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RESEARCH ARTICLE

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Improving sustainability teaching by grouping and interrelating pedagogical approaches and sustainability competences: Evidence from 15 Worldwide Higher Education Institutions

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Abstract

There has been increasing research on pedagogical approaches, sustainability competences, and how to connect them in Higher Education Institutions (HEIs). This paper's aim is to provide deeper insights into the system of pedagogical approaches and sustainability competences, as well as how these interrelate. A survey was developed to

investigate sustainability teaching in 15 HEIs. The survey was sent to educators of each HEI from which 668 responses were obtained. The responses were analysed in a five-step process: (1) descriptive statistics; (2) Pearson correlations; (3) principal component analyses (PCAs) to detect groups; (4) Pearson correlations between the groups; and (5) regressions. The first step provided the base to carry out the PCAs, from which three groups for the pedagogical approaches (Universal, Social, and Environmental) and three for the sustainability competences (Extrospective-social, Introspective-personal, and Cogitative-processual) were obtained. The correlations between the groups showed that: (1) the competences are closely interrelated; (2) the pedagogical approaches are somehow interrelated; and (3) the pedagogical approaches are somehow interrelated to the competences. The regressions showed that the Universal and Social groups would be most suitable to develop all the competences' groups. The Environmental group develops only the cogitative-processual competences' group. The results served as bases to propose the Sustainability Teaching System (STS), which provides deeper insights into the system of pedagogical approaches and sustainability competences by grouping them, as well as showing directionality and strength. To improve sustainability teaching, it is necessary to understand the pedagogical approaches' groups and how they can develop the competences' groups.

KEYWORDS
education for sustainable development, Higher Education Institutions, holistic thinking, pedagogical approaches, sustainability competences, systems thinking

1 | INTRODUCTION

Addressing sustainability dimensions (economic, environmental, social, and time, as well as their interrelations) has become a priority in many Higher Education Institutions (HEIs), where systems thinking, that is, interconnecting elements compose the system (Lovelock, 2007), is paramount (Friman et al., 2018; Holm et al., 2015; Vare et al., 2019).

In this process, one of the main priorities of HEIs has been incorporating sustainability into their curricula (Holm et al., 2015; Rögele et al., 2022; Seatter & Ceulemans, 2017), which is instrumental in educating students with the skills and capabilities to make societies more sustainable (Lozano, 2006; Stough et al., 2018).

In this context, there has been increasing research during the last 15 years on pedagogical approaches (see Cotton & Winter, 2010; Desha & Hargroves, 2014; Segalàs et al., 2010), sustainability competences (e.g., Bianchi, 2020; Brundiers et al., 2021; Lozano et al., 2019), and how to connect them in an effective way (see Lozano et al., 2017, 2019; Sipos et al., 2008). Educators play a key role in this process, since they are the ones who can facilitate the development of sustainability competences in their students (Ceulemans & De Prins, 2010; Desha et al., 2019; Kalsoom & Khanam, 2017; Rögele et al., 2022).

Lists of pedagogical approaches have been proposed by several authors (e.g., Ceulemans & De Prins, 2010; Cotton & Winter, 2010; Lozano et al., 2017). The discourses on pedagogical approaches have assumed that each pedagogical approach is independent to the others with the exceptions of Lozano et al. (2017), who proposed three groups of pedagogical approaches and then updated it to four rank groups from their use (see Lozano et al., 2019).

In parallel, a number of sustainability competences have been proposed (see Brundiers et al., 2021; Lambrechts et al., 2013; Lozano et al., 2017; Wiek et al., 2011). The lists of competences have assumed that each of the competences is independent to the others with the exceptions of Bianchi et al. (2022), who proposed four groups of sustainability competences with three competences that arose from workshops with experts, and Lozano et al. (2019), who detected four groups from their use.

In addition, there have been efforts to connect pedagogical approaches with sustainability competences (see Sipos et al., 2008; Sprain & Timpson, 2012). One of the few frameworks connecting sustainability competences and pedagogical approaches is proposed by Lozano et al. (2017), and then updated with empirical data (Lozano et al., 2019). However, the directionality and strength between the pedagogical approaches and competences is still under-researched.

The aim of this paper is to provide deeper insights into the system of pedagogical approaches and sustainability competences, as well as how these interrelate.

The rest of the paper is structured in the following way: Section 2 provides a review of pedagogical approaches and sustainability competences; Section 3 explains the methods used; Section 4 presents and discusses the results; and Section 5 provides the conclusions of this research.

