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Implementing Competence Orientation: Towards Constructively Aligned Education for Sustainable Development in University-Level Teaching-And-Learning

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Abstract: The call for integration of competences in tertiary education for sustainable development (ESD) has been heard. Helpful competence models for ESD are available but little exists about how to put them into practice. As illustrated in this article in an initial review of competence models for change agency, this is not easy because competences are fundamentally context-bound and generalized models make little sense. Faculty staff who wish to foster competences for SD therefore need help with contextualising and operationalising competences. They often lack the pedagogic-didactic understanding needed to implement competence orientation in their teaching, in an institutional context where knowledge transmission is traditionally rated higher than competence development. Using a reflective practitioner approach, this paper addresses the need for methodological guidance by introducing a heuristic procedure and a didactic planning tool from adult education that enable lecturers to establish coherent ESD teaching-and-learning environments and curricula: the tree of science model and constructive alignment. Two case studies show how these instruments can be used to increase coherence when operationalising competences for SD. The article concludes by outlining three factors that foster integration of competence orientation in ESD: pedagogic-didactic tools, professional development for ESD, and institutional change.

Keywords: competence orientation; tertiary education; ESD pedagogy; ESD teaching; constructive alignment; reflective practitioner approach

1. Introduction

Competences are increasingly the focus of attention when assessing the quality of education systems, in the wake of a growing interest among education specialists in evaluating the actual impacts of education beyond classroom results [1,2]. This focus on competences in relation to the definition of quality education also characterizes education for sustainable development [3] (see also the Sustainable Development Goal 4, Quality Education). However, when it comes to implementing education for sustainable development (ESD) in teaching, the focus on competences is a challenge, particularly for higher education institutions, as most countries still lack concrete institutional, thematic, and methodological guidance for how to shape teaching-and-learning processes [4]. They also lack

systematic professional development for university teachers interested in integrating sustainable development into their courses [5]. The present article addresses these challenges.

The United Nation's Decade of Education for Sustainable Development, which ran from 2005 to 2014, resulted in countless invaluable initiatives, papers, and recommendations, paving the way for focusing on competences for sustainable development in teaching at a larger scale. Some voices called for adoption of education for sustainable development (ESD) at universities early on [6,7]. But it was only towards the end of the ESD decade that a larger community began discussing how higher education institutions (HEIs) should implement ESD in teaching [4,8,9] and how the emphasis of learning outcomes in HEIs should shift towards a competence orientation [10–12]. A stronger focus on competences in relation to the debate on sustainable development had been prepared by Rychen and Salganik [2,13] and other forerunners such as Sterling and Thomas [6] and de Haan, whose *Gestaltungskompetenz*-based model for ESD [14] was successfully introduced in 200 schools at secondary level in 15 of the 16 German federal states [15]. But HEIs were not yet ready for this step [16,17].

Indeed, what we need for sustainable development (SD) are change agents with a normative orientation, not just students who acquire knowledge about SD but do not know how to act accordingly [18]. Change agents need to be able to deal with the challenges of transformation towards SD [19,20], which are often wicked problems and ethical dilemmas [21,22]. At the level of educational objectives, this implies a shift from knowledge-orientation to action-orientation and therewith a shift to competence-orientation in teaching at all levels of education [3,23], including in HESD, where this shift is even harder to achieve [24,25].

The need for a shift in teaching requirements and the corresponding institutional change at HEIs have been explored in different ways. European and American researchers and university lecturers such as Matthias Barth, Gisela Cebrián, Gerhard de Haan, Rodrigo Lozano, Marco Rieckmann, Arnim Wiek, and colleagues [9,26–32] conducted research and developed strategic agendas before the end of the ESD decade, reflecting on both prevailing and sustainability-oriented teaching practices at various universities. In addition, today, various overviews of competences for SD in HE [33,34], comparisons between different approaches, and reflections on potential pathways for taking into account competences in teaching-and-learning practices are available [6,9,35,36]; but the debate is fragmented and rarely based on thorough pedagogic foundations [37] (pp. 2771–2772). Moreover, very often the call for action- and value-oriented competences in teaching has come from the community of scientists interested in conducting research for sustainable development; they have argued for training competences for inter- and transdisciplinary research at the PhD level [38], often without being aware of the ESD debate.

The implementation of competence orientation at HEIs is also hampered by didactic challenges and a lack of knowledge and experience among university teachers regarding how to adapt their teaching practices to the need for competence orientation [5,21,37]. Faced with the multiplicity of options currently offered in the literature on sustainable development, it is not easy for university teachers who do not have a background in didactics (a) to choose what competences are aligned with their educational objective and (b) to operationalize these competences in their teaching, in particular with regard to verifiable learning outcomes and other didactic decisions when designing educational settings [9,39].

The need for developing pedagogic and didactic foundations when debating how to implement ESD at tertiary level is also necessary from an institutional point of view: how can competences in tertiary education be fostered in a structural setting that is sceptical of the need to move towards a "great transformation" [40]? Despite the Bologna process, the majority of HEIs still do not see the need for the paradigm change from teaching to learning [16,41]; in addition, the habitus of science shapes teaching, stressing the importance of knowledge generation rather than competence development, and the HEI context is characterized by a primacy of research over teaching [42], leading to low numbers of faculty staff with systematic professional development in didactics and pedagogics, as this is rarely a career incentive [43,44]. Most faculty staff today develop their teaching skills in an autodidactic manner instead of attending professional development programs [5]. As a result, they know how to provide *knowledge* on sustainable development-related aspects in their disciplines, but they lack

experience of shifting their teaching towards a *learning* approach. Indeed, even at higher education institutions where ESD has been integrated in a systematic way in curricula, e.g., at some HEIs in Belgium or the Netherlands, more support for implementing ESD in teaching-and-learning practices seems to be needed [45].

Our ambition in the present article is to support enhancement of the professionalism of university-level teaching committed to ESD (HESD) and to improve its reference framework. We aim to offer faculty staff more appropriate pedagogic-didactic foundations to enhance the quality and impact of their university teaching-and-learning for sustainable development. We do this

(a) by showing that it does not suffice to only answer the question "which competences should we select when implementing HESD" at a purely theoretical level, as this neglects the very nature of competences and particularly their context-dependency [2],
(b) by shifting the focus from the "which competences" question to the question of "how" to operationalize them in teaching situations based on pedagogic-didactic foundations,
(c) by showing how (a) and (b) can be addressed constructively when using a combination of constructive alignment [1] and a tree of science approach [46].

2. Approach and Methods

We adopted a qualitative approach shaped by our tertiary teaching-and-learning experiences, as well as by repeated discussions with ESD peers and literature reviews. We worked in an iterative way and used a process of reflection on practice led by theoretical assumptions, adopting a "reflective practitioner" approach [47,48]. Our pedagogic-didactic argumentation is characterized by a systemic-constructivist understanding of education [30,49] and of learning [50] (p. 86). Our understanding of transformation is based on the German Advisory Council on Global Change's Flagship Report [40] while our definition of change agents is inspired by Hesselbarth and Schaltegger [19], among others. Although the reflective practitioner approach does not generate comparable and quantifiable results, it is considered a sound and appropriate method in the context of systemic-constructivist pedagogy.

