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Critical attributes of Sustainability in Higher Education: a categorisation from literature review

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ABSTRACT

Sustainability in Higher Education has been investigated mainly through examining institutional approaches, curricula content, or students' and teachers' perceptions of sustainability in practice. However, a deep characterisation of the foundations of this phenomenon is lacking. This article aims to address the existing lack of depth and comprehensiveness by identifying and categorising the critical attributes of Sustainability in Higher Education. Categories are the basic levels for knowledge classification, and critical attributes relate to the main perceived characteristics within categories. Both were structured through a literature review and a systematic analysis using the Proknow-C method. A set of 2513 studies on sustainability in education and related fields, published between 2000 and 2015, enabled the identification of 259 as appropriate for devising four categories: foundations, knowledge, personal, and integrative assets with 4, 4, 4, and 3 attributes respectively. From these, 129 papers presented at least four relationships among attributes of all categories. An assessment between the attributes identified for the selected studies delivered 85 analyses, with the following findings: (i) epistemologies of Sustainability in Higher Education develop in learning context; (ii) creativity should better link foundational and personal assets; (iii) transdisciplinarity is an epistemic transgression; (iv) resilience of active learners emerges in knowledge and personal assets relationships; (v) knowledge deconstruction and affectiveness form active learning; (vi) personal assets need to fit to complex dynamics of reality. Our analysis provides a means of benchmarking existing practice for Sustainability in Higher Education, and can be used as the basis for building capacity in a systematic way.

1. Introduction

Higher Education (HE) and environmental issues have a long shared history, providing the focus for a great number of studies with diverse, and often inconsistent, conclusions. One clear controversy relates to the conceptualisation of sustainability and sustainable development, that are generally used interchangeably and without clarification of their meaning within the HE context. Sustainability is about the dynamics between ecological and all other dimensions of human life (Foster, 2001; Khalili et al., 2015), and a core feature of the term is the impossibility of dissociating the ecological and socioeconomic aspects. Sustainable development, on the other hand, can be interpreted as 'sustained growth' given that it highlights the need for 'development' (Lélé, 1991). Both terms relate to "the growing awareness of the global links between mounting environmental problems, socioeconomic issues to do with poverty and inequality and concerns about a healthy future for humanity" (Hopwood et al., 2005: 39) across a wide spectrum of paradigms

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List of acronyms

AT	Attitudes
CO	Constructivism
CX	Complexity
BF	Beliefs
BH	Behaviours
EBL	Enquiry Based Learning
EE	Environmental Education
EfS	Education for Sustainability
EP	Epistemology
ESD	Education for Sustainable Development
FA	Foundational Assets
HE	Higher Education
HT	Holistic Thinking
IA	Integrative Assets
ID	Interdisciplinarity
KA	Knowledge Assets
LE	Learning
LI	Literacy
PA	Personal Assets
PE	Pedagogies
PH	Philosophy
SHE	Sustainability in Higher Education
TE	Teaching
TD	Transdisciplinarity
VA	Values

and practices (Beringer and Adomßent, 2008), but with little agreement on how to achieve sustainable conditions (Carew and Mitchell, 2008). The interchangeability between sustainability and sustainable development idea is challenged by the diversity and breadth of its conceptions and evolution.

In education, anthropocentric bias separates the sustainability of the environment from the sustainability of the resources, the workforce, and the market (Christie et al., 2014). The education system is inclined to break down human and environmental relationships into instrumental strategies for consumption interests (Cotgrave and Kokkarinen, 2010) and for resources depletion minimisation (Lozano, 2006a,b). The foundational basis for sustainability, including philosophical debates, and aspects of pedagogies, personal values and inherent complexity, are examples of attributes which are usually absent from programmes on sustainability in higher education (SHE). This article aims to address this lack of depth and comprehensiveness by identifying and categorising the critical attributes of SHE based on theoretical and practical aspects drawn from the academic literature.

Categories are constructs that facilitate the gathering of knowledge about a subject – in this case, SHE – with maximum information and minimum cognitive effort, and attributes are perceived features that can be grouped by similarity to form a category (Rosch, 1999). 'Critical attributes' are those which are recurrent in the literature focussing on sustainability related to education, and vise versa. This categorisation is important because SHE, although widely researched, presents unexplored debates that mask the relationships between the reflective (individually targeted) and reflexive (societally addressed) dimensions of human thinking necessary to raise awareness and facilitate responsible action on the current sustainability issues. Reflectivity represents situated thinking on some practice (Galea, 2012), while reflexivity refers to "the capacity of the individual to position himself or herself within the broader social and organisational causes of particular problems" (Malthouse et al., 2014: 599), as expression of self-consciousness (Popoveniuc, 2014).

This framing of the essential attributes of SHE, and classification according to conceptual and descriptive categories dispersed in sustainability studies, does not focus on the differences between Environmental Education (EE), Education for Sustainable Development (ESD), and Education for Sustainability (EfS). Such distinctions, that describe the ways in which education and sustainability has evolved, are not relevant for our purpose. Furthermore, several studies have already investigated this issue (for example, Crofton, 2000; Hansen and Lehmann, 2006; Quist et al., 2006). Our focus is on the widest possible range of theoretical and practical characteristics and their inter-relationshisps, aiming at organizing SHE attributes. Following the methods of systematic review and analysis content, four categories were identified – foundational (FA), knowledge (KA), personal (PA), and integrative assets (IA). They embrace a set of 15 attributes – philosophy (PH), epistemology (EP), interdisciplinarity (ID), transdisciplinarity (TD) for FA; pedagogies (PE), literacy (LI), learning (LE), teaching (TE), for KA; values (VA), beliefs (BF), attitudes (AT), behaviours (BH), for PA; and constructivism (CO), complexity (CX), holistic thinking (HT) for IA. This identification was based on an exhaustive literature review.

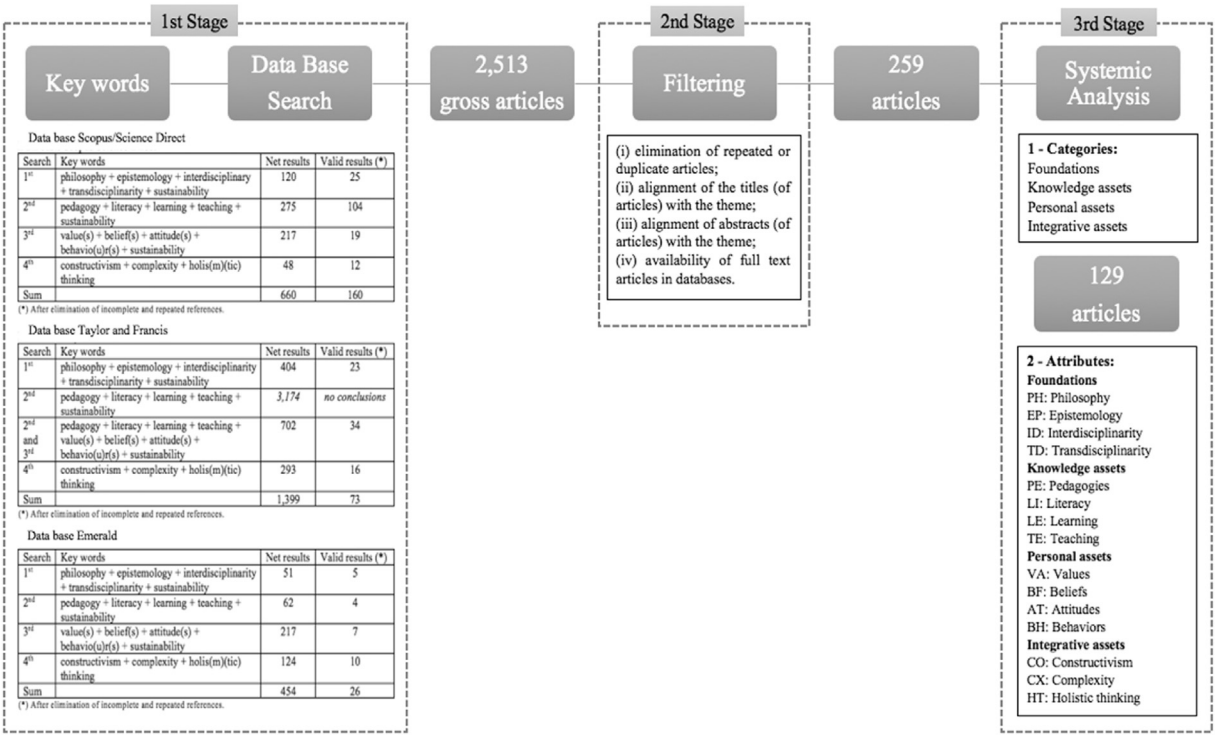
The paper is structured as follows: in the second section, the methods are described; in the third section, results are presented in to two subsections: 3.1, that conceptualises and describes the 15 attributes of SHE under the four categories; and 3.2, that provides pairwise relationships between categories. Conclusions and recommendations for future research are delivered in the fourth section.