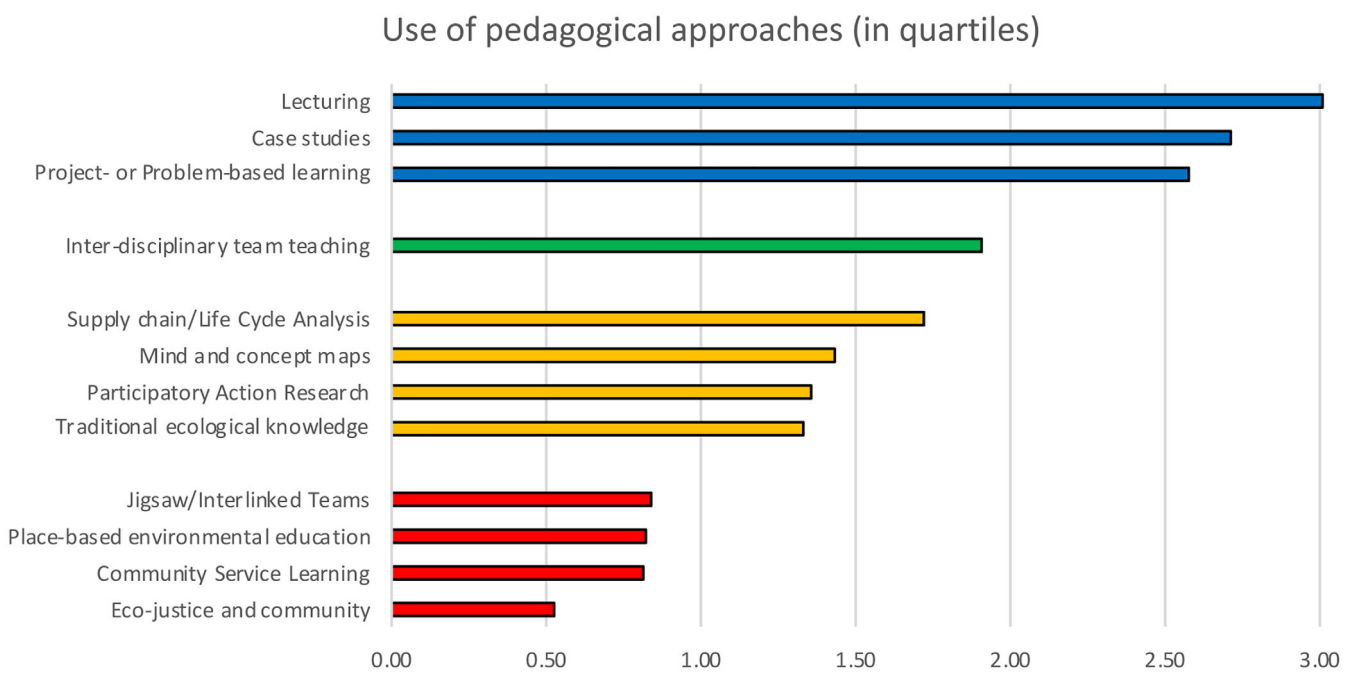

FIGURE 1 Ranking of the pedagogical approaches. *Source*: Lozano et al. (2019) [Colour figure can be viewed at wileyonlinelibrary.com]

2 | PEDAGOGICAL APPROACHES AND SUSTAINABILITY COMPETENCES

Pedagogical approaches are used to develop sustainability competences (see Ceulemans & De Prins, 2010; UNESCO, 2006, 2012). Lists of pedagogical approaches have been proposed by several authors. Ceulemans and De Prins (2010) proposed a range of student-activating methods (e.g., videos, brainstorming, case studies, team work, jigsaw, assignments, problem-oriented education, oral presentations, and project learning). Cotton and Winter (2010) suggested several pedagogical approaches (e.g., role-plays and simulations; group discussions; stimulus activities; debates; critical incidents; case studies; reflexive accounts; personal development planning; critical reading and writing; problem-based learning; fieldwork; and modelling good practice). Lozano et al. (2017) synthesised 12 pedagogical approaches from previous works and divided them into three groups: (1) Universal, that is, pedagogical approaches that have been used in many disciplines and contexts; (2) Social, that is, those developed specifically for use in addressing social justice and community-building; and (3) Environmental, that is, those from environmental sciences and environmental education practices. The last typology is used in this paper since it provides a synthesis of the most widely used pedagogical approaches.

It should be noted that the discourses on pedagogical approaches have, in general, considered them to be independent to each, with some exceptions: Lozano et al. (2017) proposed three groups from a discussion between experts (Universal, Social, and Environmental); and Lozano et al. (2019) a categorisation based on the ranking of the use of the pedagogical approaches divided into four groups rank (see Figure 1): First quartile (lecturing, case studies, project- or problem-based learning); Second quartile (inter-disciplinary team teaching); Third quartile (supply chain/life-cycle analysis, mind and concept maps, participatory action research, traditional ecological knowledge); and Fourth quartile (jigsaw/interlinked teams, place-based environmental education, community service learning, and eco-justice and community).

A number of sustainability competences lists have been proposed. Wiek et al. (2011) discussed five overall competence groups: Systems-thinking; Anticipatory; Normative; Strategic; and Interpersonal competences; Rieckmann (2012) proposed 12 competences: Systemic thinking and handling of complexity; Anticipatory thinking; Critical thinking; Acting fairly and ecologically; Cooperation in (heterogeneous) groups; Participation; Empathy and change of perspective; Interdisciplinary work; Communication and use of media; Planning and realising innovative projects; Evaluation; and Ambiguity and frustration tolerance. Lambrechts et al. (2013) identified six competences: Responsibility; Emotional intelligence; System orientation; Future orientation; Personal involvement; and Ability to take action. Lozano et al. (2017) synthesised previous works to propose 12 competences: Systems thinking, Inter-disciplinary work; Anticipatory thinking; Justice, responsibility, and ethics; Critical thinking and analysis; Interpersonal relations and collaboration; Empathy and change of perspective; Communication and use of media; Strategic action; Personal involvement; Assessment and evaluation; and Tolerance for ambiguity and uncertainty.