As we are educating change agents in a higher education context, we explored literature focusing specifically on competences for SD and on the relation between knowing and doing (action-orientation). Our intention was not to compile a complete overview of competences for SD; such overviews already exist [27,34]. Instead, we looked for models in specific contexts of application in the tertiary education context: we focused specifically on work that offers insights into how to enable students as well as lecturers or external partners of university-level teaching to become problem solvers, change agents, or transition managers coping with transformation in society on an individual or collective level. We wanted to select contrasting cases from different areas of practice with a view to comparing a variety of competence models. Our goal was to find out what competence profiles exist for leaders and change agents for SD, using two lead questions:

1. What competences do we select for the educational objective of fostering change agency at tertiary level?
2. How can we implement competence orientation in tertiary teaching and operationalize competences in learning outcomes?

In addressing question 1, we compared and structured various competence profiles based on the educational objective of educating change agents who are contributing to sustainable development in a broader sense. The educational goals are either explicitly mentioned by the authors of the competence profiles or were summed up by the authors of the present article. We decided to use the key competences formulated by Wiek et al. [27] as a reference framework, as the authors derive them from educational objectives that answer our question 1. These objectives are:

- to enable students to become systemic problem solvers, change agents, and transition managers [27] (p. 204) towards more sustainable development of our society in different areas,

- to enable them to deal with wicked and complex problems and ambivalent situations related to sustainable development in uncertain and often rapidly changing environments,
- and to help them develop leadership skills.

While reviewing the literature, we tried to identify what the competences had in common, how they complemented each other, and how they differed, always in relation to our focus on change agents or leaders for SD and the context of higher education. In the course of this review we identified several challenges that made it difficult to compare competence models. These challenges were all related to issues of concretization and operationalization. We categorized the challenges according to six issues. After characterizing the issues, we decided to move from focusing on "what competences do change agents need" to "how can these competences be fostered in a higher education context", since it had become obvious that questions related to concretization and operationalisation always had to be answered before a comparison was possible. A further step was to refine our understanding of "competence" and to explicitly address the need for paying attention to the contextualization of a competence.

To address question 2, we used the tree of science model [46] as a heuristic procedure and combined it with a didactic procedure, constructive alignment [1]. Both procedures are state-of-the-art in didactics but are hardly known in the context of ESD. They helped us overcome the challenges of comparison that we had identified. They also helped us shift our attention from *what* competences are needed to *how to foster* them. Use of the two procedures also helped us analyse examples from our teaching practice. We then selected two examples from our own practice as case studies to illustrate the application of the tree of science model and the constructive alignment procedure within the HESD context.

In the following sections, we present and discuss the results of this reflective practitioner process and explain how using tree of science heuristics and constructive alignment can help address the challenge of operationalizing competences when teaching in the context of HESD, and support learning for change.

3. Structuring and Comparing Competences for SD in HE

Our literature review confirmed that a very rich body of work is available on competences for SD [8,14,27,29,33,51–53] but that not much of this work focusses on the perspective of fostering ESD teaching from a pedagogic-didactic perspective [5,9,35].

Using Wiek et al. [27] as a reference model for tertiary education for sustainable development, we identified commonalities and differences among the selected competence models (Tables 1 and A1). Where the authors to whom we refer in the first column of Table 1 did not explicitly define educational objectives (*Bildungsziele* in German), we complemented the information by relying on an interpretation of their reference to an HEI's mission.

Table 1. Overview of the selected competence models for education for sustainable development (ESD), structured according to fields of application and educational objectives.

References	Fields of Application	Educational Objectives
Wiek et al., 2016; Wiek et al., 2011a; Wiek et al., 2011b [27,28,54]	ESD in higher education (tertiary level)	Focus on systemic-problem solvers, change agents and transition managers [28] (p. 4) to take lead(ership) in change and transformation processes towards sustainable development.
Rieckmann 2011; Rieckmann 2012 [29,33]	ESD in higher education (tertiary level)	"Education for Sustainable Development (ESD) aims to develop (key) competences that enable individuals to participate in socio-political processes and hence to move their society towards sustainable development" [29] (p. 128)

Table 1. *Cont.*

References	Fields of Application	Educational Objectives
de Haan 2006; de Haan 2008 [14,55]	ESD in primary education, though the model can be and has been transferred to higher education	"'Gestaltungskompetenz', or 'shaping competence', means the specific capacity to act and solve problems" [14] (p. 22); related to sustainable development challenges.
Folkmann and Zenger 2016; Zenger and Folkman 2009 [52,56]	Change agents and leadership in general; transferable to education for SD in higher education	Capacity to lead in an extraordinary way; aim to become an extraordinary leader for change who has real impact on customers, customer satisfaction, profitability; this includes change situations. Take lead(ership) in change and transformation processes.
OECD 2005 [51]	Key competences in general in society, assumption that ESD in higher education contributes to ESD in society in general	The educational objective is to enable citizens of OECD countries to develop key competences to master change in complex and rapidly changing environments and to cope with the main challenges of the 21st century, i.e. (1) rapidly and continuously changing technology, requiring "not just one-off mastery of processes but also adaptability". (2) "More diverse and compartmentalized society, with interpersonal relationships requiring more contact with those who are different from oneself". (3) Globalization, which "is creating new forms of interdependence" (p. 7).
UNECE 2012 [8]	Key competences in teacher training; assumption that ESD in HE contributes to quality ESD in the education system; this competence model is meant as a basis to train educators in every field of ESD: formal, non-formal, and informal, with a special focus on formal education.	Focus on empowering educators to become agents of change within education systems that aim towards ESD. Effective educational transformation is dependent upon educators being motivated to bring about change, as well as their being capable of and supported in doing so (pp. 9–10).
Meijers et al., 2005 [53]	Higher education (basic academic competences), particularly in engineering sciences	Based on the higher education institutions (HEIs)'s mission statement, the educational objective is to enable students of universities to develop an academic profile particularly in the complex world of engineering sciences, where design and application play an important role in addition to the development of theories (pp. 2–3).

There is an overall coherence between the models offered by Wiek, Rieckmann, and de Haan, in so far as they relate to a core or key competence of *gestalten*, i.e. designing or shaping. Thus, they address problem solving, and therefore *taking action*. In addition, de Haan [55] refers to the OECD model [51] and matches his competences with the OECD categories. The other models show a connection with Wiek et al. [27] but less similarities with Rieckmann, de Haan, and OECD. Interestingly, Folkman and Zenger [52] overlap with Wiek, as they are educating not just leaders, but leaders for *change*. But in their case, the aim of fostering competences to take leadership is not specifically oriented towards transformation for sustainable development. The competence profile developed by Meijers et al. [53] is an exception: it is formulated for academic degrees in engineering and aims to enable students to cope with complex, messy, and elusive problems. Although not mentioned explicitly, these include to be able to address change and sustainability topics.

Our review also showed that most models do not explicitly include competences to initiate and navigate personal change and learning, which, in our understanding, is fundamental to cope with, and in particular to lead, change [56,57]. Indeed, transformative learning needs to take place both at an individual and a collective level, taking into consideration the interdependency between individual and collective learning processes [49]. Folkman and Zenger [52] are an exception: they explicitly address personal change capabilities, including self-reflection, personal resilience, and role consciousness. Meijers et al. [53] address the personal level as well, in relation to an individual's own role as a professional in society. This role is characterized by professional behaviour and includes drive, reliability, commitment, accuracy, perseverance, and independence (p. 21).