2. Methods

This study applies a systematic literature review with the use of the Knowledge Development Process – Constructivist, referred to as the 'Proknow C method' (Ensslin et al., 2010). It is anchored in content analysis (Bardin, 1993), which is the result of reflective/reflexive assessments (Gelter, 2003; Malthouse et al., 2014) in order to enable the interpretation of the results of the review.

The Proknow-C method is a systematic approach to organize knowledge from a literature review, and comprises three main steps: elaboration of bibliographic portfolio; bibliometric analysis, and systemic analysis. The selection of bibliographic references takes place recursively using the following steps: selection of scientific articles in databases using keywords; definition of a set of relevant articles and redundancy elimination; and alignment of the results with the scope of the researcher aims (Ferenhof et al., 2014). This final step was performed along with the content analysis.

The filtering of articles took place using the following process: (i) elimination of redundant articles; (ii) alignment of the titles of the remaining articles with the theme; (iii) alignment of the article abstracts with the theme; (iv) availability of full text articles in the databases. These steps are described in Fig. 1 which also sets out



Data base Scopus/Science Direct

Search	Key words	Net results	Valid results (*)
1st	philosophy + epistemology + interdisciplinary + transdisciplinarity + sustainability	120	25
2nd	pedagogy + literacy + learning + teaching + sustainability	275	104
3rd	value(s) + belief(s) + attitude(s) + behavio(u)r(s) + sustainability	217	19
4th	constructivism + complexity + holis(m)(tic) thinking	48	12
Sum		660	160

(*) After elimination of incomplete and repeated references.

Data base Taylor and Francis

Search	Key words	Net results	Valid results (*)
1st	philosophy + epistemology + interdisciplinarity + transdisciplinarity + sustainability	404	23
2nd	pedagogy + literacy + learning + teaching + sustainability	*3,174*	*no conclusions*
2nd and 3rd	pedagogy + literacy + learning + teaching + value(s) + belief(s) + attitude(s) + behavio(u)r(s) + sustainability	702	34
4th	constructivism + complexity + holis(m)(tic) thinking	293	16
Sum		1,399	73

(*) After elimination of incomplete and repeated references.

Data base Emerald

Search	Key words	Net results	Valid results (*)
1st	philosophy + epistemology + interdisciplinarity + transdisciplinarity + sustainability	51	5
2nd	pedagogy + literacy + learning + teaching + sustainability	62	4
3rd	value(s) + belief(s) + attitude(s) + behavio(u)r(s) + sustainability	217	7
4th	constructivism + complexity + holis(m)(tic) thinking	124	10
Sum		454	26

(*) After elimination of incomplete and repeated references.

Fig. 1. Bibliographic review procedures and quantitative results.

the keywords used in the searches of the Scopus/Science Direct, Taylor & Francis, and Emerald databases for the period January 2000 to July 2015: “philosophy”, “epistemology”, “interdisciplinarity”, “transdisciplinarity”, for the first search; “pedagogy”, “literacy”, “learning”, and “teaching”, for the second search; “value(s)”, “belief(s)”, “attitude(s)”, and“behavio(u)r(s)”, for the third search; and “constructivism”, “complexity”, “holis(m)(tic) thinking” for the fourth search. The keywords were chosen after reading more than a hundred articles related to sustainability and education falling within the scope of this research. 2513 articles were initially identified, with the number dropping to 259 upon completion of the filtering process.

Interpretation of results employed a combination of systemic analysis proposed by Proknow-C, and content analysis that embraces reflexivity and reflectivity procedures (Bardin, 1993). Reflectivity is an interpretive process (Gelter, 2003) supported by first instance cognition (Bleakley, 1999); it enables the researcher to reflect upon the assumptions capable of influencing a given situation – such as the sustainability issue in higher education. Reflexivity, a second instance cognition (Fook, 1999; Malthouse et al., 2014), is about considering the unexamined assumptions on the relationships between concepts and attributes involved in SHE.

After the interpretative procedures, it was possible to determine the main categories (4) and their respective attributes (15), as indicated in Fig. 1. In addition, the analysis facilitated identification of the articles that contain all the identified attributes; and a pairwise analysis between the categories – a total of six analyses that result from a combination of the categories' content, taken two by two. The research design is presented in Fig. 2. The main methodological limitation was the consideration, in the searches, of studies that are not only focused on SHE, but maintain content related to sustainability foundations.

3. Results: critical attributes of SHE – analysis and framing

After the analysis of 2513 articles on SHE and the theoretical aspects of sustainability, 259 (10.3%) were identified as being within the scope of the study. From these, 129 (49.8%) exhibited four or more of the considered attributes. Appendix 1 presents the full sample employed in the content analysis.

Of the four categories identified, the first (FA) relates to the foundations of SHE; the second to the knowledge assets (KA); the third to the personal assets (PA), and the fourth to the integrative assets (IA). These are considered in turn below.

3.1. Foundational assets (FA)

Four attributes characterise FA: philosophy, epistemology, interdisciplinarity, and transdisciplinarity.

3.1.1. Philosophy

Philosophy in the context of sustainability refers to the historical relationships between man and nature, mediated by ethical values (Foster, 2001), and primarily addressing the criticism of pure economic rationality (Tilky and Barrett, 2011). It relates to diverse worldviews about the role of nature – whether mainly as a place for living and enjoyment, or a set of resources to be harnessed for economic progress. It underpins the basis of choices for the future development of humankind (O'Brien et al., 2013). The inquiry about the philosophical roots of sustainability brings into focus the distinction between weak and strong sustainability that is reflected in dualistic paradigms: the reformist, ruled by market regulations to the detriment of environmental conservation, and the transformist, which advocates deep social changes aimed at future states where humans live harmoniously with nature (Hopwood et al., 2005), or ecophilosophy (Hampson, 2012).