The lists of competences have assumed that each of the competences is independent to the others, with some notable exceptions. Bianchi et al. (2022) proposed four groups of sustainability competences with three competences that arose from workshops with experts: (1) Embodying sustainability values (valuing sustainability,

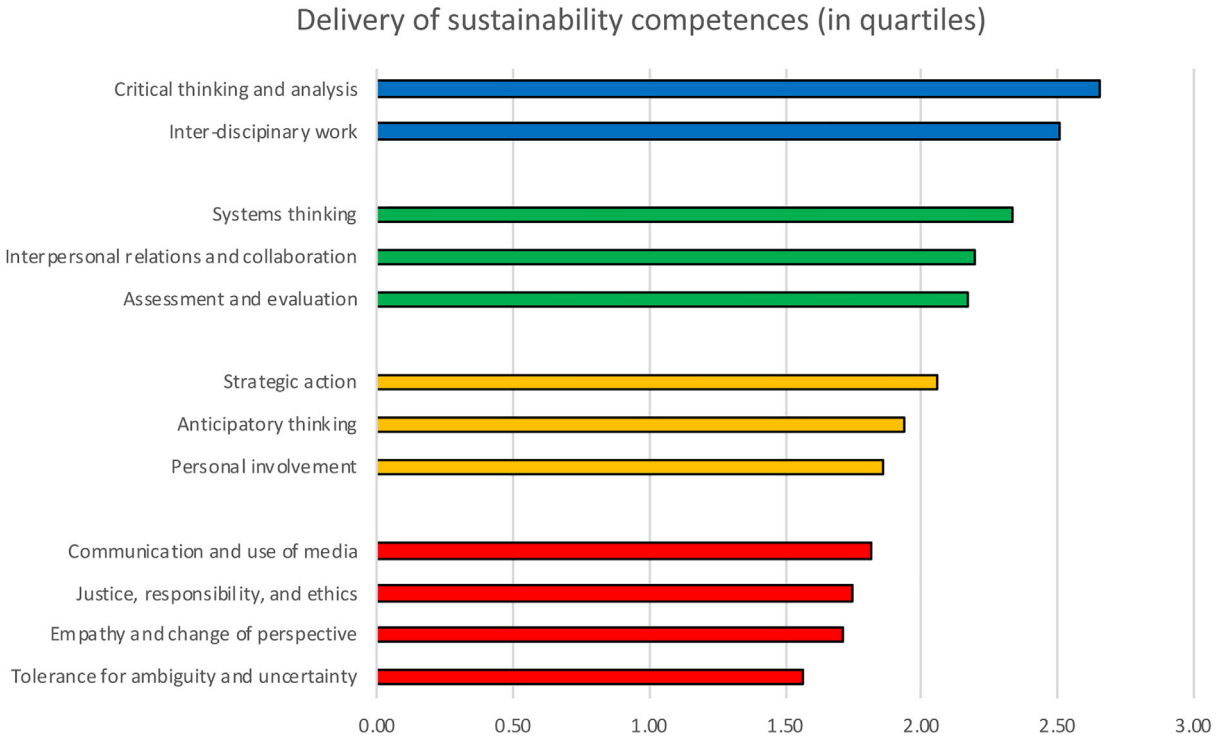

FIGURE 2 Ranking of the sustainability competences. *Source*: Lozano et al. (2019) [Colour figure can be viewed at wileyonlinelibrary.com]

