainability learning must be about making use of knowledge and acquiring skills, rather than the delivery of largely factual or practical knowledge about specific subjects or preconceived 'solutions'.
- *Pedagogy and the learning environment—the ways that learners are taught and assessed*: In order to support students as learners in a sustainability context, teaching and assessment need to be aligned to the nature of sustainability education.

Although this approach is being developed within the context of sustainability education, we suggest that it can be extended or adapted to more general application across higher education. In particular, as Wiek et al. [14] emphasize, the importance of students' ability to operate across and between areas of expertise to their effectiveness in the workplace

2. Conceptual Basis

Here we develop a conceptual framework wherein we consider content and pedagogy for sustainability education. Within this defined space we construct a more generalized model that represents learning objectives, before considering learner progression.

2.1. Content: 'Disciplinarity' and Systems Thinking.

Sustainability as an academic subject involves, at least potentially, a very wide range of disciplines. Although it is not unique in this respect, sustainability learning has an explicit requirement for this

breadth to be considered [15]. It also demands not just that students and practitioners have a critical appreciation of knowledge from these different disciplines, but that they can also bring these together within a single framework, to identify the linkages, key actors and dynamics of these as a functional system [15–17]. This not only involves information and knowledge from diverse subject areas, but an understanding of the academic cultures and practices in these areas [18]. Here we explore the concept of 'disciplinarity' and how this can be described in order to support a model of sustainability education. We envisage a continuum from the study of a single discipline, to learning that involves both knowledge and practice across different disciplines.

In educational literature, away from the study of single subjects, the terminology becomes confusing and inconsistent. The terms 'multidisciplinary', 'interdisciplinary', 'cross-disciplinary' and 'transdisciplinary' are often defined ambiguously and used interchangeably [19]. It is useful to clarify these terms, as they each provide different challenges for teachers and for learners. We suggest that a 'multidisciplinary' approach is compartmentalized, and describes a situation where students study topics or modules from different subjects areas but within their individual contexts. Assessment is subject-specific with no attempt to assess learning across subjects or modules. Typically, students are left to construct their own connections.

We use the term 'interdisciplinary' here (and here equate this also to the term 'cross-disciplinary') to identify a situation that involves the study of a particular topic by drawing on knowledge from several disciplines at the same time. This requires learners to penetrate unfamiliar language and conventions, but it is relatively straightforward to implement because everything is set within a common disciplinary context. Interdisciplinary learning is interactive, expecting students to work across or between disciplines and is concerned with the links and the transfer of knowledge, methods, concepts and models from one discipline to another. It generally requires teacher facilitation to highlight the linkages rather than simply providing content and, as a result, often changes the balance between knowledge acquisition and application/skills development [18].

'Transdisciplinary' learning is a step further, and is concerned with what lies between the disciplines, across the disciplines and beyond the disciplines [16,20]. It requires students to analyze, synthesize and harmonize their connections into a coherent whole that lies beyond the culture of any single discipline, and is therefore emergent. In this sense some authors, (e.g., [21]) describe transdisciplinary knowledge as holistic. The term 'holistic', however, is used in the literature to describe many different types of learning. It is sometimes aligned with the concept of disciplinarity, implying integration and making connections [21]. At other times it is associated specifically with 'whole person learning' which engenders meaning, identity and purpose in the learner [22]. Given this ambiguity we avoid the term 'holistic' in this paper.

In Table 1, we summarize disciplinarity in a way that contributes to a conceptual model of sustainability education. We represent this later as a continuum but also recognize that learners may occupy different places in this space at different times. Where learners are located will depend on their 'learning context'; that is what is required of them at any particular point in the program and their perceptions of this [23].

Table 1. Disciplinarity—the categories are seen here as forming a continuum. The 'locus' is a label for the position of the learner on that continuum.

Locus	Disciplinarity	Looks Like
Da	Single discipline	All learning takes place within a prescribed subject area
Db	Multidisciplinary	Learning includes elements from different subject areas, but remains compartmentalized.
Dc	Interdisciplinary (also cross-disciplinary)	Learning includes elements from different subject areas that are used to construct coherent learning activities which sit at or between subject boundaries.
Dd	Transdisciplinary	Learning embodies the cultures of different subject areas to develop emergent properties which provide new approaches to complex or 'messy' problems.

2.2. Pedagogy and the Learning Environment: Ways of Learning

There are numerous taxonomies of learning, which describe different kinds of learning behaviors and characteristics that we wish our students to develop. Taxonomies are also often used to identify different stages of learning development and most have a hierarchical structure (e.g., [24,25]). In general, they divide into descriptions of the form of learning, for instance theoretical versus practical; the degree of involvement of the learner, for instance active versus passive, and the context of the learning, for instance individual versus social (see also O'Neill and Murphy [26] for a useful review).