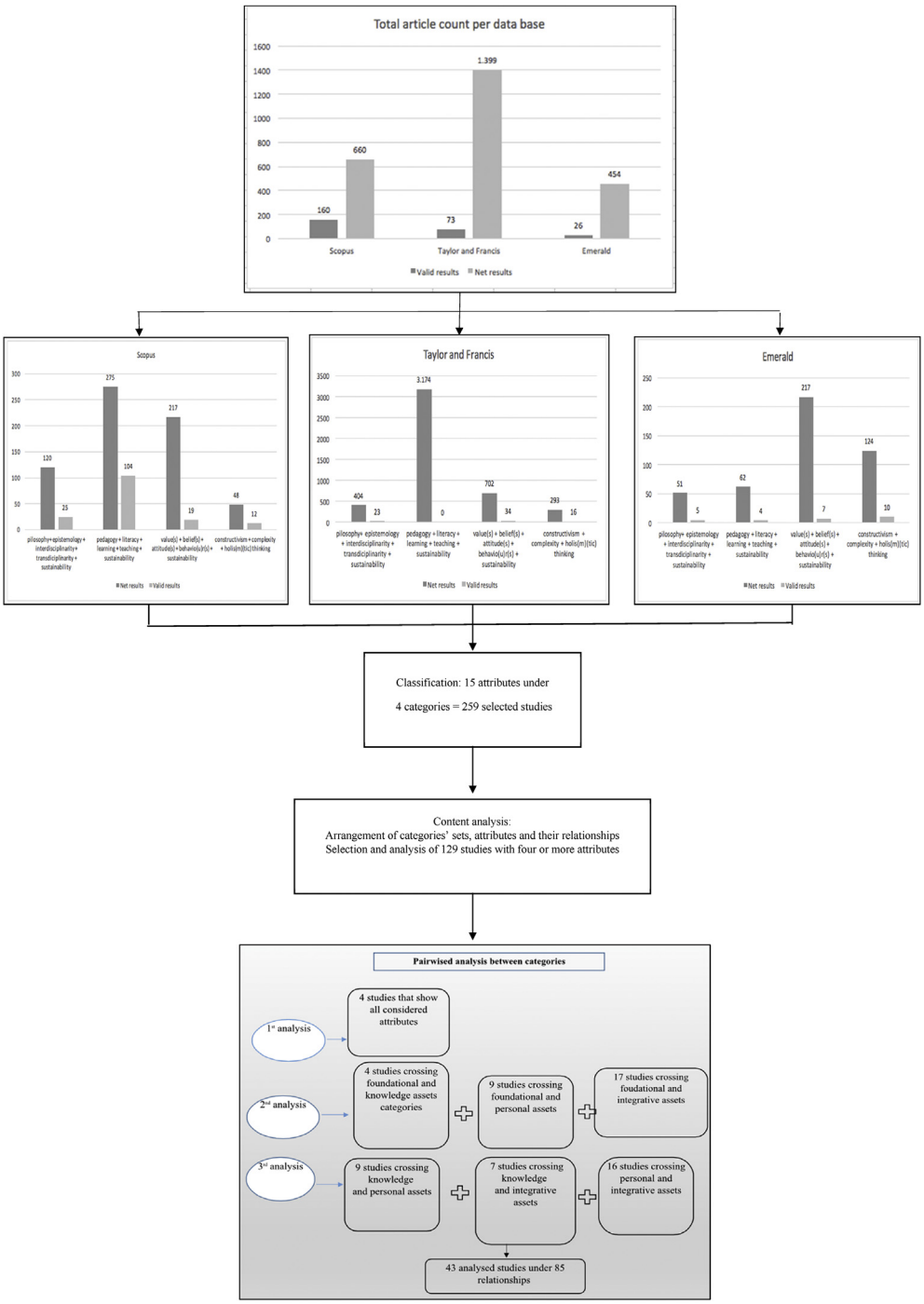


Fig. 2. Research design.

Such philosophy has a tradition of critical assessment: it embraces systems thinking; inquiry into values; and challenges for joint knowledge development. Costel (2015) observed misunderstanding about the managerial and educational aspects involved in sustainability research. SHE requires a "philosophy of action" (Gross et al., 2011), learning-oriented (Segalàs et al., 2010), and self-organized (Levine, 2002; Sterling, 2010), and a "philosophy of becoming", that embraces the possibility of deconstructing and reconstructing worldviews (Coleman, 2013; Clarke and Mcphie, 2015). Another philosophical basis for sustainability relates to the ways of envisioning the world combining inner reflection (Holloway and Gouthro, 2011), like reading, with forms of reflexion, like writing (Clarke and Mcphie, 2014). However, philosophical studies are not usual in undergraduate curricula of technical and scientific courses (Sherren, 2008a, 2008b; Celeumans and De Prins, 2010).

3.1.2. Epistemology

Epistemology relates to the kinds of knowledge possible and ways in which it is generated (Birkin and Polesie, 2013), or

confirmed (Osorio et al., 2009). Knowledge has plural strategies of production, that are rooted in both traditional, and lay forms (Scheman, 2012; Hampson, 2012; Robinson and Cole, 2015). Diversity of knowledge experiences (Dekker et al., 2013; Aktas, 2015; Baker and Däumer, 2015) has been emphasised through experimental knowledge (Bacon et al., 2011; Watagodakumbura, 2013) and through contextualisation of knowledge application (Nikitina, 2006), where competences for sustainability are assessed (Wiek et al., 2011; Eagle et al., 2015). Baumgartner et al. (2008) highlight two epistemics for sustainability: radical empirism – which assumes that all human knowledge comes from experience and observation – and rationalism – according to which human knowledge comes from the human mind alone. More recently, Sustainability Science has been claimed as a summary of epistemology for sustainability (Vincent and Focht, 2009; Rives-East and Lima, 2013; Bremer and Funtowicz, 2015). It includes characteristics such as co-knowledge production (Klein, 2004, 2008, 2015; Nicolescu, 2014; Powell and Larsen, 2013), uncertainties management (Vare and Scott, 2007; Becker, 2011) through collaborative (O'Brien et al., 2013), collective (Ardoin et al., 2013), constructivist (Cristea, 2015), experimental knowledge (Bacon et al., 2011; Watagodakumbura, 2013), and adaptive or critical system thinking (Blackmore, 2007; Bell et al., 2014; Brunstein et al., in press). Christie et al. (2013, 2014) and Chernikova and Chernikova (2015) consider Sustainability Sciences a social epistemology.

3.1.3. Interdisciplinarity

Interdisciplinarity is an epistemological bridging, a capacity to transit between disciplines, with the possibility of methodological exchange from which new knowledge arises (Darbellay, 2015). It is also an integration of ideology, policy and science (Bursztyn and Drummond, 2014). Huutoniemi (in press) regards interdisicplinarity as a social epistemics mechanism for coordination, control and compromise between disciplinary regimes of knowledge. ID is repeatedly mentioned as a relevant foundation for SHE and as a combination of experiences and skills in cross-disciplinary form (Cantalapiedra et al., 2006; Ellis and Weekes, 2008; Burandt and Barth, 2010). Ramos (2009) consider ID to be largely exclusive to academia, but courses or curricula which incorporate ID can pose challenges to teachers (Lozano and Lozano, 2014), and are typically avoided by students (Lidgren et al., 2006), irrespective of their relevance (Koester et al., 2006; Cotgrave and Kokkarinen, 2010; Richter and Schumacher, 2011). This is because ID defies linear thinking, and demands knowledge openness and inquiry about the connections between disciplines (Newell, 2011). When ID is attempted, epistemological tensions between human and natural sciences can become difficult to manage (Rives-East and Lima, 2013). Epistemic accountability – a process of understanding and assessing the diverse forms of evolution among disciplines to form a big picture of a problem – is therefore necessary (Hamlin, 2012). Such accountability is regarded as a reflective action to research that involves methods such as inquiry and construction of narratives (Bossio et al., 2014), and requires an ability to fill gaps in order to address social demands (Huutoniemi, in press). ID is required for environmental literacy (Flint et al., 2000; Jucker, 2002; Goodnough et al., 2009; Vassigh and Spiegelhalter, 2014) and for the development of competences in sustainability (Ferreira et al., 2006; Disterheft et al., 2012), such as collaboration (Sibbel, 2009; Waas et al., 2010; Adomßent et al., 2014) and the ability to investigate complex problems (Dieleman and Huisingh, 2006; Sherren, 2006; Juárez-Nájera et al., 2010).

3.1.4. Transdisciplinarity

Transdisciplinarity relates to "a strong form of interdisciplinarity" (Hampson, 2012: 77), or a socially applied interdisciplinarity (Nicolescu, 2014). It articulates multiple levels of reality and epistemologies that evolved in sustainability studies – such as Human Ecology, Environmental Sciences, Environmental Management, and Ecological Economics (Rasmussen and Arler, 2010). Popa et al. (2015: 46) define TD as "critical and self reflexive research approach that relates societal with scientific problems". It is also defined as "research across disciplinary boundaries and in collaboration with stakeholders" (Kemp and Nurius, 2015: 131). TD emerges as result of transcendence in science, which means it is addressed to ethics and creativity (Alvargonzález, 2011; Nicolescu, 2014; O'Brien et al., 2013). Mobjörk (2010) understands TD as a transgression of the well established languages and methodologies of science. Madanipour (2013) sees it as a continuum between research, researcher and methods of research. TD introduces the need for acceptance of non-academic knowledge, and it is still deemed as being not fully practicable in SHE (Pearson et al., 2005), or is confined to human and health care sciences (Mitchell, 2011). Lack of contact with lay knowledge in universities, competition among disciplines, and lack of acquaintance with specific methods result in no space for TD in *campi* (Pohl, 2005; Wickson et al., 2006; Minguet et al., 2011; Augsburg, 2014). However, it is required in higher education (Moore, 2005; Lozano, 2010), mainly because of the emergent demands of complexity in learning (Ramirez, 2012; Wooltorton et al., 2015). TD is a key asset for theoretical and practical studies that enable complex problems to be unfolded (Steiner and Posch, 2006; Sterling, 2010; Adomßent et al., 2014), including within regional contexts (Martínez et al., 2006; Stauffacher et al., 2006). TD is also characterized by pluralism and critical realism (Hampson, 2012), normative accountability (Hessels and van Lente, 2008), and for the possibility to deliver a combination of diverse epistemologies, such as empirism (Chernikova, 2014), and pragmatism (Hadorn et al., 2006).

3.2. Knowledge assets (KA)

Pedagogy, literacy, learning and teaching were found to be attributes of KA.