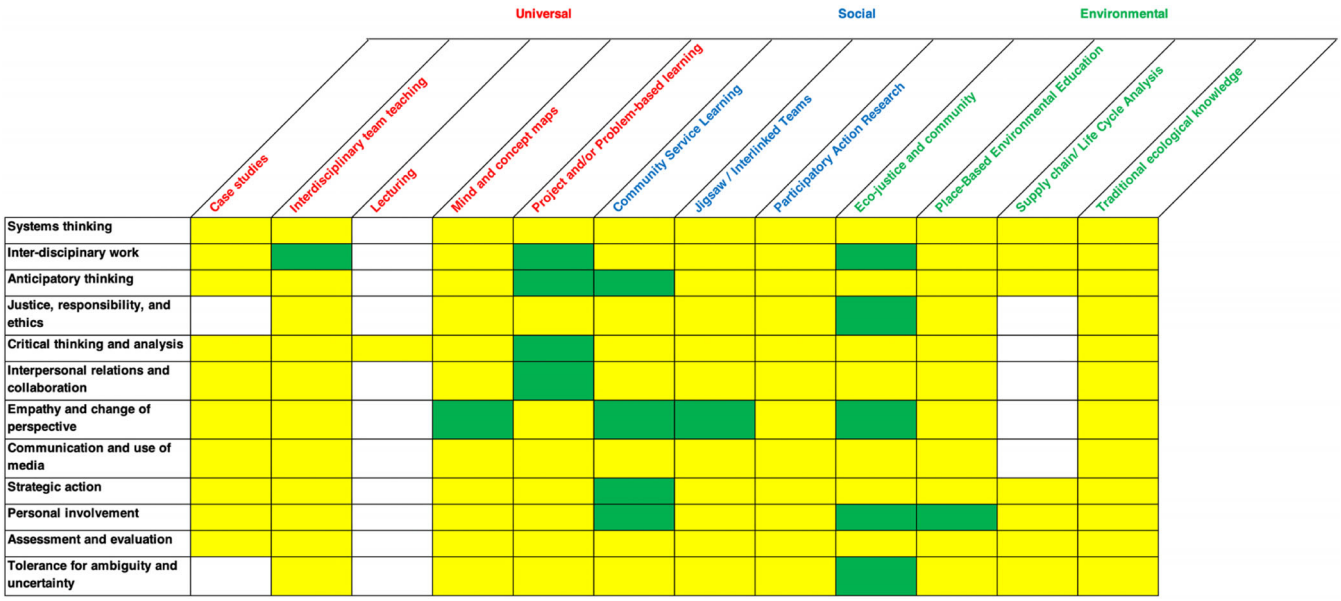

FIGURE 3 Updated framework connecting sustainable development pedagogical approaches to competences. The green cells indicate a high likelihood of addressing the competence, the yellow cells indicate that the approach may address it, and the white cells indicate that the approach does not address the competence. *Source*: Lozano et al. (2019) [Colour figure can be viewed at wileyonlinelibrary.com]

supporting fairness, and promoting nature); (2) Embracing complexity in sustainability (systems thinking, critical thinking, and problem framing); (3) Envisioning sustainable future (futures literacy, adaptability, and exploratory thinking); and (4) Acting for sustainability (political agency, collective action, and individual initiative). Lozano et al. (2019) proposed four groups from their use (in descending order) of sustainability competences (see Figure 2) First quartile (Critical thinking and analysis, and Inter-disciplinary work); Second quartile (Systems thinking, Interpersonal relations and collaboration, and Assessment and evaluation); Third quartile (Strategic action, Anticipatory thinking, and Personal involvement); and Fourth quartile (Communication and use of media, Justice, responsibility, and ethics,

TABLE 1 Details of the case study HEIs

Name of HEI	Level	Country	Students FTE	Educators FTE
University of Gävle	Whole institution	Sweden	16,000	400
University of Helsinki	Whole institution	Finland	31,000	3900
University of Parma	Whole institution	Italy	27,000	1700
Universidade da Coruña (UDC)	Whole institution	Spain	17,000	1400
European University of Lefke	Whole institution	North Cyprus	12,000	120
Universidad de las Américas Puebla (UDLAP)	Whole institution	Mexico	9700	317
Universidad de Ciencias Aplicadas y Ambientales (U.D.C.A.)	Whole institution	Colombia	5000	175
Nyíregyháza University	Whole institution	Hungary	4000	200
Griffith University	Whole institution	Australia	50,000	4000
Universidad Autónoma de Madrid	Whole institution	Spain	33,633	2368
Universidade Aberta (UAb)	Whole institution	Portugal	6000	340
Central University of Technology (CUT)	Faculty	South Africa	6000[a]	123[a]
Warsaw University of Technology	Faculty	Poland	2400[a]	150[a]
University of Belgrade	Faculty	Serbia	1000[a]	300[a]
University of Zaragoza	Faculty	Spain	4400[a]	300[a]

[a]Numbers are at faculty level.

Empathy and change or perspective, and Tolerance for ambiguity and uncertainty).

In addition, there have been some efforts to connect pedagogical approaches with sustainability competences (see Sipos et al., 2008; Sprain & Timpson, 2012). One of the few frameworks connecting sustainability competences and pedagogical approaches is proposed by Lozano et al. (2017), and then updated with empirical data (Lozano et al., 2019), as illustrated in Figure 3. The framework is aimed at helping educators in creating and updating their courses to provide a more complete, holistic, and systemic sustainability education to future leaders, decision makers, educators, and change agents. However, the directionality and strength between the pedagogical approaches and competences is still under-researched.

3 | METHODS

A survey was developed to investigate teaching sustainability competences in 15 HEIs (see Table 1). The HEIs were selected upon their willingness to participate in the research (as discussed by Lozano & Barreiro-Gen, 2021). The survey was sent to educators of each HEI and consisted of six sections (this paper is focused on parts 1, 3, and 4):

1. Background questions about the respondents' characteristics, and their teaching;
2. Self-assessment of sustainability criteria taught;
3. Pedagogical approaches used, on a five-point scale;
4. Competences covered in the course, on a five-point scale;
5. Types of learning, on a five-point scale; and
6. Open ended questions about the incorporation of sustainability in courses.