Overall, these competence models focus on the need for enabling individuals to shape the future, i.e. for going beyond acquiring knowledge in order to take action; but they do it in different ways. All models insist on the ability to deal with complex problems and future challenges, i.e. on tasks in social contexts that require a multidimensional perspective and the involvement of different disciplines and heterogeneous groups of actors. Supporting change and developing sound solutions includes the ability to conduct dialogues and to negotiate between different perspectives and values (normative aspect). These results confirm the findings of Barth [50] (pp. 63–64), who compares partly similar models, describing them in terms of ESD learning objectives. Highlighting the need for fostering competences for taking action—as underlined by all the above-mentioned authors—does not mean, however, that this will lead an HEI to systematically implement action-oriented and problem-based learning [25]. Indeed, it remains very challenging to foster such competences in a higher education context, as HEIs are still mainly knowledge oriented [16,31].

Our closer analysis of the chosen competence models revealed discrepancies in the basic understanding of what constitutes a "competence" (see Table A1). Most of the authors described *aspects* of behaviour or rather *areas* of competence that have to be specified, rather than competences. Moreover, the level of specification of these behaviours or areas of competence differed and it remained unclear *what* concrete competence needs to be fostered to achieve what *specific* action. While it was possible to compare the competence models, the comparisons pertained only to the *areas* of action. Comparisons of the models at the level of clearly operationalized competences in the form of learning outcomes were not possible: either the models remained vague about specifics, or the specifications were too different to be comparable. This was probably due to the fact that the competence models either did not explicitly take into account the relevance of the contexts in which the competences are applied, or did so only in a vague way. In his analysis of the state of the art in the field of ESD competences, Rieckmann [58] came to the same conclusion and therefore asked for a stronger differentiation between competence profiles according to fields of application (p. 95). To avoid using the term "competence" in an imprecise way, we therefore found it necessary to further clarify the concept itself.

3.1. Revisiting the Concept of Competence

In pedagogy, the concept of competence implies normative decisions and context dependency [2,51,59,60], leading to value-guided action in concrete situations. Context and values are essential premises for the very understanding of a competence for sustainable development. We therefore relied on Rychen and Salganik [2] (pp. 41–62), who defined the concept in the broader context of "cop[ing] with the main challenges of the 21st century". According to OECD [51] (p. 4), competences cover knowledge, skills, attitudes, and values. This involves the ability to meet complex demands by drawing on and mobilising psychosocial resources (including skills and attitudes) in a particular context. This definition of competences is similar to Le Boterf's understanding [59,61]; with regard to change agency, however, Le Boterf's definition is slightly more adequate than Weinert's [62], and should therefore be preferred when reflecting on how to operationalize competences. Indeed, Le Boterf defines competence as the ability to mobilize resources for solving problems and challenges in life in specific contexts, insisting on the importance of considering performances (see Figure 1),

while Weinert focuses mainly on cognitive and personal aspects of competences, thus insisting on the importance of the individual. For Le Boterf, it is important to *empower* the individual to *solve* sustainability problems. For Weinert, it is essential to *increase* an individual's *willingness* to act, the conclusion being that adequate action will automatically result from enhanced consciousness of sustainability problems.

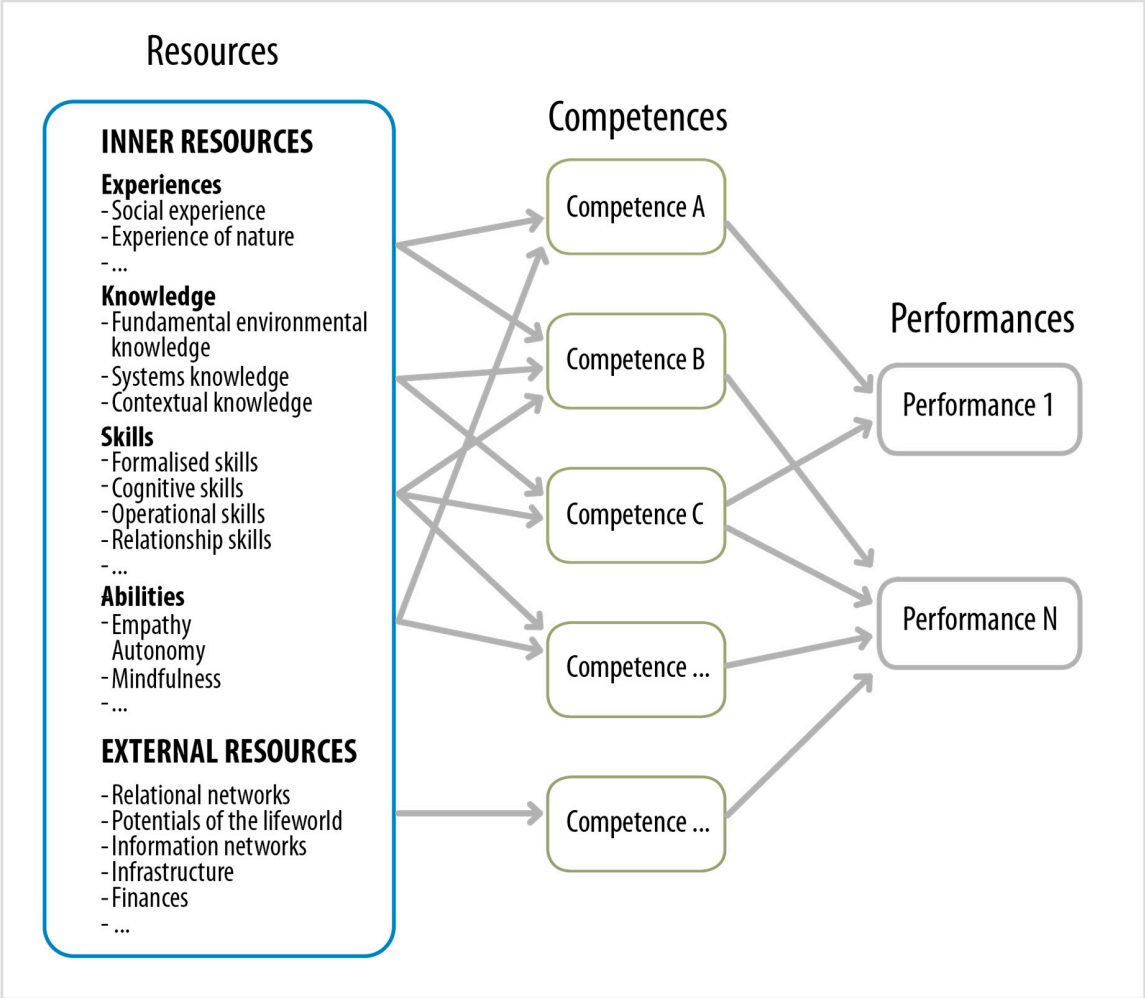

Figure 1. The Swiss Conference for Environmental Education's [63] definition of competences, based on Le Boterf [59,61], translated by the authors of the present article.