Cognitive learning, or 'learning to know', has been the dominant learning paradigm in formal western education for at least the past two centuries [22]. Although there is an acknowledgement that learning is not only a cognitive concept, it is learning in the cognitive domain which has dominated our attention. Unsurprisingly, the majority of educational literature focuses on 'how best to know' from both theoretical and practical perspectives. For example, Bloom's [24] and Krathwolhl's [25] educational taxonomies, based on a staircase or pyramid of ascending skills in dealing with acquired knowledge, are widely cited. Despite their numerous criticisms and revisions [27], they continue to influence the development of curriculum and assessment.

The outcomes of sustainability learning are likely to lead to a change in learners' perspectives and may therefore be described as transformational [28]. However, we posit that they require more than the rational and analytical processes central to Mezirow's theory of transformational learning [29]. In this respect they align more closely to the ideas of those who argue that a transformational learning process is also spiritual and emotional (e.g., [30,31]). Sustainability learning is also distinct in that its transformational outcomes are specifically directed towards the goal of a creating a sustainable future. In Mezirow's theory of transformational learning, critical thinking and reflection are central components, and these skills are widely and positively promoted across higher education [32], not only sustainability education. Although critical thinking and reflection are essential pre-requisites for sustainability learning, these are largely cognitive traits which, on their own, are insufficient to bring about action and change, defining features of sustainability education [33,34]. In the sustainability education literature, Bateson's 'learning levels' [35] and Sterling's 'levels of knowing' [36] are similarly constrained within the cognitive domain, although Sterling does acknowledge the work of Rogers [37], Hicks [38] and others who emphasize the importance of non-cognitive dimensions of learning.

Whilst cognitive education is necessary for changing human behavior, it is not sufficient; there also needs to be personal emotional engagement [38–40]. The cognitive and intellectual understanding of sustainability may only be weakly associated with individuals' engagement with major environmental issues [41,42] and, to date, we have not seen sustainability education engage seriously with this basic issue [43]. The need to operate beyond the cognitive dimension also addresses the so called 'value-action' gaps, and 'knowledge-action' gaps which appear to be particularly prevalent in matters concerning the environment [44,45]. These are the subject of substantial research and debate amongst psychologists, e.g., cognitive dissonance theory [46] and, more recently, social scientists, e.g., social

practice theory [e.g., 34]. From this research, it is possible to glean the conditions under which societal behavior can change, but not the conditions which prompt such change.

Non-cognitive dimensions of learning are described by Sipos, Battisti and Grimm [22] as affective, existential, empowerment and action dimensions. The authors note that both the cognitive and non-cognitive dimensions of learning have to be present for what they describe as transformational sustainability learning (TSL). In short, they refer to this learning as learning with 'the head, the heart and the hands' and it corresponds to the cognitive (head), psychomotor (hands) and affective (heart) domains of learning [22,47]. Dettmer [48] also identifies four domains of learning, which she terms as the cognitive, affective, sensorimotor and social domains. She then adds a fifth 'unifying' domain to unite "the phases of all four domains into a function of the whole" [48] (p. 76). For all these authors, the purpose of learning beyond the conventional cognitive domain is to bring about personal change in the learner, and specifically personal and societal transformations to sustainability. We characterize a simple continuum of learning that unites these features in Table 2.

Table 2. A continuum of learning in the context of sustainability education.

Locus	Ways of Learning	Looks Like
La	Factual recall	Cognitive and passive: Learning is passive, comprising assimilation and recall of factual material
Lb	Understanding and interpretation	Cognitive and active: In addition to factual recall, learning engages with underlying processes, enabling extension and generalization. Learning literacies emerge and are reinforced.
Lc	Analytical and experiential	Cognitive and psychomotor *: Learning is active and is based on authentic experience and higher-level skills, with reduced emphasis on knowledge and information by comparison with analysis and interpretation. Personal development as a lifelong learner.
Ld	Emotional and reflexive	Cognitive, psychomotor and affective **: Learning is also immersive and social, with a high level of personal engagement and personalization. Personal development as a lifelong learner and an agent for change.

* Psychomotor learning involves practical engagement with the subject, either intellectually or physically, and is associated with, and reinforced by, exploration, analysis and the application of knowledge, perhaps leading to the creation of knowledge or artefacts. ** Affective learning, in contrast, is strongly personal and reflective, and is more concerned with attitude and values than with absolutes of knowledge and understanding.