The survey was translated to the local languages of each HEI (English, Finnish, Hungarian, Italian, Polish, Portuguese, Serbian, Spanish, Swedish, and Turkish) and double-checked by sustainability experts who are native speakers in respective languages, so that the meaning of the questions was not misconstrued, misinterpreted, or misunderstood.

The survey was applied using the online survey tool Qualtrics (2018) and opened between September 2019 to January 2020. Three reminders were sent out. The survey was sent via the gatekeepers to ensure anonymity and comply with ethical issues (including General Data Protection Regulation [GDPR] in the European HEIs).

The survey was sent via the gatekeepers to mailing-lists or emails in each of the HEIs (for details refer to Table 1). For Central University of Technology (CUT) and Universidad Autónoma de Madrid (UAM), the gatekeepers had to engage in face-to-face contact to obtain results. In the case of Griffith University and CUT, ethical approvals had to be obtained at the university level prior to sending the survey.

The pedagogical approaches and competences questions included: (1) the use of the 12 pedagogical approaches, with six possible answers (not applicable/do not know it, never, seldom, from time to time, often, and all the time); and (2) development of the 12 competences in their courses, with five possible answers (not at all; just mentioned during the course; discussed from time to time; complementary to the course, and integral to the course).

The responses were analysed in a five-step process (as shown in Figure 4): (1) descriptive statistics; (2) Pearson correlations; (3) principal component analysis (PCA) to check for groups; (4) Person

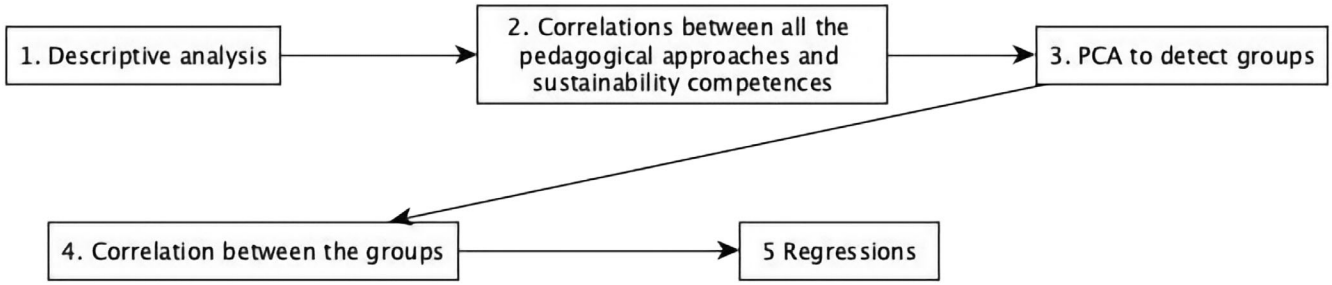

FIGURE 4 Analysis steps to detect groups and interconnectedness between pedagogical approaches and sustainability competences

TABLE 2 Principal component analysis of the pedagogical approaches [Colour table can be viewed at wileyonlinelibrary.com]

Rotated component matrix			
	Component		
Pedagogical approaches	1	2	Group
Place-based environmental education	0.836	0.219	Environmental
Eco-justice and community	0.832	0.228	
Traditional ecological knowledge	0.829	0.125	
Supply chain/life cycle analysis	0.752	0.098	
Participatory action research	0.602	0.461	Social
Community service learning	0.492	0.457	
Jigsaw/Interlinked teams	0.461	0.422	
Inter-disciplinary team teaching	0.360	0.502	
Project- or problem-based learning	0.058	0.797	Universal
Case studies	0.101	0.69	
Mind and concept maps	0.209	0.609	

Note: Extraction method: Principal Component Analysis. Rotation method: Varimax with Kaiser Normalisation.

correlations between the groups; and (5) regressions. These were done using IBM SPSS 24 (IBM, 2015).

3.1 | Limitations of the methods

The internal validity of this research might have been limited by the survey, which may not have offered a complete model of sustainability being taught at the case study HEIs. There might have been problems of interpretation of the survey items, reliability issues due to self-assessment, or problems of understanding the terms in another language. The number of respondents of each HEI may not allow a complete generalisation to sustainability teaching in each institution. A non-response bias may be caused by people who refused to answer or complete the survey. In two cases, the gatekeepers had to engage in face-to-face contact with the respondents, which may reduce the generalisability of the results due to non-random sampling. The survey was carried out in four different continents, where the academic years, may be different, and some educators might have been overloaded with their normal academic activities and did not have the time to answer the survey. The responses were from educators provide a one-sided perspective to sustainability learning, and should be complemented with the student perspective.

4 | RESULTS AND DISCUSSION

In the first step of the analyses, a total of 668 responses were obtained, from which 311 were female, 331 male, and 25 preferred not to say. A total of 249 educators (from the 668 responses) have been teaching more than 20 years, 219 between 10 and 20 years, 79 between 5 and 10 years, 104 between 1 and 5 years, and 17 less than a year.