The value of this model is that it distinguishes between resources, competences, and performances. Indeed, in teaching situations, it is only possible to transmit and train resources, not competences [64]: theoretical debates on competences insist on the fact that competences can neither be transferred nor taught, but only acquired in a specific context [2,18,30,65]. A competence is expressed in a performance (*Gestaltung* or shaping) and can thus only be assessed in the actual achievement of a task when solving problems and dealing with challenges. However, a performance never reveals a person's *entire* competence: it only shows the part that enables a person to act in a specific situation [61]. This is another reason why the context is so important in describing competences. In addition, when sustainable development is defined as the ultimate goal of education, as is the case for ESD, it is essential to integrate the value dimension of action in the definition of competences; in Figure 1, values are implicitly integrated in the inner and external resources, thus also permeating the competences and performances.

When planning a teaching-and-learning situation, the didactic principle of "competence orientation" thus requires asking about future contexts [9] in which knowledge, attitudes, and skills will be necessary. Moreover, when dealing with competence orientation, we have to explicitly define for what kind of problem and in what contexts the performance should be shown; this should be formulated as an educational objective and operationalized as learning outcomes.

3.2. Moving from Comparison to Operationalisation

To sum up, although we found common elements and some similarities among the competence profiles, the models turned out not to be comparable because they did not clearly refer to the concrete context to which they apply, although this context plays a role in their conception. In addition, they were shaped by a rather broad spectrum of understandings, framings, and definitions of competences. This fuzziness has also been underlined by other authors [20,58,66,67].

Because of the fundamental context-boundedness of competences, trying to compare competence models developed in different contexts and based on different understandings of the role of education does not make it possible to answer the following question: "what competences are key competences for sustainable development?" Nor is it useful to try and develop a universal meta-profile to help universities structure their efforts towards implementing education for sustainable development. This was the original goal of our comparison. But the spectrum of descriptions and lists of competences was so heterogeneous that it could at best serve as a "shopping list", not as a meta-profile for ESD at HEIs. In addition, it became clear that the ambition of developing a meta-profile is inspired by a claim of absoluteness that is inadequate in the context of sustainable development [68].

Further systematic analysis of the challenges we met in comparing competence models revealed additional reasons why they were difficult to compare:

Issue 1: Specificity of the field of application For example, different levels of expertise are required in the professional fields in which students will perform specific tasks after completing their HE degrees.

Issue 2: Granularity (level of detail/resolution) The granularity of the competence categories and subcategories was very different. Thus, attempts to establish matches among the models seemed partly arbitrary.

Issue 3: Hierarchies and dependencies When comparing competences among models, it would be necessary to take into account hierarchies and dependencies among competences.

Issue 4: Operationalisation For all models, it seemed difficult to break down the competences into tangible learning outcomes, since they are quite abstract (see also Issue 2). There is a trade-off between being precise enough and over-differentiating competences. But operationalisation *must* take place when applying the model to a concrete context and application [18]. It may seem particularly demanding, however, to operationalise a model that has more than 40 competences, which in turn must be further broken down into learning outcomes, and finally also be assessed [53].

Issue 5: Learning environments It is not clear at which level of educational offer the proposed competences are meant to be applied: for a curriculum or for a single course? This will necessarily influence operationalisation.

Issue 6: Taxonomy The level of expertise to be achieved by learners was often unclear: do they need to be experts in the field or only novices? The models we analysed did not specify this, except for Meijers et al. [53].

These challenges are rooted in the nature of competences, particularly in their contextuality (Issue 1) and in the way they have to be operationalised (Issue 4). In the following sections, we only deal in detail with Issues 1 and 4, as they are the challenges that have the greatest influence on didactic decisions. To be useful, contextualization needs to consider a comprehensive framework of analysis:

this can only be achieved through a balanced analysis of the target group and an in-depth inquiry into the future professional fields that students will choose and the tasks they will fulfil as change agents.

In relation with this problem, we found that competences in the chosen competence models were partly formulated in similar ways, but the implied application context differed in terms of target groups as well as educational contexts (school, teacher education, tertiary education, professional education, non-formal learning). The need to take into account this diversity, too, requires different solutions when operationalizing competences.

4. Toward a Pedagogic-didactic Anchoring of ESD in HE

As shown above, the identified challenges connected with the implementation of competence models are not specifically related to the ESD context: they are mostly general pedagogic-didactic questions. Therefore, we suggest shifting the focus of inquiry to pedagogic-didactic practices. Indeed, the scientific ESD debate focusing on "*what competences* need to be promoted" can be enriched if we turn to pedagogical expertise and knowhow from HE didactics and to learning theories [9] (p. 86). This will allow us to move the focus from the "what competences" question (Issues 2 and 3) to the question "how can concrete competences be fostered?" (Issue 4). As our focus in the present article is on macro-didactics and the designing of educational settings, we will not deal with didactic and curricular details (Issues 5 and 6).

We suggest overcoming the challenges of fostering specific competences by means of two practices applied in didactic practice: tree of science heuristics [46] and constructive alignment [1]. In combination, these tools are very useful for structuring ESD teaching in a coherent way.

4.1. Tree of Science

Given the complexity of the tasks of professionalizing higher education and implementing outcome-oriented planning of university education, it is essential to build a coherent understanding of teaching-and-learning practice. The tree of science heuristic model (Figure 2) provides valuable services, not only for the development of a theory-based vocational theory and for reflective practice as faculty staff, but also for the development of a coherent and contextualized ESD competence profile. Indeed, using the tree of science model leads to a coherent relationship between one's meta-theoretical assumptions (including worldview and socio-cultural norms), theoretical-conceptual perspectives (including scientific angle, educational objectives, and competence model), and teaching models and practices (including planning instruments for modules and courses, and concrete didactics) [46] (pp. 12–15), [69] (p. 609), [70] (p. 21). The tree of science approach reveals how our choice of learning outcomes, learning environments, and assessment framework depend on our ontological and epistemological assumptions as well as on our disciplinary habits. Usually, this framing of our thinking and doing is implicit. But in the context of wicked problems and with the need for a systemic approach, it is important to make the framing explicit in order to detect where incoherence may emerge; this will in turn increase the coherence of our teaching in relation to the fundamental values that we are pursuing in ESD.