3.2.1. Pedagogy

Pedagogies are teaching strategies aiming at improving students' skills (Mintz and Tal, 2013), and transforming them (Thomas, 2009) not only based on their competences and abilities (Redman, 2013), but also with respect to their behaviours (Lozano, 2010; Azeiteiro et al., 2015). It is "the awareness of our philosophical beliefs and the role these play in shaping our educational practice" (Holdsworth and Thomas, in press: 7). In SHE, PE refers to skills acquisition (Azeiteiro et al., 2015; Blanchet-Cohen and Reilly, 2013), to environmental awareness (Blum, 2008), and to literacy, that is the "ability to actively engage with social, environmental and economic aspects of sustainable development" (Murray and Murray, 2007: 285). Self-directed learning, through the creation of learning environments, problem-solving purposes, and teaching-learning in collaborative forms are considered pedagogical principles for sustainability (Vassigh and Spiegelhalter, 2014). Pedagogies need to support cultural diversity and self-reflective strategies (Thaman, 2010; Blanchet-Cohen and Reilly, 2013), but they are not usually integrated with critical teaching (Friedriksson and Persson, 2011; Figueiró and Raufflet, in press). Many pedagogies lack epistemologies (Ramsaroop and van Rooyen, 2013). More recently,

Information and Communication Technologies have boosted the potential for teachers to implement new pedagogical strategies (Bridgland and Whitehead, 2005; Konting, 2012; Wang et al., 2014). However, pedagogies can fail to achieve sustainability understanding if they lack criticism about production and consumption relationships (Green, 2013; Matthewman and Morgan, 2013). Hutchinson and Herborn (2012) warn about the need for pedagogies that guide students from theoretical to practical experiences. Redding and Cato (2011) call it enquiry pedadogies; Bell et al. (2014), pedagogies of experience transformation; Saravanamuthu (2015), pedagogies for transforming learning. Eilam and Trop (2010), Manteaw (2012) and Sidiropoulos (2014) understand pedagogies for sustainability as inseparable from emotional learning.

3.2.2. Literacy

Literacy is "an active phenomenon, deeply linked to personal and cultural identity" Freire (2000, apud Dale and Newman, 2005: 355). For environmental literacy, individuals need to realise sustainability challenges and change their behaviours accordingly (Eagle et al., 2015). Diamond and Irwin (2013: 339) define environmental literacy as "having the understanding, skills, attitudes and attributes to take informed action for the benefit of oneself and others, now and into a long term future". It goes beyond the development of competences (Koester et al., 2006; Holloway and Gouthro, 2011; Zoller, 2013). LI embraces cultural features of SHE (Winter and Cotton, 2012) such as ethics (Holdsworth et al., 2008), values, beliefs, attitudes (Murray and Murray, 2007; Ramsaroop and van Rooyen, 2013), and behaviours (Bridgland and Whitehead, 2005; Thomas, 2009). It entails modifying curricula (Waas et al., 2010; Sidiropoulos, 2014) for solving ill-defined problems (McDonald, 2006), and it is a requirement for advancement in sustainability studies (Sharon and Wright, 2006). Remington-Doucette et al. (2013) understand environmental literacy as a strategy for systemic thinking. Kokkarinen and Cotgrave (2013) see it as the way students interact within a group to express what they learnt on sustainability. Although illiteracy is what prevails in sustainability education (Jucker, 2002), because most academic courses just deliver patchy content instead of articulated programs (Winter and Cotton, 2012), scholars insist that ladders of literacy need to be climbed (Holt, 2003; Macris and Georgakellos, 2006; Correia et al., 2010; Shephard et al., in press). Cotgrave and Kokkarinen (2010) propose indicators for environmental literacy: curriculum alignment, definition of the expected learning and themes to be addressed, interdisciplinary arrangements employed in case studies, and depth of reflection in learning. LI can be expressed as declarative, procedural, social and effective (in action) knowledge (Redman and Redman, 2014). O'Brien et al. (2013: 56) propose literacy, "a systematic approach to improving anticipatory systems that emerges from the field of future research".

3.2.3. Learning

Learning for sustainability is direct experience for skills improvement on the environment (Barratt, 2006; Dieleman and Huisingh, 2006; Redman, 2013). According to Remmen and Lorentzen (2000), and Christie et al. (2013, 2014), LE is meant to improve the quality of life (Ellis and Weekes, 2008); therefore, it is addressed by several authors as life-long learning (Foster, 2001; Posch and Steiner, 2006; Sherren, 2006) as a strategy (Cantalapiedra et al., 2006; Adomßent et al., 2014) towards transition to a better (Jucker, 2002), transformative (Wals, 2010; Malthouse et al., 2014; Holdsworth and Thomas, in press) and innovative society (Yarime et al., 2012).

Learning for SHE is variously called collaborative (Medellín-Milan, 2006; Wells et al., 2009; Burandt and Barth, 2010), participatory (Mintz and Tal, 2013; Stubbs, 2013; Khalili et al., 2015), complementary to self-directed learning (Burandt and Barth, 2010; Zsóka et al., 2013), and affective (Shephard, 2008).

Scholars refer to creative or flexible LE as typical for sustainability education (Sage, 2000; Bodorkós and Pataki, 2009; Stephens and Grahamm, 2010). LE for sustainability requires time that ordinary curricula do not provide (Fisk and Ahearn, 2006; Hens et al., 2010; Biswas, 2012). It explains why other learning arrangements are proposed as catalysts for clustering knowledge, understanding, skills, abilities, affectiveness, awareness and attitudes alignment (Mintz and Tal, 2013). Juárez-Nájera et al. (2006) advocate that learning to know, to live together, to do, and to be, comprise autonomy for SHE. This is similar to the combination of Enquiry Based Learning (Steiner and Laws, 2006; Murray and Murray, 2007) with experimental and active learning (Mac Vaugh and Norton, 2012). LE can be seen from the point of view of the participatory processes of the universities engaged in sustainability programs or curricula (Disterheft et al., 2015).

3.2.4. Teaching

There are few studies dedicated to identifying academic teaching conceptions for SHE (Clarke and Khouri, 2009; Christie et al., 2014). It is partially explained by the lack of communication between academia and industry about SHE (Cotgrave and Kokkarinen, 2010). Furthermore, policies to promote sustainability operate at a faster pace than those addressed to TE and LE in this field (Winter and Cotton, 2012). However, institutional programs for boosting sustainability are influencing TE work in higher education (Disterheft et al., 2012).

Instrumental TE is dominant in SHE, primarily focussing on natural resources depletion (Lozano, 2006a), and cleaner production techniques (Fisk and Ahearn, 2006; Manring and Moore, 2006). Also business courses are a focal point for efforts on SHE TE (Holt, 2003), but as they are highly specialized (Ferreira et al., 2006), they prevent teachers from experimenting with interdisciplinary strategies (Boks and Diehl, 2006). As a consequence, tutorials and lectures are preferred to critical debates, brainstorming, simulation, experimentation, presentations, and project development (Erdogan and Tuncer, 2009; Wals, 2010). Pearson et al. (2005) and Walshe (2008) identify flaws for SHE TE, including lack of transdiciplinary exercises and flexible models (Minguet et al., 2011), and a dearth of subjective techniques such as story-telling (Khalili et al., 2015). Evangelinos et al. (2009) and Qablan et al. (2009) highlight the relevance of collaborative teaching, especially metaphor building (Walker and Seymour, 2008) and action research (Tormey et al., 2008; Rioux and Pasquier, 2013). Nevertheless, few academics are adequately trained for SHE content (Ramirez, 2006; Holdsworth et al., 2008). They lack expertise, and sustainability matters are left to already overloaded disciplines (Walshe, 2008). Visionary TE techniques necessary for SHE are generally not practicised in classes (von Blottnitz, 2006), and TE does not follow the faster rhythm of research (Adomßent et al., 2014).

3.3. Personal assets (PA)

PA relate to values, beliefs, attitudes and behaviours.

3.3.1. Values

In a broad sense, VA are considered "needs, personality types, motivations, goals, utilities, attitudes, interests, and nonexistent mental entities" (Sidiropoulos, 2014: 472). VA for SHE are

variously assigned as human capital (Khalili et al., 2015) or social capital (Krasny et al., 2013) capable of producing judgement (Foster, 2001), knowledge and skills (von Blottnitz, 2006; Shephard et al., 2014a). A value is regarded as "a direction or set of goals that helps guide our actions" (Butler et al., 2014: 457). Holt (2003) states that awareness of environmental problems encourages people to get more responsible, encouraging pro-environmental VA, and Le Hebel et al. (2014) observe that positive VA arise when separation between self and nature fades away. Environmental VA can be individual or collective (Moore, 2005), internal – mediated by emotions, motivation, control – and external – shown through pro-environmental action, or its observed effects (Breunig et al., 2014). Environmental literacy (Ferreira et al., 2006; Shephard et al., in press), including that embedded in career-based programs (Lozano, 2006 a; Murray and Murray, 2007), as competencies development (Hoover and Harder, 2015), and institutional work (Winter and Cotton, 2012; Stubbs, 2013), are supposed to lead and change environmental VA. Parkes and Blewitt (2011) associate sustainability VA with ethics and social responsibility in business. More recently, sustainability VA are depicted as reflective (Perdan et al., 2000; Pacheco et al., 2006; Du et al., 2013), individual and inner attributes as compassion, equity, justice, peace, cultural sensitivity, and care for the rights of future generations (Thomas, 2009). This is also referred to as value consciousness, driven by criticism in disregarding future generations (Juárez-Nájera et al., 2010) and governance for citizenship (Bremer and López-Franco, 2006). However, VA are no assurance of effective behaviour: "We have life-affirming values, but we cannot consistently demonstrate behaviours that represent such values" (Pappas et al., 2015 332). VA is therefore a first step in PA for SHE.