A proportion (31.9%) of all respondents (213) indicated that they teach sustainability explicitly in their courses. Of this, 27 educators have been teaching more than 20 years, 44 between 10 and 20 years, 53 between 5 and 10 years, 82 between 1 and 5 years, and 7 less than a year.

Regarding the academic cycle, 206 educators taught solely at the bachelor level, 56 solely at the master level, 2 solely at PhD level,

245 at bachelor and master levels, 32 at bachelor and PhD levels, 18 at master and PhD levels, and 105 at bachelor, master, and PhD levels.

The second step of the analysis was a Pearson correlation between the pedagogical approaches and the sustainability competences. This showed interrelations within and between the two systems, which warranted further analyses. It should be noted that Lecturing had the lowest correlations to other pedagogical approaches and to the competences, and thus, was removed from further analyses (as discussed by Lozano et al., 2019, 2021).

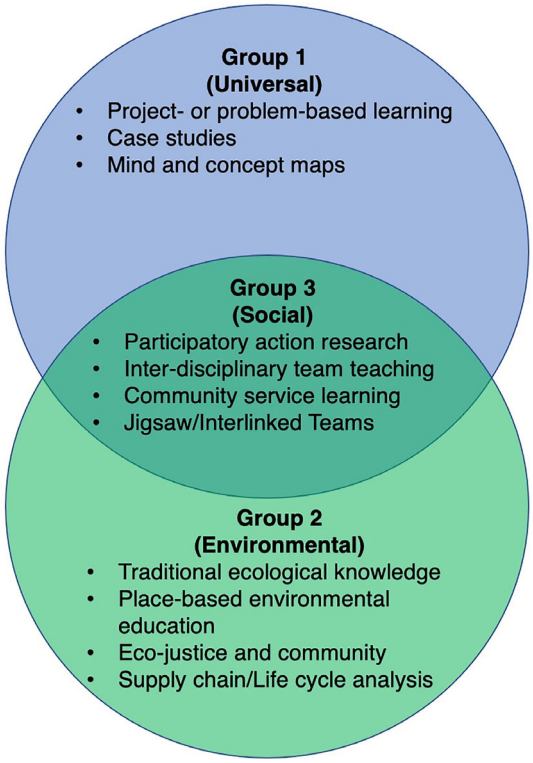

FIGURE 5 Pedagogical approaches groups and their proximity according to the PCA [Colour figure can be viewed at wileyonlinelibrary.com]

The third step in the analyses was to carry out PCAs to detect if any groups would form from their inherent characteristics and compare them against proposed categorisations, that is, Lozano et al.'s (2017, 2019) pedagogical approaches groups, and Bianchi et al.'s (2022) and Lozano et al.'s (2019) competences' groups.

Table 2 shows the PCA of the pedagogical approaches, where it can be observed that three groups were obtained: (1) Environmental, with Place-based environmental education, Eco-justice and community, Traditional ecological knowledge, and Supply chain/Life cycle analysis; (2) Social, with Participatory action research, Community service learning, Jigsaw/interlinked teams, and Inter-disciplinary team teaching; and (3) Universal, with Project- or problem-based learning, Case studies, and Mind and concept maps.

These categorisation confirms the ones proposed previously, with the exception of Inter-disciplinary team teaching was previously considered to be in the Universal group of pedagogical approaches (see Lozano et al., 2017, 2019). The Social group is between the Environmental and Universal groups, Figure 5 illustrates this. This categorisation provides more insights into the groupings than the ranking one as shown in Figure 1 (see Lozano et al., 2019), where Mind and concept maps is in a group with the Universal group (first quartile ranking), the Social group has elements from the all but the first quartile ranking, and the Environmental group has elements from the third and fourth quartile rankings.

Table 3 shows the PCA of the sustainability competences, where it can be observed that three groups were obtained:

TABLE 3 Principal component analysis of the sustainability competences [Colour table can be viewed at wileyonlinelibrary.com]

Rotated component matrix			
	Component		
Sustainability competence	1	2	Group
Empathy and change of perspective	0.854	0.243	Extrospective-social
Interpersonal relations and collaboration	0.837	0.264	
Critical thinking and analysis	0.756	0.285	
Communication and use of media	0.719	0.300	
Justice, responsibility, and ethics	0.697	0.362	Introspective-personal
Tolerance for ambiguity and uncertainty	0.626	0.499	
Inter-disciplinary work	0.542	0.503	
Personal involvement	0.472	0.676	
Strategic action	0.320	0.770	Cogitative-processual
Anticipatory thinking	0.264	0.735	
Systems thinking	0.153	0.725	
Assessment and evaluation	0.398	0.682	

Note: Extraction method: Principal Component Analysis. Rotation method: Varimax with Kaiser Normalisation.

(1) Extrospective-social (since these competences relate are more outward focused), with Empathy and change of perspective, Interpersonal relations and collaboration, Critical thinking and analysis, and Communication and use of media; (2) Introspective-personal (since these competences are more inward focused), with Justice, responsibility, and ethics, Tolerance for ambiguity and uncertainty, Inter-disciplinary work, and Personal involvement; and (3) Cogitative-processual (since these competences are more thinking and process oriented), with Strategic action, Anticipatory thinking, Systems thinking, and Assessment and evaluation. The Introspective-personal group is between the Extrospective-social and Cogitative-processual groups, Figure 6 illustrates this.