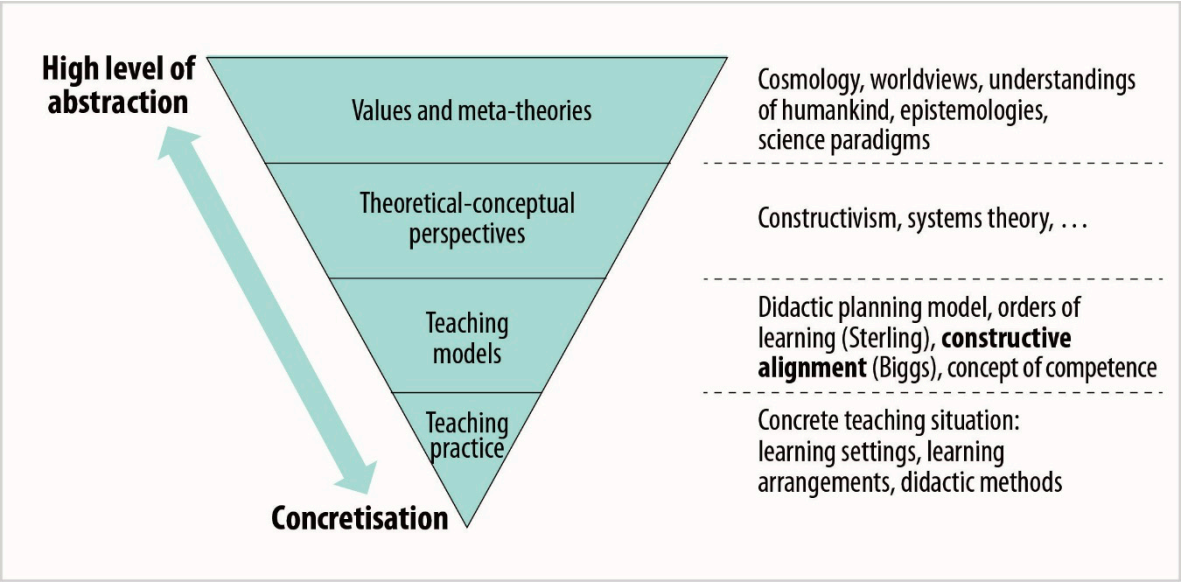

Figure 2. Illustration of the tree of science for competence-oriented teaching [46,69,70]. Use of tree of science enables faculty staff to understand the relationship between the various levels of theoretical and practical reflection that guide operationalisation of ESD-coherent teaching-and-learning.

Operationalized as a set of clear questions that each individual needs to answer in their own way, the tree of science heuristics helps structure and analyse the implicit and explicit characteristics of teachers' choices of ESD teaching-and-learning environments:

(1) Values and meta-theories:

- What is our prevailing view of human beings and understanding of education?
- What are the underlying norms and values in the course contents and learning outcomes?

(2) Theoretical-conceptual perspectives:

- What characterises our understanding of education for sustainable development?
- Upon what learning theories is our own understanding of teaching based?

(3) Teaching models:

- What teaching models do we apply or do we need to know?
- What understanding of competence do we have?
- What references do we make to existing models of competence for SD?
- What didactic principles guide our course work?

(4) Teaching practice:

- What educational objectives have we formulated?
- What set of competences should students develop?
- What specific competences for SD have we formulated?
- What didactic methods do we need to apply?

4.2. Constructive Alignment

Once we have clarified our assumptions and reached the level of practice using tree of science heuristics, we can rely on constructive alignment for further clarification of pedagogic-didactic implementation of the educational objectives. Biggs and Tang [1] describe this process as the

instructional triangle of learning designs [10]. Concretely, with regard to SD competences, this means trying to achieve a coherent alignment between (1) the general educational objective of a "change agent" on the one hand, and the underlying competence profile and learning outcomes on the other, (2) learning environments and activities, and (3) type of assessment (Figure 3).

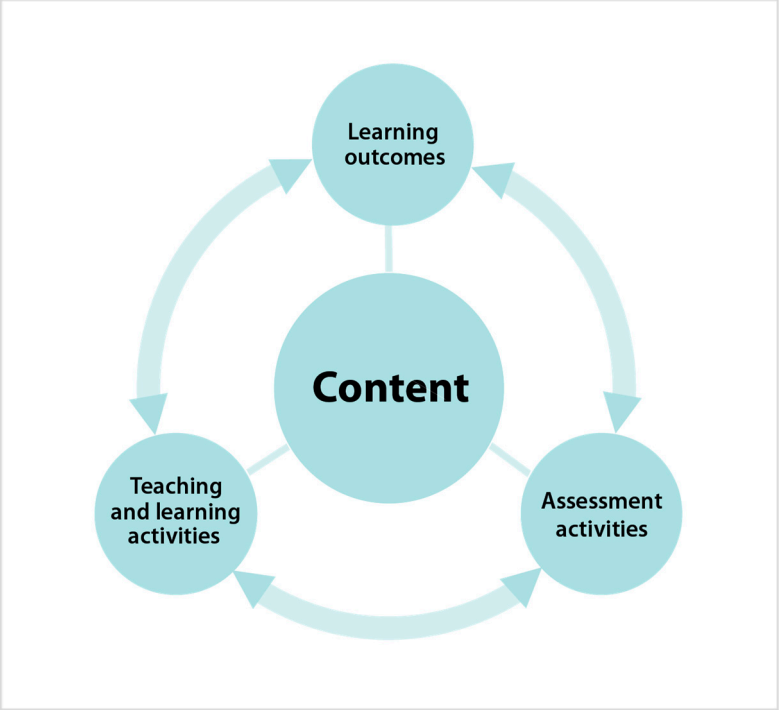

Figure 3. Model for aligning all the elements of teaching, learning, and assessment [71]. Alignment takes places in several stages and leads to constant re-alignment.

In brief: it is essential to clarify whether teaching activities will actually foster what is required: can the learning activity chosen on the basis of a methodological decision really foster what has been defined as a learning objective? With regard to change agency, does the educational environment really support students in developing the ability to act with sustainable development as a guiding principle? Do the chosen assessment methods help to make the intended learning achievement visible? Until now, teaching-and-learning in higher education has provided few opportunities for students to develop their own values, skills, and attitudes to become *change agents* in the area of sustainability [7], even if there are notable examples of change (e.g., in Europe: Leuphana University, the Centre for Sustainable Futures at Plymouth University, the Schumacher College, the UNESCO Chair of Social Learning and Sustainable Development at Wageningen University). Using constructive alignment makes the shift from teaching to learning possible: the aim is no longer to "pass on knowledge" [35] (p. 25). Instead, teaching is aligned with the chosen competences. To really foster the competences targeted by the learning objectives, teaching staff must ensure that learning environments are coherent—or they will have to decide to be more modest and adapt the learning objectives. The question remains whether HEIs are prepared to accept learning environments that help students to become change agents for sustainable development.

The concepts of constructive alignment and tree of science offer both a compass and a practicable journey, as they serve as a structuring aid for designing, integrating, and evaluating coherent study programs along with the chosen competences for SD. Both tools help faculty staff to position themselves, achieve clarity, plan and conduct teaching in a purposeful and comprehensible manner, and reflect on their own professional practice [47]. "Theory-led reflection is both a tool and a duty when working as a professional in the field of education" [46] (p. 18, authors' translation). As both tools are rooted

in the context of university teaching-and-learning as well as in the field of professional development of vocational and higher education practitioners, faculty staff should easily be able to adopt them in everyday practice. Besides, such conceptual orientation helps to make current sustainability education even more effective, as it creates a theory-based and reflexive framework to evaluate and optimize existing higher education offers. In addition, it points to perspectives and options for the development of ESD in higher education and provides legitimizing arguments to policy makers and authorities when it comes to establishing new modules and ESD-compatible programs [72] (p. 11) and corresponding assessment frameworks [73].

In the following sections, we present two examples to illustrate the advantages and challenges of applying the tree of science heuristics and constructive alignment model.

5. Coherent ESD Practice in Higher Education: Two Examples

The following two case studies show how ESD can be integrated into a curriculum in a competence-oriented manner: either through a longer learning and adaptation process or by design, based on clear pedagogical principles. In the first case, a PhD curriculum was developed and adapted ad hoc over a decade, based on the need for training PhDs in a new inter- and transdisciplinary research program focusing on sustainable development. In the second case, a curriculum within a Bachelor program was designed with a view to make it conform to ESD pedagogical principles and serve competences for SD. Both cases illustrate how important it is to achieve coherence between learning outcomes, teaching-and-learning processes, and assessment of outcomes when aiming to foster competences for SD. In addition, the second case reveals how the use of tree of science considerably shortened the process of consistent alignment between theory and practice. Moreover, while the first case only represents one course within a conventional curriculum, the second case covers a complete master minor aiming at trainers of trainers. Describing the case studies, we refer to Issue 1 und Issue 4 (see Section 3.2 above), illustrating the process of contextualization and operationalisation of competences for SD in teaching.