3.3.2. Beliefs

BF come from a system of aligned knowledge and VA (Balgopal et al., 2012; Christie et al., 2013), and are consolidated through experiences with positive results (Christie et al., 2014), so that trust is formed. Du et al. (2013) state that belief systems are based on normative aspects and on societal arrangements, both giving directions for individuals to act. Behaviour is affected by BF (Le Hebel et al., 2014), that cannot be dissociated from action (Rioux and Pasquier, 2013). Murray and Murray (2007) consider BF as inseparable from VA and AT. The expected consequences of BH and actions reinforce BF, that have also a strong subjective or not fully rational component (Juárez-Nájera et al. 2010), and are usually related to worldviews (Christie et al., 2013). Changing BF is not easy, but necessary for fostering environmental BH (Cotgrave and Kokkarinen, 2010; Mintz and Tal, 2013; Zsóka et al., 2013). BF are behind attitudes towards the conception of environment (Mintz and Tal, 2013). BF can be constructed upon epistemologies and it is built over reflection about VA of environmental assets (Kokkarinen and Cotgrave, 2013).

3.3.3. Attitudes

"Attitudes are defined as the enduring positive or negative feeling about some person, object or issue" (Mintz and Tal, 2013: 149). They are a mix of feelings and BF (Balgopal et al., 2012; Breunig et al., 2014), as part of affective knowledge for the environment (Shepard et al., 2014a,b). According to Zsóka et al. (2013: 124), "environmental knowledge and pro-environmental attitudes are highly interconnected". Environmental AT are associated with learning encouragement (Qablan et al., 2009), and depend also on education (Mintz and Tal, 2013), but can be confused if conceptions about sustainability are not clear (Christie et al., 2014). Le Hebel et al. (2014) classify environmental AT as egoistic (anthropocentric) or altruistic (ecocentric), and in this last category can be included AT which are difficult to find and assess, such as empathy (Remington-Doucette and Musgrove, 2015). AT can be (but might not be) deliberately planned (Rioux and Pasquier, 2013), and are considered practical attributes (Winter and Cotton, 2012) because they impact on daily life and are changeable under general education (Juárez-Nájera et al., 2010), academic formation (von Blottnitz, 2006), skills development (Juárez-Nájera et al., 2006; Stubbs, 2013), and VA evolution (Ferrer-Balas et al., 2010). Ismaili et al. (2014) call the readiness to act towards environmental protection a performance that shows alignment between AT and BH. O'Brien et al. (2013) link AT with philosophical systems as being reformism – addressed, in this context, to changes in curricula, political structures, and societal perspectives about the future. Recent research indicates contradictory results when knowledge on sustainability is compared to action. Álvarez-Suárez et al. (2013:10), analysing consumerism awareness after teaching program intervention, found a mismatch between increasing conceptual and factual knowledge and indifferent attitudes towards sustainability. Chaplin and Wyton (2014) found that students, although considering sustainable living to be a valuable attribute, face barriers to make their convictions turn into actions in terms of BH. This is called the action-gap, because even though individuals seem aware of undesirable consequences of their actions on the environment, they still perform AT and BH in the face of such awareness.

3.3.4. Behaviours

Behaviour is the ultimate goal of learning in general (Mintz and Tal, 2013). Pro-environmental BH can be stimulated but not always maintained because it is influenced by changes related to family, neighbourhood attachment, self affirmation, and perceived environmental control on situations (Rioux and Pasquier, 2013). Zsóka et al. (2013) add to these factors: educational level, norms, pressure, tradition, and infrastructure. Rioux and Pasquier (2013) found that openness to change towards pro-environmental BH is more common when awareness has just arisen rather than when individuals are already conscious of a given environmental issue. In a similar way, Breunig et al. (2014) state that knowledge of environmental problems does not always correspond to favourable BH in terms of solutions because it is common for individuals to claim they have a limited range of actions – the comfort zone prevails over the willingness to act. Therefore, BH can be influenced by awareness and BF (Le Hebel et al., 2014), but is not determined by them.

Self-behaviour, or cognition of self-efforts (Steiner and Posch, 2006), ascription of responsibility, personal intelligence and universal VA (Juárez-Nájera et al., 2010) are relevant, but cannot ever sustain friendly environmental BH. According to Shephard et al., (in press: 12), "high levels of pro-environmental attitude, ecological worldview or environmental concern may not be a sufficient predictor for environmental behaviour". Zsóka et al. (2013:136) reinforces that knowledge and education cannot be despised, but "causalities between environmental education and pro-environmental behaviours are difficult to measure in a reliable way". Knowledge, AT and BH are inter-related (Stubbs, 2013), but formal education relies basically on technical rather

than on behavioural proposals (Sherren, 2006). There is a strong demand for pro-environmental behaviour change, especially addressed to the culture of care (Clarke and Mcphie, 2015). Nevertheless, as BH are contextual and dynamic, it is almost impossible to make them always coherent with environmental pledges (Hargreaves, 2012).

3.4. Integrative assets (IA)

Integrative assets are considered to be those that lay behind, between, and beyond the other sustainability attributes in SHE and include: constructivism, complexity, and holistic thinking.

3.4.1. Constructivism

Constructivism is a form of knowledge structuring according to which reality cannot be accessible unless through mediation of human consciousness; therefore, it denies the possibility of knowledge only from external reality (Zehetmeier et al., 2015). Construction of shared VA, and self-directed LE (Burandt and Barth, 2010) are a significant task derived from epistemology (Christie et al., 2013), through critical thinking. This type of construction facilitates creativity (Christie et al., 2014), collaboration (Foster, 2001), and maturity (Fisk and Ahearn, 2006). Social construction for SHE is a consequence of positive bonds between a constructive epistemology (Christie et al., 2013; Stubbs, 2013) and a subjective process of continuous VA reassessment that lead to conscious action (Rioux and Pasquier, 2013; Zeheteimer et al., 2015). Butler et al. (2014) refer to social constructivism as etiology in the sense of explanation about how knowledge is constructed, deconstructed, and co-constructed, involving negotiation for achieving consensus (Savelyeva and McKenna, 2011). Nevertheless, in education, environmental constructs are not usually connected to human constructs (Holdsworth et al., 2008). Deconstruction of previous abstractive knowledge and rethinking about hyper specialized skills is considered necessary (Manteaw, 2012; Coleman, 2013) as well as observation of hidden curricula as knowledge that helps students to make sense of sustainability as educational practice (Winter and Cotton, 2012). Constructive LE in SHE is a permanent movement between reflective/subjective and reflexive/collective thinking in problematisation (Stauffacher et al., 2006). Lawhon et al. (2010) understand CO as a critical process for knowledge building, and Reed et al. (2015) as a critical epistemological paradigm applied to sustainability practices.

3.4.2. Complexity

Complexity is referred to as the net of inter-relationships typical of real life problems, immersed in sustainability demands (Glassey and Haile, 2012; Sandri, 2013a,b; Khalili et al., 2015). Higher education is supposed to provide structures and tools for dealing with CX because universities hold plural knowledge (Sibbel, 2009) and potential for transdisciplinary practices (Steiner and Posch, 2006; Powell and Larsen, 2013). However, inefficacy in solving complex problems, thereby compromising the ability of future generations to deal with CX, is what has been identified in most SHE initiatives (Lozano-García et al., 2008). Not only technical competences (Redman, 2013), but emotional maturity (Eilam and Trop, 2010; Biswas, 2012; Breunig et al., 2014) and creativity (Lehmann et al., 2009; McDonald, 2006; Steiner and Laws, 2006) need to be developed together because rapid change underlies CX (Fisk and Ahearn, 2006). Mastering such a pace of change is not possible with passive learning or a focus only on theoretical approaches (von Blottnitz, 2006). CX is intrinsic to adaptive systems (Olds, 2013), that are considered epistemics of sustainability (Dale and Newman, 2005). CX creates a synthetic and balanced combination of uncertainty layers of sustainability, including equity and justice (Macris and Georgakellos, 2006; Sandri, 2013a,b). It is both reflective – individual thinking about practices – and reflexive – expression of intricate relationships between individuals and social systems (Powell and Larsen, 2013; Malthouse et al., 2014). Fenwick (2012) argues that awareness of CX principles – like emergence, exposure to risk, feedback loops, and self-organisation of systems – enables better practice of co-productive LE. Jasman and McIlveen (2011) advocate the creation of strategies to prepare individuals for a type of education in which principles of complex systems will embrace all higher education theories and practices.