2.3. Pedagogy: Ways that Learners are Taught and Assessed

We have argued that sustainability education, which requires a personal engagement and change, exists at the inter-and trans-parts of continua of disciplinarity (Section 2.1 and Table 1) and ways of learning (Section 2.2 and Table 2). It therefore follows, that forms of teaching and assessment also need to support learners to operate in this position.

The 'classical' teaching model in higher education is caricatured as the 'sage on the stage' [49], where learners receive information from an 'expert' and are expected to be able to provide evidence that they have assimilated or can recall that information—'assessment **of** learning' (Ta: Table 3). This sits squarely within the cognitive domain of learning, where subject knowledge is the primary currency rather that learning skills or literacies. It does not provide good support for active cognitive learning, nor for psychomotor or affective learning, because the model is effectively one-way or transmissive [40].

In modern higher education in the UK and many other countries, there is an increasing emphasis on teaching that develops learner's skills in addition to their assimilation of subject knowledge (Tb: Table 3). 'Flipped' approaches to teaching [50], provide good examples of the process of giving learners more responsibility for their learning, at the same time developing interpretative skills that support the application of knowledge. Instead of assessment being a test of information assimilation and recall, assessment forms part of the learning process—'assessment **for** learning' [51]. As a by-product of this form of teaching, learners gain skills that they can apply outside of their studies, for instance in

employment, and it is often highly appropriate to academic fields where subjects change rapidly or where new subjects emerge at discipline boundaries.

Beyond the facilitation model, which remains fundamentally in the hands of the institution and teachers, lies a learner-led environment that supports collaborative learning (Tc: Table 3). Students have a fundamental role in their own learning alongside their peers, teachers and a wider academic community. They have the freedom and, crucially, the support, to learn in their own way (Ld: Table 2). Assessment is woven into this process as a reflexive activity—'assessment **as** learning' [51]. Learners gain the practical and emotional skills that they need as life-long learners.

Table 3. A simple continuum of teaching and assessment (compare with Tables 1 and 2).

Locus	Ways of Teaching and Assessing	Looks Like
Ta	Transmissive, 'assessment of learning'	Teacher-led, didactic, asks 'has it been learned?'
Tb	Facilitation, 'assessment for learning'	Fostering active learners, supporting learning skills such as criticality, asks 'what has been learned?'
Tc	Co-production, 'assessment as learning'	Learner-led. A learning community, peer support, assessment as reflexive process, asks 'how do we know?'

3. A Pedagogic Framework

We have suggested three scales or continua—disciplinarity, learning, and teaching and assessment, which summarize these essential aspects. The pedagogic dimensions describing how learners learn and how they are taught can be considered as axes defining a pedagogic domain. Although our classification is highly generalized, it reflects current approaches to pedagogy in all areas of higher education [52,53] and provides the foundation for a conceptual framework. Furthermore, we have already noted that there are likely to be relationships between the two axes, in that active learning will be fostered by teaching and assessment in a learning community.

We have identified that 'disciplinarity' provides a way to describe learning and we argue that sustainability education, which includes sustainability both as a 'subject' and as an 'approach', places special demands on learning and teaching (see Section 2.1). That is, as a taught 'subject', it operates outside the confines of discipline boundaries and as an approach it must engage learners in cognitive, psychomotor and affective learning. The ways in which learners learn, and are taught and assessed, must take this into account.

To represent this, we can construct a three-dimensional space, where disciplinarity forms the z-axis (Figure 1). We suggest that it is at least conceptually possible to describe how the attainment or development of learners can be represented in this pedagogic space.

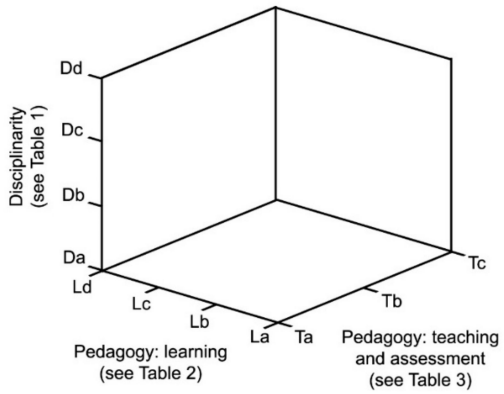

Figure 1. A three-dimensional pedagogic space defined by two pedagogic (x- and y-) axes and disciplinarity.