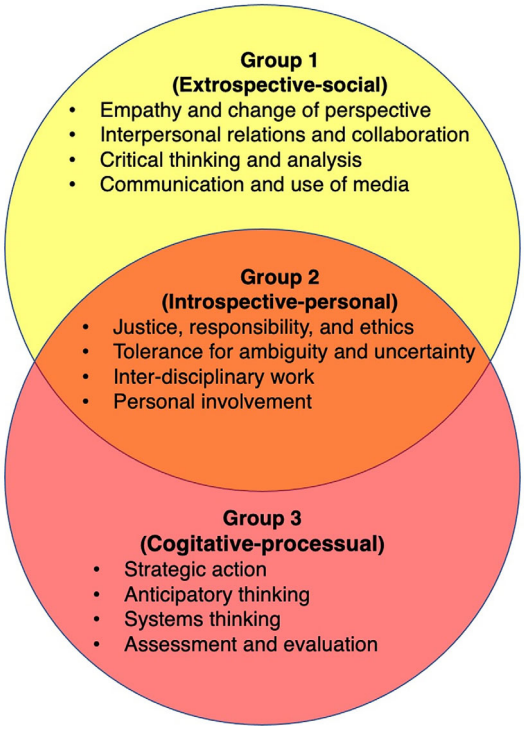

FIGURE 6 Sustainability competences' groups and their proximity according to the PCA [Colour figure can be viewed at wileyonlinelibrary.com]

This grouping, based on empirical research, differs from Lozano et al.'s (2019) ranking and Bianchi et al.'s (2022) categorisation by having three groups instead of four. The group categorisation provides more insights into the groupings than the ranking one (see Figure 2), where the Extrospective-social group has elements from the first, second, and fourth quartile rankings, the Introspective-personal group has elements from the first, third, and fourth quartile rankings, and the Cogitative-processual group has elements from second and third quartile rankings.

The fourth step in the analyses was to carry out a correlation between the pedagogical approaches' and sustainability competences' groups (see Table 4). The results show that the highest correlations are between the competences (high between the Extrospective-social and Introspective-personal (0.801) and Introspective-personal and Cogitative-processual (0.843)). The correlation between the Extrospective-social and Cogitative-processual are slightly lower (0.675), which has the same pattern as the union showed in Figure 6. The pedagogical approaches are relatively less correlated than the competences, where the correlation between the Social and Environmental group is the highest (0.666), followed by the Universal and Social (0.536). The lowest one is between the Universal and Environment (0.398), which has the same pattern as the union showed in Figure 5. These results indicate that the union between the competences is stronger than between the pedagogical approaches.

Table 4 also shows the correlations between the pedagogical approaches' and competences' groups, where it can be seen that the highest ones are between the three pedagogical approaches groups and the Cogitative-processual group (between 0.512 and 0.562), followed by the Introspective-personal group (between 0.411 and 0.488), and to the Extrospective-social group (from 0.243 and 0.475). The Universal and Social groups are similarly correlated to the competences' groups (between 0.441 and 0.562), whereas the Environmental group is the least correlated to the competences' groups (between 0.243 and 0.543). The highest correlation is between the Social group and the Cogitative group (0.562), whereas the lowest one is between the Environmental group and the Extrospective-social group (0.243).

TABLE 4 Correlations between the pedagogical approaches and sustainability competences' groups [Colour table can be viewed at wileyonlinelibrary.com]

		Competences' groups			Pedagogical approaches' groups		
		Extrospective-social	Introspective-personal	Cogitative-processual	Universal	Social	Environmental
Competences' groups	Extrospective-social	-					
	Introspective-personal	0.801	-				
	Cogitative-processual	0.675	0.843	-			
Pedagogical approaches' groups	Universal	0.475	0.488	0.512	-		
	Social	0.441	0.483	0.562	0.536	-	
	Environmental	0.243	0.411	0.543	0.398	0.666	-

TABLE 5 Regressions between the pedagogical approaches' groups and the competences' groups

Dependent variable	Independent variable(s)		Standardised coefficients (Beta)	Sig.	*R* square	Adjusted *R* square
Extrospective-social	Universal		0.475	0.000	0.226	0.225
	Environmental		0.243	0.000	0.059	0.057
	Social		0.441	0.000	0.194	0.192
		Universal	0.316	0.000		
	All groups	Environmental	−0.134	0.022	0.315	0.309
		Social	0.405	0.000		
Introspective-individual	Universal		0.488	0.000	0.238	0.237
	Environmental		0.411	0.000	0.169	0.167
	Social		0.483	0.000	0.233	0.231
		Universal	0.281	0.000		
	All groups	Environmental	0.092	0.100	0.372	0.367
		Social	0.344	0.000		
Cogitative-processual	Universal		0.512	0.000	0.262	0.261
	Environmental		0.543	0.000	0.294	0.293
	Social		0.562	0.000	0.315	0.314
		Universal	0.290	0.000		
	All groups	Environmental	0.213	0.000	0.478	0.474
		Social	0.326	0.000		