A further example of applying competence orientation within SD curriculum development and corresponding didactic principles in higher (postgraduate) education is provided by Förster and Grau [74]. They describe a newly developed postgraduate study program at the ETH Zurich and show how a competence profile and competence-oriented didactics can be implemented by using constructive alignment, among other tools.

5.1. Case Study 1

In 2001, the National Centre of Competence in Research (NCCR) North–South was launched as a twelve-year international research program involving a large number of universities and other research institutions in Switzerland and in countries in the Global South [75]. The declared aim of the research program was to investigate pathways for sustainable development in the context of syndromes of global change, using disciplinary, interdisciplinary, and transdisciplinary research [76]. Numerous disciplines were involved and most of the research was to be conducted by PhDs. A doctoral school was set up to support PhD candidates in their efforts to understand and master the tasks ahead. But those responsible for organizing the doctoral school had had no exposure to ESD debates, although sustainable development was the declared ultimate goal of research; nor had they formally trained as university teachers. Moreover, they were confronted with institutional demands for meeting the requirement of "excellence", defined mainly as a high number of publications published in peer-reviewed (disciplinary) journals [77].

The doctoral school therefore started as a collection of inputs offered by disciplinary experts trying to satisfy a number of identified but disparate needs. After two years of dissatisfaction on the side of the organizers with teaching events oriented towards disciplinary requirements, the crew involved in organizing the course decided to close its ears to legitimate but far too diverse demands. Several senior researchers involved in teaching had developed skills in inter- and transdisciplinary

work in a learning-by-doing manner; they began translating this into teaching modules. Moreover, the coordinator of the doctoral school, Karl Herweg, took his experience with monitoring and evaluation of development programs [78] as a model for rethinking the doctoral school: what impact did the research aim for? It was obviously a normative goal, something mainstream science had difficulties dealing with. And what skills should students develop to be able to carry out the inter- and transdisciplinary research needed to move towards this normative goal? This step made it possible to start aligning teaching modules with the program's goals—a move that one could interpret as the beginning of applying tree of science heuristics and constructive alignment. In 2003, a psychologist and social scientist, Philippe de Leener, was invited to observe and comment on learning processes in the transdisciplinary field contexts that had always been a feature of the program's common training event; his observations led to new insights, in particular regarding how researchers interacted with local people and what a learning process implied. The objectives of the training event were redefined, with a main focus on inter-and transdisciplinary skills, which were perceived as something that needed to be developed, not something one could teach about. In addition, a case-study-based approach was introduced, which meant leaving the classroom and enabling encounters between international students and local actors and environments. In hindsight, this turn could be described as the discovery of ESD competences. None of the institutions involved offered a formal program with a focus of this kind, although inter- and transdisciplinary research was a key objective of the NCCR North–South program.

In the next few years, the organizing crew steadfastly designed and redesigned the training event, eventually giving it a programmatic new name, the Integrative Training Course (ITC). What was now offered was an increasingly interactive program with a massive reduction of lectures and a corresponding increase in group work, with exposure to limitations of epistemological boundaries, power issues related to conceptual frameworks, and the muddy boundaries between knowing and doing in the field. Over the years, the purpose of the group work was refined, leading to the definition of a simple but highly effective outcome: a (mock) common research proposal with distinct inter- and transdisciplinary components [38]. In hindsight, it is obvious that a coherence was thus achieved between the learning outcome of "developing inter- and transdisciplinary skills" and the design of the group work, in the sense suggested by a constructive alignment approach. Indeed, the group work is designed to promote dialogue, cooperation, self-reflection, and correction of preconceptions after exposure to completely different cultures and visions of the future in the field.

Assessment was explicitly included as a skill to be developed, using a guided peer-review exercise: the groups are asked to assess another group's presentation according to clear criteria. This evaluation is complemented by feedback from senior researchers. If time allows, a final module focusses on scientific writing and publication and communication with non-scientific audiences. Overall, the course lasts 7–12 days, depending on availability of funds.

Over time and thanks to generous funding provided by the NCCR North–South program, a number of different pedagogic options were tested and improved, not least of all through a systematic process of evaluation at the end of each Summer School. This led to realizing, in correspondence with the constructive alignment approach, that the only option was—on the one hand—case-study-based and experiential learning, and on the other a focus on group work to develop cooperation skills and self-reflection, i.e. peer learning. The most important step was made when the format of the school stopped wanting to test what PhD candidates had done (the conventional disciplinary logic) and moved to offering them a context and tasks in which to interactively develop inter- and transdisciplinary skills. Moreover, from the moment the organizers started focusing on the overall goal of the NCCR North–South, i.e. context-bound research in partnerships aiming for sustainable development, and as soon as they understood that this could not be offered by a disciplinary logic [77], they intuitively began to apply a tree of science logic that made them reach a far more effective and appreciated program. The use of constructive alignment was equally intuitive, until a newcomer in the team

with pedagogic background offered explanations that made it possible to become more systematic and explicit.

5.2. Case Study 2

The second case describes an ESD curriculum development process within the context of the Bachelor program "Environmental Engineering" at the Zurich University of Applied Sciences. This Bachelor offers students knowledge and skills to find solutions to the challenges that arise in situations where economic and social demands conflict with sustainable use of natural resources. One of the components of the Bachelor is a minor program in "education and consulting", consisting of five modules. Because sustainability is at the core of the Bachelor program, it made sense to align the minor program with ESD competences. The overall educational objective of the five modules constituting the minor program aims at empowering students to contribute to a future-oriented and sustainable society by developing their own educational concepts and designing opportunities for sustainability learning in the field of environmental engineering.

From the very beginning, the undisputed aim of the coordinators of the minor program, Roger Johner and Bruno Scheidegger, was to align the learning objectives with the pedagogical principles [72] (p. 45), [79] (p. 217), as defined in the constructive alignment approach [1], and to propose an operationalisation of the desired competences that makes it possible to verify the existence of these competences at a later stage. At the same time, we searched for models of ESD competences and checked them against our understanding of the pedagogics of adult education according to the tree of science heuristic model, in order to provide the overall educational objective of the minor program with a sound theoretical foundation based on the state of the art in ESD. Looking for models of ESD competences also made sense from a thematic point of view because the aim of the minor program was to train "trainers of trainers" in the field of sustainable development.

The ESD competence models we were looking for had to be compatible with our systemic constructivist understanding of education. Indeed, in our view, human beings—i.e. learning individuals—construct their reality as active and self-determining personalities (values and meta-theories). De Haan's overall *Gestaltungskompetenz* (shaping competence) [14,55] seemed very appropriate as a model for defining our central educational objective. The project team, consisting of educational experts, then tried to coherently and consistently define sub-competences for the minor, as well as the corresponding learning outcomes. Nine of de Haan's twelve sub-competences seemed adequate for the learning outcomes of the five modules. This led the team to assume that the minor would thus indeed contribute to building *Gestaltungskompetenz*. But we were not certain that our interpretation was correct. Indeed, to date de Haan has provided no in-depth description of the sub-competences and has offered no insights into their operationalisation and assessment.