Using the Framework as a Space to Describe Learning Objectives and Outcomes

Having defined a 'pedagogic space', how are learning objectives and outcomes situated within it? We need to visualize how the three axes constrain how learning takes place and where particular forms of learning are situated. We suggest that didactic teaching and assessment (Ta: Table 3) and passive learning (La: Table 2) would be unlikely to allow learning beyond a single discipline. Conversely, learning at cross-disciplinary and transdisciplinary levels would require active and reflective learning (Lc, Ld: Table 2) and teaching and assessment that supports this as a collaborative activity (Tc: Table 3). We expect that, for a given level of teaching and assessment, increasingly active and experiential learning will allow learners to progress cumulatively along the disciplinarity axis. Similarly, for a given level of learning, more facilitative teaching and assessment will also allow learners to address more complex issues further along the disciplinarity axis. We represent this relationship by a surface within the pedagogic space defined by the three axes (Figure 2). Sustainability education occupies the part of the space where transdisciplinary learning is supported. This implies that curriculum design needs to adopt pedagogic approaches that facilitate learners to reach and occupy that space.

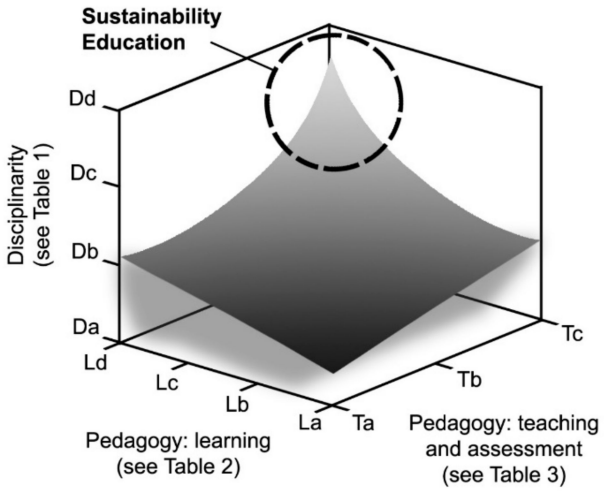

Figure 2. A conceptual model of the inter-relationships between the continua of pedagogy and disciplinarity (Sections 2.1–2.3 and Tables 1–3). The surface illustrates the levels of learning, teaching and assessment needed to enable learners to operate at different disciplinarities, and suggests that sustainability education needs to incorporate 'higher' levels of both learning, and teaching and assessment in order to support learners' autonomy and their capacity as agents for change.

4. A Learning Journey?

We have also tried to envisage what this approach means for an individual learner. If our model has some validity, it should be possible to plot their position in the pedagogic space. In Figure 3 we have indicated some of these positions by the 'balls on sticks'. We envisage that learners may occupy various locations within the space defined by the three axes at various times and in different contexts, but that the surface defines the upper boundary for possible learner locations within this space (Figure 2). In particular, we propose that transdisciplinary learning is unlikely to occur where learning is passive and teaching is content-driven (see Sections 2.2 and 2.3). Based on that assumption, the surface in Figure 2 divides the space into two parts. Beneath the surface are compatible combinations of the three variables: appropriate combinations of the pedagogic variable that support the corresponding disciplinarity (Figure 3). The remaining volume above the surface contains combinations that should be incompatible: pedagogy is inappropriate to the disciplinarity.

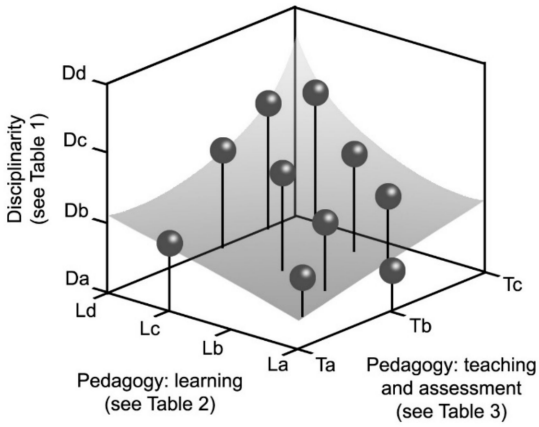

Figure 3. Students can be located on and below the pedagogic surface to represent different feasible combinations of pedagogy and disciplinarity (see text in this Section).

Based on a typical discipline-specific learning background, we posit that a sustainability learner will enter this space with relatively low 'pedagogic capital' and function only at a single-discipline level, constrained to what Sterling [3] refers to as lower levels of learning and what Vare and Scott [13] describe as ESD I. With developing pedagogic capital, a student is able to engage with higher levels of disciplinarily, and to function in a manner which we liken to Sterling's higher levels of learning and Vare and Scott's ESD II [13]. In Figure 4, we visualize this as a generalized trajectory with a hypothetical student progressing 'upwards and backwards' within the space to the region where sustainability education needs to operate in order to support learners fully and to address the requirements of the SDGs (Sustainable Development Goals) [5].