3.4.3. Holistic thinking

Holistic thinking is the result of constructive and complex approaches such as orientation (Beringer and Adomßent, 2008), integration (Shriberg, 2000; Christie et al., 2013), capacity of knowledge, and intuition all at the same time (Sandri, 2013a,b) for changing the portfolio-type of SHE curricula, from hierarchical (Wals, 2010), to a transdisciplinary set of syllabuses (Lozano, 2010; Lozano and Lozano, 2014). Mingers (2015) establishes strong relationships between critical realism as epistemological thinking that combines empiricism and constructivism, with the achievement of holistic attributes in SHE. According to Sriskandarajah et al. (2010), and Togo and Lotz-Sisitka (2013), holistic views or systems thinking require a very well structured epistemology in order to create awareness of complexities involved in real life practices. The ability to think holistically can facilitate a sustainability transition (Burandt and Barth, 2010; Lukman et al., 2010; Sandri, 2013a,b), but it does not come without conditions for creativity (Kagawa, 2007; Winter and Cotton, 2012) and critical expression (Kitamura and Hoshii, 2010). Articulation of multiple scales (Walker and Seymour, 2008) through dialetic information and formation approaches (Bremer and López-Franco, 2006) can lead to transformative evolution (Thomas, 2009), typical of SHE ideals, but the opposite is what actually takes place (Ferreira et al., 2006; Disterheft et al., 2012). It is very difficult to achieve HT in SHE (Wells et al., 2009) because educational structures are resistant to openness to society, and teachers are used to giving and taking back from students disciplinary knowledge they consider to better fulfil professional requirements under formal curricula. Pappas et al. (2015) take holism as a perspective of well balanced endurance in time that holds material, social and spiritual aspects of being simultaneously.

4. Articulating relationships between SHE attributes and categories

In order to identify and understand what properties arise from SHE categorisation, an assessment of all the attributes, using pairwise analysis between categories, was carried out. There were selected studies with all attributes of all categories (Fig. 3), besides studies with at least all attributes of two categories (Fig. 4). The results show the emergence of properties very indicative of the necessary change in paradigms of SHE.

4.1. Full attributes' studies: the evidence for a curricular gap

From the selected studies, four were found to include all the attributes identified in this study. They infer strong evidence for a

Author(s)	SHE's Categories (*)														
	Foundations				Knowledge organization				Personal assets				Integrative assets		
	PH	EP	ID	TD	PE	LI	LE	TE	VA	BF	AT	BH	CO	CX	HT
Du *et al*. (2013)													#	#	#
Remington-Doucette *et al*. (2013)													#	#	#
Sidiropoulos (2014)													#	#	#
Sterling (2010)													#	#	#

(*) PH: Philosophy; EP: Epistemology; ID: Interdisciplinarity; TD: Transdisciplinarity; PE: Pedagogies; LI: Literacy; LE: Learning; TE: Teaching; VA: Values; BF: Beliefs; AT: Attitudes; BH: Behaviors; CO: Constructivism; CX: Complexity; HT: Holistic Thinking; SHE: Sustainability in Higher Education.

Fig. 3. Studies with full attributes of Sustainability in Higher Education.

Author(s)	Type of relationship (*)					
	FA-KA	FA-PA	FA-IA	KA-PA	KA-IA	PA-IA
Alvargonzález (2011)						
Ardoin *et al*. (2013)						
Baker and Däumer (2015)						
Balgopal *et al*. (2012)						
Bell *et al*. (2014)						
Birkin and Polesie (2013)						
Bossio *et al*. (2014)						
Bremer and Funtowicz (2015)						
Butler *et al*. (2012)						
Clarke and Mcphie (2015)						
Du *et al*. (2013)						
Eilam and Trop (2010)						
Fenwick (2012)						
Figueiró and Raufflet (2015)						
Hadorn *et al*. (2006)						
Hampson (2012)						
Holdsworth and Thomas (2015)						
Hoover and Harder (2014)						
Klein (2004)						
Klein (2015)						
Lawhon *et al*. (2010)						
Levine (2002)						
Max-Neef (2005)						
Mitchell (2009)						
Mobjörk (2010)						
Montuori (2013)						
Newell (2011)						
Nikitina (2006)						
O'Brien *et al*. (2013)						
Osório *et al*. (2009)						
Pappas *et al*. (2015)						
Patterson and Williams (2005)						
Pearson *et al*. (2005)						
Popa *et al*. (2015)						
Redman and Redman (2014)						
Remington-Doucette *et al*. (2013)						
Remington-Doucette and Musgrove (2015)						
Saravanamuthu (2015)						
Sidiropoulos (2014)						
Stauffacher *et al*. (2006)						
Sterling (2010)						
Togo and Lotz-Sisitka (2013)						
Winter and Cotton (2012)						
SUM (number of relationships)	08	13	21	13	11	19

(*) FA: Foundational Assets; KA: Knowledge Assets; PA: Personal Assets; IA: Integrative Assets.

Fig. 4. Pairwise relationships between categories of Sustainability in Higher Education.

relevant gap related to the curricular aspect of SHE. The inconsistency of the development of bonds between theory and practice in higher education relies partially on reluctance to embrace curricular change, and it affects both students and teachers (Du et al., 2013). It is explained as resistance in transdisciplinary curriculum implementation (Remington-Doucette et al., 2013), and by a lack of introductory courses for integrating sustainability LE and BE (Sidiropoulos, 2014). Such a situation reflects a resilience and reflection coming from the actors within the educational system (Sterling, 2010). For these four studies, it is clear that SHE needs to be rooted in a deep conceptual understanding and in PE addressed to integration between different types of knowledge, innovation in real world problem solving, and daily life difficulties, all based in CO as liaison between subjective experiences and concrete challenges.

4.2. FA and KA: the relevance of context

A common feature of eight relationships explored between the categories FA and KA is the relevance of context for SHE. It is noticeable mainly when considering links between ID and forms of TE and LE (Baker and Däumer, 2015; Nikitina, 2006; Remington-Doucette et al., 2013), or between PH and PE (Sidiropoulos, 2014). The context is the place for testing, contesting, and reconstructing knowledge for sustainability (Baker and Däumer, 2015). It is also the place in which individuals exercise their points of view (Hampson, 2012), and problematise their perceptions and LE concepts (Nikitina, 2006) against philosophical assumptions (Sterling, 2010). Alternatively, context is a type of TD laboratory where project based learning can be developed (Stauffacher et al., 2006) over participative EP (Du et al., 2013).

4.3. FA and PA: creativity as value

FA and PA relationships were identified in 13 studies. Scholars that explore the philosophical and epistemological aspects of sustainability claim that VA and BF are pivotal to overcome fragmentation of knowledge and creation of robust links between science and society (Hadorn et al., 2006; Alvargonzález, 2011). Ways of knowing enable BF systems building (Ardoin et al., 2013), but authentic BF can only arise from AT of self-awareness (Birkin and Polesie, 2013). VA are usually related to normative principles (Sterling, 2010; Remington-Doucette et al., 2013; Sidiropoulos, 2014) and to the centrality of knowledge (Stauffacher et al., 2006). The bridge between FA and PA is paved through TD (Alvargonzález, 2011), with purposive BH (Hadorn et al., 2006). It is assumed that transdisciplinary work requires creativity and intuition (Max-Neef, 2005). TD entails axial transformation mainly in BF (O'Brien et al., 2013), because researchers interchange their positions as inquirers and targets of inquiry (Montuori, 2013) in a reflexive practice for legitimating social and civic forms of knowledge production (Du et al., 2013; Popa et al., 2015).