Opting for constructive alignment [1] seemed to be the right path to take from there, since the debate regarding competences and the educational shifts proposed by ESD [35] (p. 25) had influenced our curriculum design and the chosen praxeology. If empowering "change agents" was to be our goal, we needed to design action-oriented learning environments for the individual teaching modules, instead of simply offering knowledge for receptive receivers of information. The didactic principles therefore included problem orientation, action-oriented, and transdisciplinary learning, and participatory learning, as well as methods like project work, case studies, group work, and problem-based learning. As reflection is a key competence in ESD, we used the portfolio method along with assessment by others and self-assessment in all five modules. Self-responsibility for one's own learning process was quite a challenge for the students at the beginning, requiring a fair amount of persuasion from the lecturers.

Our understanding of competence also referred to Le Boterf [59], who argues that the assessment of learning outcomes must be oriented towards concrete performances (see Figure 1). Thus, ESD competences should be assessed by evaluating the performance corresponding to a specific competence. Therefore, the project team had to describe concrete expected behaviour by means of operationalized

indicators. This turned out to be a major challenge, as de Haan's competence model [14,55] does not offer any suggestions regarding assessment and operationalization. We chose a formative assessment instead of a summative examination at the end of every module in order to offer an assessment that was consistent with the expected learning outcomes. We asked students to design teaching concepts and to put them into practice. We observed their performance with the help of ad-hoc observation grids and commented on the portfolio entries in which students reflected on their concrete performances. To this purpose, we developed quantitative and qualitative criteria, e.g., a visible documentation of personal learning progress and integration of several perspectives in the writing of portfolio entries. We communicated these assessment criteria at the beginning of each module so that students clearly recognized how their performance would be assessed.

De Haan's *Gestaltungskompetenz* [14,55] offered us a useful orientation for selecting ESD competences at the beginning of our curriculum development process. But it is only when we started thinking about what the learning outcomes of the minor program might really mean in context that de Haan's rather general sub-competences really started shaping up. Without our pedagogic expertise in adult education and ESD, we would probably have given up on this very demanding task. In addition, we found no insights in the literature regarding granularity and taxonomies; suggestions regarding the different degrees of learning objectives would be an invaluable addition to the various competence models.

6. Making Learning Processes ESD-Compatible: Insights and Recommendations

Competences for sustainable development are profoundly contextual and normative; moreover, they are action-oriented. These characteristics make it difficult to provide a meta-profile of SD competences and corresponding general guidelines for fostering competences in HE teaching. Since faculty staff usually lack pedagogic-didactic knowledge to develop courses and curricula in a systematic way, we have suggested two tools to support them in the difficult process of making coherent SD competence-orientation possible in their teaching. The tools are based on pedagogic-didactic expertise and on insights from the lively ESD debate; they will hopefully help educators overcome some of the challenges of contextualisation (Issue 1) and operationalisation (Issue 4) met when implementing competences for SD in teaching. We believe that these tools will also generally enhance the quality of ESD in higher education.

6.1. Moving Towards ESD Didactics

As our case studies show, fostering SD and ESD competences at tertiary education level certainly requires pedagogic and didactic expertise. However, specific didactics for SD and ESD in tertiary education hardly exist, except for a few individual cases such as Leuphana University, Schumacher College, and others. Despite the lively debate on ESD at tertiary level, there is a lack of guidelines within this debate about how higher education didactics, competence orientation, and aligned ESD teaching can be put into practice. Authors such as Sterling and Thomas [6], Tilbury [35], Barth [9], and Hoffmann [36] provide in-depth descriptions of typical teaching-and-learning environments and corresponding didactic principles and methods. But they do not provide guidance for faculty staff about how to implement competence orientation and operationalise SD competences at the level of teaching practice, according to appropriate didactic principles. We have shown that combining use of tree of science heuristics with constructive alignment helps to "walk the talk".

Both processes—tree of science heuristics and constructive alignment—require iteration between educational objectives, competences, and didactic practices, including assessment. This iteration will also proove how appropriate the operationalisation of competences is in each specific case. Working through the two processes in continuous cycles is demanding and requires that faculty staff use new approaches for developing curricula, for planning their teaching, and for organizing their learning environments. But this will not suffice: in addition, there is a need to strengthen professional

development for ESD (see Section 6.2) and to rethink the institutional context of tertiary education [80], see also Section 6.3.

6.2. Professional Development of University Educators

Didactic expertise as well as an in-depth understanding of how to achieve competence orientation in teaching is needed at the level of university educators. Our case studies demonstrate the need for raising awareness of the benefits of coherence between the general educational objective of the study program (no longer focusing only on academic excellence), its institutional context, and new learning environments and activities as well as assessment methods. Achieving such coherence is challenging, in particular because assessment of performance is ambitious, as we need to sharpen our perception of the expected and visible outcomes [3] (p. 56).

Projects like the European "University Educators for Sustainable Development" project [4] acknowledge this need for professional development of university educators in the area of ESD, as well as for faculty training and development. Higher education institutions should actively develop and support continuous learning and qualification programs in the field of HE didactics [81], the aim of which should be to combine the content challenge (what is sustainable development and how can my discipline contribute to sustainable development?) and the challenge of a sound pedagogic-didactic foundation. More ESD research, subject knowledge, and methodological skills are needed as well; until now, only very few ESD chairs have been created. As a result, so far competences for SD have been fostered mostly ad hoc, rather than based on expertise provided by professional development. In the Swiss university context, with the exception of the universities of applied science, candidates for a chair normally do not need to show that they have had professional development in pedagogics. Promoting didactic expertise and collaboration with experts who come from the field of education would undoubtedly lead to added value for ESD. In addition, universities should develop a system of rewards and career acknowledgement for engaged teachers [82] (p. 337).

6.3. Institutional Context

Our case studies also show that the path towards competence orientation for sustainable development in teaching is a challenging one. Not only was it ambitious in both cases to want to better implement tertiary teaching-and-learning for sustainable development by choosing appropriate competences. Our experiences also reveal that the current curriculum design policies and teaching practices at HEIs make it difficult to adopt competence-oriented teaching-and-learning practices. Creating coherent and integrated learning opportunities as well as well as dialogue-oriented learning activities challenges the traditional understanding of education in Higher Education institutions [31,41,82]. In addition, learning and assessment settings require more resources because they are action-oriented and not just knowledge-oriented; in particular, formative assessments require more time. These settings also challenge teachers to unlearn their power as holders of knowledge and rethink their role as educators. Such changes are very much needed to ensure that students, teaching staff, and researchers are empowered as future problem solvers [10] (p. 72). After a decade devoted to ESD at the global level, this has been acknowledged worldwide: "ESD is about empowering and motivating learners to become active sustainability citizens who are capable of critical thinking and able to participate in shaping a sustainable future. Pedagogical approaches that are adequate to this aim are learner-centered, action-oriented and transformative." [3] (p. 54).