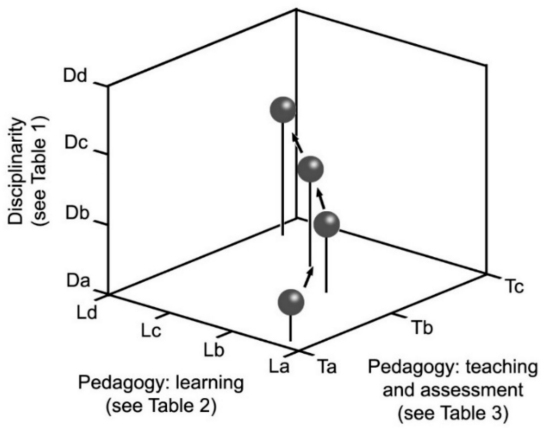

Figure 4. Generalized trajectory to effective sustainability education.

5. Reflection and Conclusions

As part of SDG4, Quality Education, Target 4.7 calls for all learners to acquire the knowledge and skills needed to promote sustainable development. For at least a decade there have been calls for 'a paradigm change in thinking, teaching and learning for a sustainable world' [54] (p. 3) and intense discussion of the pedagogical approaches which make possible the development of the key competencies needed for promoting sustainable development (e.g., [3,55–57]). In this paper we have explored a conceptual model of what this might look like, based on our experiences of designing and delivering a Master's program in Sustainability in a modern (post-1992) UK university.

We have developed this conceptual model using the notion of disciplinarity, combining this with ways of learning to visualize the development of students' perceptions towards emancipatory change agency. Within this space we might also expect students, not only to have gained mastery of individual

competencies, but also the ability to combine these in a meaningful and effective way [17,58]. In this case disciplinarity becomes a useful metric for many other areas in higher education in the current environment where, for example:

- Employers place emphasis on transferable skills in addition to, or even over, academic mastery [59];
- Successful graduates are likely to move through several different employment rôles, some or most of which will not relate specifically to the subject of their degree;
- Subject boundaries are blurred, new subject areas are emerging, and subject specialisms are developing from the fusion of different fields with different cultures (for instance within biotechnology where 'classical' bioscience and data science are fusing).

How Can We Use the Model?

The model is a visualization of the elements that we have identified as important in sustainability learning in higher education, interpreting the UNESCO objectives [5] as three scales that we can use to represent learning, teaching and content. It has two potential uses. First, it can inform the design of curricula which address SDG Target 4.7. Specifically, this is a curriculum designed to support learners' progression towards transdisciplinary learning and change agency. In so doing, learners will also be gaining competencies valued by employers, such as an understanding of the complexity and uncertainties associated with system interactions, and the ability to be reflexive.

Second, it will allow learners to plot their progression as a developmental activity. To be useful in this context, the model needs to be applied in a way that allows a learner's locus to be defined within the space. A variety of metrics could be suggested, but since the process is learner-centered, we propose that the most useful way to represent a learner's trajectory in this space is to encourage them to reflect and self-assess. This could form part of an auditing process such as module feedback questionnaires, or as dedicated research on the three dimensions of the model. In either case, it would need to be replicable, and robust for different educational and cultural backgrounds. We are currently trialing the use of responses to three sets of statements, each of which was designed to embody one of the loci on one of the scales (for example: "Most of my recent learning has included different subjects or disciplines, but each has been studied on its own without relating it to the others" to represent disciplinarity locus Db). Students are asked to select the statement most appropriate to their current experience at different points through the program. We are happy to share this and invite readers to apply this model to their programs in order to test, refine and develop this model further.

In our context (a UK Level 7 program which adopts an active learning approach), we are interested in the change in students' perception of their learning as they progress through the program, contrasting this with their educational experience on entry. If the model were applied to an undergraduate program it might be useful to consider how different approaches to teaching could be introduced at different levels, for instance, active- versus passive-learning [49–53] or changes in the nature of independent learning [60].

We also propose that the model could be adapted to other pedagogic purposes. As noted earlier, the framework underpinning the model (the x- and y- axes) derives from conventional perspectives on the various forms/styles of learning, teaching and assessment [23–27]. We have adopted a specific, although generalizable, third (z-) axis that is suited to our objectives in sustainability education. However, it is easy to envisage alternative formulations of this axis that could embody measures of competence, autonomy or personal/professional development.

Author Contributions: Both authors contributed to the conceptualization and writing of this article. The graphics were produced by J.P.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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