4.4. FA and IA: the transgression challenge

The way knowledge is articulated links FA and IA in 21 relationships. Sustainability is acknowledged as a vague concept (Figueiró and Raufflet, in press), so the epistemologies behind it are claimed to be complex and experience-dependent (Pearson et al., 2005). CX of real life problems bring unpredictable attempts at solution (Sterling, 2010), usually grounded in forms of constructivist approaches (Birkin and Polesie, 2013) that require collaboration among diverse stakeholders (Mobjörk, 2010) and space creation for knowledge (Patterson and Williams, 2005). However, constructivist solutions become difficult when criticism does not follow the escalation of CO (Du et al., 2013). Participatory action is a strategy for articulation of contents and methods between disciplines in order to reframe complex problems. Scholars highlight ID (Mobjörk, 2010; Newell, 2011; Bossio et al., 2014) and TD (Max-Neef, 2005; Ardoin et al., 2013; Montuori, 2013), or both (Du et al., 2013; Sidiropoulos, 2014) as means of tackling such types of problems (Alvargonzález, 2011). Nevertheless it is still not clear how to practice ID and TD. This issue is reframed with HT for organising reflection (Bremer and Funtowicz, 2015) through community participation (Ardoin et al., 2013) and through construction and dissemination of alternative ways of knowledge transformation (Bossio et al., 2014) and narratives (Bremer and Funtowicz, 2015). A strong socio-cultural basis is part of ID and TD as plural epistemologies that enable dialogue between and beyond disciplines (Klein, 2004). But as complex problems usually tend to be tackled with reductionist thinking and tools (Osorio et al., 2009), transgression of this barrier is still a challenge (Klein, 2015).

4.5. KA and PA: resilience and vision

PE, LI and LE are the main KA categories associated with PA in 13 identified relationships. Environmental LI is seen as processes supplied by centred learning that results in the use of scientific knowledge for decision making in human-environmental links (Eilan and Trop, 2010; Balgopal et al., 2012) and processes that involve multiple forms of thinking (Remington-Doucette et al., 2013; Remington-Doucette and Musgrove, 2015). PE strategies for sustainability are referred to as project or problem-based learning (Du et al., 2013), problem-oriented TE (O'Brien et al., 2013), and enquiry-based problem solving (Sidiropoulos, 2014) or generative knowledge (Clarke and Mcphie, 2015). The goal of SHE PE is to facilitate change for environmental AT enduring over time, and such changes are enabled by LE processes that become complex – starting from information, at the first level; criticism, at the second; and individual/societal transformation at the third (Sterling, 2010; Du et al., 2013; Holdsworth and Thomas, in press). Effective LE is dependent on reflexive PE (Stauffacher et al., 2006; Redman and Redman, 2014), which is value-laden and manifests when instrumental and practical knowledge are critically reflected (Holdsworth and Thomas, in press). PE, as TE and LE strategies, cannot assure pro-environmental values. However, two aspects emerge in the relationships between KA and PA that are said to be transformative: resilience of active learners (Sterling, 2010), that takes place when VA come together with emotions (Togo and Lotz-Sisitka, 2013; Remington-Doucette and Musgrove, 2015), and vision, that is an outcome of creative, anticipatory exercises (O'Brien et al., 2013).

4.6. KA and IA: the paradox of deconstruction and affective lessons

When knowledge becomes integrated in complex and holistic constructs, the understanding of causal relationships requires different strategies than those given by unidirectional PE. It is assumed that students and teachers are expected to

exercise constructivist and autonomous relationships, but it is not easily understood (Eilam and Trop, 2010; Fenwick, 2012; Du et al., 2013), because all biased conceptions need to be abandoned (Remington-Doucette et al., 2013). There are paradoxes in looking at the 11 relationships of LE, TE, PE and LI in the context of CX. Some scholars embrace HT as adaptive (Winter and Cotton, 2012; Remington-Doucette and Musgrove, 2015), transformational forms of TE and LE (Hampson, 2012), and as alternative pedagogical tools (Togo and Lotz-Sisitka, 2013), but do not make their assumptions explicit. Therefore, it is not fully explained how such tools are structured and how they work. Otherwise, there is a common reference to CO, adaptive strategies (Sterling, 2010; Togo and Lotz Sisitka, 2013), uncertainties and heterogeneous dimensions of knowledge (Hadorn et al., 2006), and even to chaotic behaviour (Remington-Doucette and Musgrove, 2015) for justifying new pedagogies that seem novel, although they are still based on structuralism (Togo and Lotz Sisitka, 2015). Some ways out of this contradiction are argued to point to the deconstruction of traditional pedagogical frames or curricula (Winter and Cotton, 2012; Saravanamathu, 2015), and in affective learning (Hampson, 2012) as assumptions of the impossible structuring of what manifests as chaotic.

4.7. PA and IA: reshaping VA, BF, AT and BH in layers of reality

Nineteen relationships between PA and IA were identified. Relevance is observed for VA and BF as personal needs, but also as resources employed by individuals to create and measure assets (Sidiropoulos, 2014). VA are applied to self-esteem and to self-efficacy, which means they are reflective – addressed to subjective levels of reality – and reflexive – aimed at evaluation for reaching some practical result or transformation (Sterling, 2010; Bell et al., 2014; Hoover and Harder, 2015). In sustainability studies, VA are difficult to define because they are placed in the context of CX (Butler et al., 2014) that also assumes a hierarchical structure (Max-Neef, 2005; Clarke and Mcphie, 2015). While normative VA are based on social and ethical norms and BF (Ardoin et al., 2013) and influence BF and BH systems, in the context of sustainability they can be deconstructed and constructed according to diverse levels of reality (Alvargonzález, 2011; Birkin and Polesie, 2013; Saravanamuthu, 2015), but such dynamics are difficult to realise. So, the lack of coherence between AT and BH in sustainability education can be created by social pressures (Eilam and Trop, 2010) or by the inherent characteristics of constructive/adaptive BH (Lawhon et al., 2010; Holdsworth and Thomas, in press). VA are formed accordingly diverse levels of reality, because they are based on complex contexts (Remington-Doucette et al., 2013; Remington-Doucette and Musgrove, 2015; Montuori, 2013).

5. Conclusions and recommendations for future research

SHE is a prolific field of study, but most research is focused on curricular, organisational, or behavioural aspects of the key stakeholders: students; teachers; academic staff. The present study offers an alternative approach to fill the gap related to the lack of a simultaneously detailed and comprehensive research work on how to organise diverse assets involved in SHE. Foundational, knowledge, personal and integrative assets of SHE were categories extracted from a broad literature review in this subject, guided by the lens of theroretical sustainability constructs and mediated by reflective and reflexive articulation. The study also provided a robust description of each identified SHE attribute in each category, the relationships among attributes, and pairwise assessment between categories. It delivered insights into the relevance of context, creativity, knowledge transgression, personal resilience and vision for deconstructing current resistance to changes in SHE paradigms.

The curricular gap is at the top of the restrictions as the cause of a lack of capacity for changing old views of sustainability that accomodate a future vision. Once curricular structure is rigid or focused on theoretical aspects that instrumentalise but do not go into detail on the philosophy of sustainability, the capacity of reflection (internalised learning) and reflexion (externalised and shared learning) gets reduced. As a consequence, the deconstruction of old paradigms becomes more difficult. Therefore, besides descriptive studies on SHE, more attention should be payed to reflective and reflexive actions that support the described relationships. This research has implications for the future curricular and pedagogical organisation of SHE's studies, aiming to improve practice in such activities, not only in curricular documents, but in forms of knowledge articulation that deliver curricula as dynamic structures for active and applied learning. It also provides a means of benchmarking existing SHE practice, and can be used as the basis for building capacity in a systematic way, and for qualitative organisation of future studies in this area. For future research, issues can be recommended to be investigated, as:

- How to reinforce bonds between theory and practice in order to mitigate barriers to curricular reform?
- What are the best means to align curricular reform and societal demands for improving SHE?
- How curricular reform can lead to increasingly awareness and effective pro-environmental attitudes?
- How to incentivate communities participation in curricular reform keeping the autonomy of the university?
- How to build strategies for leverage learning based on problem solving?
- What are the best practices to achieve constructivist approaches in SHE?
- What are the most effective means to promote alignment between AT and BH?

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Appendix 1. Primary selected studies with four or more attributes of Sustainability in Higher Education.