Despite successful examples of problem- and project-based learning opportunities [83] (p. 432) [84,85], so far, formal curricula at HEIs mainly focus on knowledge transmission, rather than on the facilitation of critical, innovative, and creative learning spaces where students can challenge their own models of thinking and practice, develop their own innovative and creative projects, or explore alternative ideas and choices [7,86]. However, sustainability is not just another issue to be added to an overcrowded curriculum; one can start with a "bolt-on" approach [6] to raise awareness among both students and teachers of sustainability issues. But awareness raising will not lead to change. To achieve

change, what is needed is a "build-in" approach through which pockets of transformed curricula exist and offer students (and teachers) the possibility of experiencing the building of competences. Ultimately, what will be needed is "curriculum redesign", which implies institutional change [81] and a different form of assessment for institutions [87].

In our experience, higher education institutions have difficulties with two aspects linked with the constructivist understanding of education that is inherent in ESD: first, the focus of universities on science dedicated to objectivity and disciplinarity [16] makes it difficult for them to identify with a mission of tertiary education that includes accountability to society and thus goes beyond developing academic excellence based on analytical expertise. This leads us to the second challenge: ESD requires action orientation and value orientation, both of which can only be achieved if students are supported in developing competences for change agency, i.e. competences that go beyond analytical skills, as revealed in our comparison of competence models, and largely accepted in the ESD literature. We hope that HEIs will soon be willing to adopt the inclusion of competences in teaching as an essential part of their mission.

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Appendix A

Table A1. Full overview of the selected competence models; the reference model chosen by the authors of the present article is in the 1st column.

Key Competences in Sustainability Wiek et al., 2011, Wiek and Kay 2015 [27,88]	**Shaping Competence for ESD ("Gestaltungskompetenz") de Haan 2008a, de Haan 2008b [26,55]**	**Key Competences for Sustainable Development Rieckmann 2011, 2012 [29,33]**	**Academic Competences Meijers et al., 2005 [53]**	**Competences in ESD for Educators, Leaders, and Decision Makers UNECE 2012 [8]**	**Key Competences for OECD Citizens OECD 2005 [51]**	**Competences for Extraordinary Leaders Zenger and Folkmann 2009 [58]**
Application: tertiary education sector, university-level teaching committed to ESD (HESD) incl. training of faculty	Application: secondary education sector, ESD	Application: tertiary education sector, HESD	Application: tertiary education sector, bachelor and master, particularly in engineering	Application: at all levels of education incl. formal, non-formal, informal	Application: all citizens in OECD countries and beyond	Application: management and organizations that educate and evaluate leadership, including change agents
6 key competences for "collectively solving sustainability problems" [88] (p. 29). (1) **Systems-thinking competence:** Ability to analyse complex systems across different domains and different scales. (2) **Anticipatory (or future-thinking) competence:** Ability to collectively analyse, evaluate and craft rich "pictures" of the future related to sustainability issues and sustainability problem-solving frameworks. (3) **Normative (or value-thinking) competence:** Ability to collectively map, specify, reconcile, and negotiate sustainability values, principles, goals, and targets. (4) **Strategic-thinking (or action-oriented) competence:** Ability to design and implement interventions, transitions, and transformative governance strategies towards sustainability; "being able to get things done" (5) **Interpersonal competence:** Ability to motivate, enable, and facilitate collaborative and participatory sustainability research and problem solving. (6) **Integrated problem-solving competence:** a meta-competence that should integrate "the five key competencies for solving sustainability problems and fostering sustainable development"	Shaping competence: "*Gestaltungskompetenz* means the specific capacity to act and solve problems" and has the following 12 sub-competences (**in bold font:** translation into English by Rieckmann, p. 130 [29]; this is followed by our own translation of de Haan's 12 sub-competences) (1) **Competence in cosmopolitan perception and change of perspectives:** Build up knowledge with an open mind, integrating new perspectives. (2) **Competence in anticipatory thinking:** analyse and evaluate developments in an anticipatory way (3) **Competence in interdisciplinary work:** Generate insights, and act in, an interdisciplinary way (4) **Competence in handling incomplete and complex information:** be able to identify and evaluate risks, dangers, and uncertainties (5) **Competence in cooperation:** be able to plan and act together with others (6) **Competence in dealing with individual decision dilemmas:** be able to include trade-offs when reflecting on options for action (7) **Participatory competence:** be able to participate in collective decision-making processes. (8) **Competence in self-motivation and motivating others:** be able to motivate oneself and others to take action (9) **Competence in reflection on individual and cultural models:** be able to reflect on own guiding principles and those of others (10) **Competence in ethical action:** be able to apply perceptions of justice as a basis for decisions and action (11) **Competence in independent action:** be able to plan and act independently. (12) **Capacity for empathy and solidarity:** be able to show empathy	12 key competences: The competence . . . (1) for systemic thinking and handling complexity (2) for anticipatory thinking (3) for critical thinking (4) for acting fairly and ecologically (5) for cooperation in (heterogeneous) groups (6) for participation (7) for empathy and change of perspective (8) in interdisciplinary work (9) for communication and use of media (10) for planning and realising innovative projects (11) for evaluation (12) for ambiguity and frustration tolerance	7 areas of competence He or she (1) is competent in one or more scientific disciplines (2) is competent in doing research (3) is competent in designing (4) has a scientific approach (5) possesses basic intellectual skills (6) is competent in co-operating and communicating (7) takes account of the temporal and the social context These 7 areas are broken down into 50 competences, each with a differentiation of degree between Bachelor and Master level, and an indication about whether the competence relates mainly to knowledge, skills, or an attitude.	41 competences structured according to (A) areas of learning and (B) essential characteristics of ESD: A1 **Learning to know:** refers to understanding the challenges facing society both locally and globally and the potential role of educators and learners (The educator understands....); A2 **Learning to do:** refers to developing practical skills and action competence in relation to education for sustainable development (The educator is able to....); A3 **Learning to live together:** contributes to the development of partnerships and an appreciation of interdependence, pluralism, mutual understanding and peace (The educator works with others in ways that....;) A4 **Learning to be:** addresses the development of one's personal attributes and ability to act with greater autonomy, judgement and personal responsibility in relation to sustainable development (The educator is someone who...)" (UNECE 2012, p13-15) B1 **A holistic approach**, which seeks integrative thinking and practice; B2 **Envisioning change**, which explores alternative futures, learns from the past and inspires engagement in the present; B3 **Achieving transformation**, which serves to change in the way people learn and in the systems that support learning." (UNECE 2012, p13-15)	9 key competences in three groups (1) **Using tools interactively** • Use language, symbols and texts interactively • Use knowledge and information interactively • Use technology interactively (2) **Interacting in heterogeneous groups** • Relate well to others • Co-operate, work in teams • Manage and resolve conflicts (3) **Acting autonomously** • Act within the big picture • Form and conduct life plans and personal projects • Defend and assert rights, interests, limits and needs	16 empirically derived competences ("capabilities"/ "behaviours") grouped in 5 categories ("Tent model"): (1) **Character:** displaying high integrity and honesty (2) **Personal Capability** • Technical and professional expertise • Solving problems and analysing issues • Innovation • Practicing self-development (3) **Focus on Results** • Focus on results • Establish Stretch Goals • Take responsibility for outcomes and initiatives (4) **Interpersonal Skills** • Communicating powerfully and politically • Inspiring and motivating others to high performance • Building relationship • Developing others • Collaboration and teamwork (5) **Leading Organizational Change** • Developing strategic perspectives • Championing change • Connecting internal groups with outside world

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