Author(s)	SHE's Categories (*)														
	Foundational assets				Knowledge assets				Personal assets				Integrative assets		
	PH	EP	ID	TD	PE	LI	LE	TE	VA	BF	AT	BH	CO	CX	HT
Adomßent *et al*. (2014)			■	■			▒	▒	▒		▒	▒			
Álvarez-Suárez *et al*. (2013)							▒	▒		▒	▒	▒	#		#
Alvargonzález (2011)	■	■	■	■			▒	▒	▒	▒	▒	▒	#	#	#
Ardoin *et al*. (2013)	■	■	■	■			▒	▒	▒	▒	▒	▒	#	#	#
Augsburg (2014)	■	■	■	■	▒		▒	▒			▒	▒		#	
Azeiteiro *et al*. (2015)			■	■	▒	▒	▒	▒	▒		▒	▒		#	#
Bacon *et al*. (2011)	■	■	■		▒	▒	▒	▒				▒		#	#
Balgopal *et al*. (2012)	■	■			▒	▒	▒	▒	▒	▒	▒	▒		#	#
Baker and Däumer (2015)	■	■	■	■	▒	▒	▒	▒	▒				#	#	
Baumgartner *et al*. (2008)	■	■	■	■				▒	▒				#	#	
Bell *et al*. (2014)		■	■		▒		▒	▒	▒	▒	▒	▒	#	#	#
Birkin and Polesie (2013)	■	■	■	■					▒	▒	▒	▒	#	#	#
Blackmore (2007)	■	■	■	■			▒		▒	▒	▒		#	#	
Blanchett-Cohen and Reilly (2013)			■	■	▒	▒	▒	▒	▒	▒	▒		#		#
Blum (2008)					▒		▒		▒		▒		#		
Bossio *et al*. (2014)	■	■	■	■	▒		▒	▒	▒				#	#	#
Bremer and Funtowicz (2015)	■	■	■	■			▒		▒	▒			#	#	#
Breunig *et al*. (2014)									▒	▒	▒	▒		#	#
Bridgland and Whitehead (2005)					▒	▒	▒	▒	▒				#		
Brunstein *et al*. (2015)	■	■	■	■	▒		▒	▒				▒	#	#	
Bursztyn and Drummond (2014)	■	■	■	■			▒	▒	▒		▒	▒			
Butler *et al*. (2012)	■	■			▒		▒	▒	▒	▒	▒	▒	#	#	#
Chaplin and Wyton (2014)		■					▒		▒	▒	▒	▒		#	#
Chernikova (2014)	■	■	■	■											#
Chernikova and Chernikova (2015)	■	■	■	■					▒			▒	#	#	
Christie *et al*. (2013)		■			▒		▒	▒	▒	▒			#		#
Christie *et al*. (2014)		■					▒	▒	▒	▒	▒		#		#
Clarke and Mcphie (2014)	■	■			▒	▒	▒		▒	▒	▒	▒	#	#	#
Clarke and Mcphie (2015)	■	■			▒	▒	▒	▒	▒	▒	▒	▒	#		#
Coleman (2013)	■	■					▒	▒	▒	▒	▒	▒	#	#	
Costel (2015)		■	■		▒		▒	▒	▒	▒	▒	▒		#	
Cotgrave and Kokkarinen (2010)			■			▒	▒	▒	▒	▒	▒	▒			
Cristea (2015)	■	■	■	■	▒		▒	▒					#		
Dale and Newman (2005)		■	■	■		▒	▒	▒	▒		▒	▒		#	#
Darbellay (2015)	■	■	■	■			▒	▒	▒		▒	▒	#	#	
Diamond and Irwin (2013)	■		■		▒	▒	▒	▒	▒		▒	▒	#	#	
Disterheft *et al*. (2015)			■	■			▒	▒	▒					#	#
Du *et al*. (2013)	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	#	#	#
Eagle *et al*. (2015)		■				▒	▒	▒	▒	▒	▒	▒			
Eilam and Trop (2010)	■	■	■		▒	▒	▒	▒	▒	▒	▒	▒	#	#	#
Fenwick (2012)		■	■		▒	▒	▒	▒					#	#	#
Ferreira *et al*. (2006)			■					▒	▒		▒				#
Figueiró and Raufflet (2015)	■	■	■	■	▒		▒	▒		▒		▒	#	#	#
Foster (2001)	■					▒	▒		▒				#		
Friedriksson and Persson (2011)	■				▒		▒	▒			▒	▒	#	#	#
Green (2013)			■		▒	▒	▒	▒		▒		▒			
Hadorn *et al*. (2006)	■	■	■	■	▒	▒	▒		▒	▒	▒	▒		#	

Hamlin (2002)	#	#	
Hampson (2012)	#	#	#
Hargraves (2012)			
Hessels and van Lente (2008)		#	
Holdsworth *et al*. (2008)	#	#	
Holdsworth and Thomas (2015)	#	#	#
Holloway and Gouthro (2011)	#	#	
Holt (2003)			
Hoover and Harder (2014)	#	#	#
Hutchinson and Herborn (2012)	#	#	
Huutoniemi (2015)		#	
Ismaili *et al*. (2014)		#	
Juárez-Nájera *et al*. (2010)			
Jucker (2003)			
Kemp and Nurius (2015)	#	#	
Khalili *et al*. (2015)		#	#
Klein (2004)	#	#	#
Klein (2008)	#	#	
Klein (2015)	#	#	#
Kokkarinen and Cotgrave (2012)		#	
Konting (2012)	#		#
Lawhon *et al*. (2010)	#	#	#
Le Hebel *et al*. (2014)			
Levine (2002)	#	#	#
Manteaw (2012)	#	#	
Mattewman and Morgan (2013)	#	#	
Max-Neef (2005)	#	#	#
Mingers (2015)	#	#	#
Mingue *et al*. (2011)			
Mintz and Tal (2013)			
Mitchell (2009)	#	#	#
Mobjörk (2010)	#	#	#
Montuori (2013)	#	#	#
Moore (2005)		#	
Murray and Murray (2007)	#		
Newell (2011)	#	#	#
Nikitina (2006)		#	
O'Brien *et al*. (2013)		#	#
Olds (2013)	#	#	#
Osorio *et al*. (2009)	#	#	#
Pappas *et al*. (2015)	#	#	#
Parkes and Blewitt (2011)			
Patterson and Williams (2005)	#	#	#
Pearson *et al*. (2005)	#	#	#
Pohl (2005)	#	#	
Popa *et al*. (2015)	#	#	
Popoveniuc (2014)	#	#	
Qablan *et al*. (2009)			
Ramsaroop and van Rooyen (2013)	#	#	#
Redding and Cato (2011)	#	#	
Reed *et al*. (2015)			
Redman (2013)		#	
Redman and Redman (2014)		#	
Remington-Doucette *et al.* (2013)	#	#	#

Remington-Doucette and Musgrove (2015)		■		■	■	■	■	■	■	■	■	■	#	#	#
Rioux and Pasquier (2013)								■	■		■	■	#		
Robinson and Cole (2015)	■	■	■	■				■		■	■		■	#	#	#
Sandri (2013)			■					■		■					#	#
Saravanamuthu (2015)		■		■	■		■	■	■	■	■	■	■	#	#	#
Savelyeva and McKenna (2011)	■		■		■		■	■	■			■		#	#	#
Segalàs *et al*. (2010)	■	■	■	■	■		■	■	■	■	■	■		#	#	
Shephard (2008)		■	■					■	■	■	■	■	■	#	#	
Sidiropoulos (2014)	■	■	■	■	■	■	■	■	■	■	■	■	■	#	#	#
Sriskandarajah *et al*. (2010)	■	■	■		■		■		■	■	■		■	#	#	#
Stauffacher *et al*. (2006)	■	■	■	■	■	■	■	■	■	■	■	■				
Sterling (2010)	■	■	■	■	■	■	■	■	■	■	■	■	■	#	#	#
Steiner and Laws (2006)	■			■	■		■	■	■	■			■	#	#	#
Steiner and Posch (2006)			■	■			■					■			#	
Thaman (2010)	■	■			■	■	■	■	■			■	#			#
Thomas (2009)					■	■	■		■			■				#
Togo and Lotz-Sisitka (2013)	■	■	■	■		■	■	■	■	■	■	■	■	#	#	#
Tormey *et al*. (2008)	■	■	■	■		■		■	■	■	■	■	■			#
Vassigh and Spiegelhalter (2014)			■		■	■	■	■							#	#
Vincent and Focht (2009)	■	■	■	■	■		■	■		■	■	■			#	#
von Blottnitz (2006)							■		■		■		■		#	
Wang *et al*. (2014)					■	■	■	■						#	#	
Walker and Seymour (2008)			■				■	■								#
Winter and Cotton (2012)					■	■	■	■	■					#	#	#
Wooltorton *et al*. (2015)	■		■	■	■		■	■	■		■	■		#	#	#
Zeheteimer *et al*. (2015)	■	■			■		■	■	■	■	■	■		#	#	#
Zoller (2013)			■	■	■	■	■	■	■						#	#
Zsóka *et al*. (2014)							■			■	■	■			#	

(*) PH: Philosophy; EP: Epistemology; ID: Interdisciplinarity; TD: Transdisciplinarity; PE: Pedagogies; LI: Literacy; LE: Learning; TE: Teaching; VA: Values; BF: Beliefs; AT: Attitudes; BH: Behaviors; CO: Constructivism; CX: Complexity; HT: Holistic thinking; SHE: Sustainability in Higher Education.

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