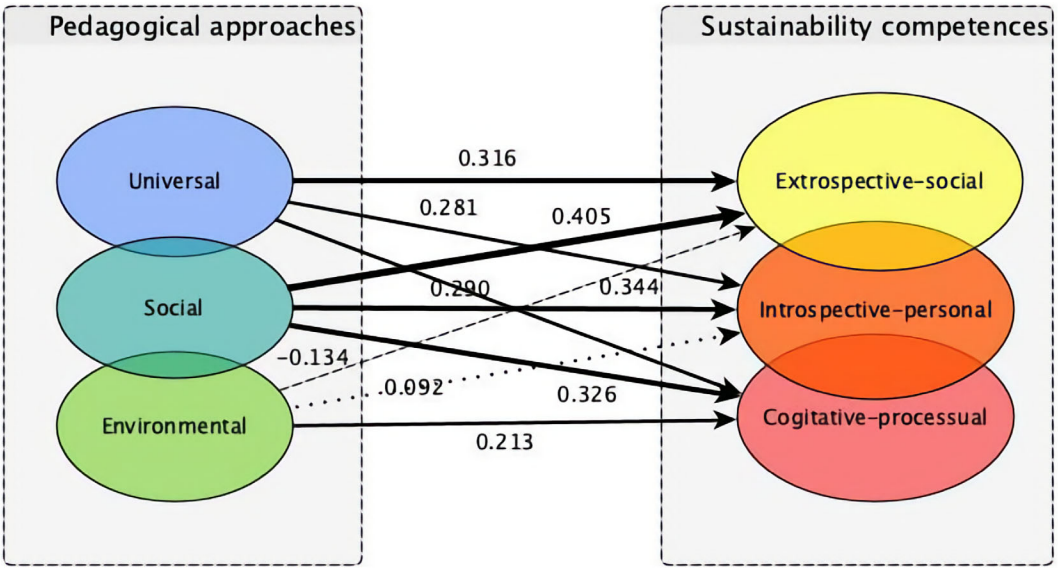

FIGURE 7 Sustainability Teaching System (STS) showing three groups in each sub-system (pedagogical approaches and sustainability competences), their directionality, and regression strength. The arrow widths show the standard coefficient between the pedagogical approaches' groups and competences' groups [Colour figure can be viewed at wileyonlinelibrary.com]

The correlations between the groups show that: (1) the competences are closely related; (2) the pedagogical approaches have medium correlations, with the lowest being between the Universal and Environmental groups; and (3) the pedagogical approaches to the competences have medium correlations, with the exception of the Environmental group that is less correlated to the Extrospective-social group. The Environmental group is less linked to the other pedagogical approaches groups, although its individual elements are closely correlated.

The fifth step was to carry out a regression analysis to investigate how the pedagogical approaches relate to the competences (see Table 5), which showed that the Universal and Social would be most suitable to develop all of the competences' groups, since their standard coefficients and *R* square are the highest with their significance at $p < .01$. The Environmental group is most suitable to develop the cogitative-processual competences, but not the other two competence groups. The combination of the pedagogical approaches

(universal, social, and environmental) develops the cogitative-processual competence group the most.

Steps four and five served as the bases to develop the Sustainability Teaching System (STS) as shown in Figure 7. The STS shows the interdependences between the pedagogical approaches where (1) the Social group is between and joining the Universal and Environmental ones; (2) the Introspective-personal group is between and joining the Extrospective-social and Cogitative-processual ones; and (3) the development of the competences by the pedagogical approaches. The sustainability competences' groups are more interrelated than the pedagogical approaches' groups. The arrows represent the effect of the pedagogical approaches' groups to the competences' groups, where it can be seen that the Universal and Social are relevant in explaining the competences' groups, whereas the Environmental group only develops the Cogitative-processual group. The arrows width in Figure 7 represent the effect of the pedagogical approaches' groups to the competences' groups.

The STS provides deeper insights into the system of pedagogical approaches and sustainability competences by grouping them from empirical evidence, as well as showing directionality and strength, thus complementing previous works (see Bianchi, 2020; Brundiers et al., 2021; Lozano et al., 2019).

5 | CONCLUSIONS

Addressing sustainability holistically has become a priority in HEIs. One of the main efforts for this has been incorporating sustainability into curricula. During the last decade, there has been increasing research on pedagogical approaches, sustainability competences, and how to connect them.

In general, the pedagogical approaches and sustainability competences have been considered each to be independent to the others, with some exceptions grouping the former into Universal, Social, and Environmental, or ranked into four groups; and the latter divided into four groups (Embodying sustainability values, Embracing complexity in sustainability, Envisioning sustainable future, and Acting for sustainability), or ranked into four quartiles. In addition, there have been some efforts to connect pedagogical approaches with sustainability competences; however, the directionality and strength between the pedagogical approaches and competences is still under-researched.

A survey was developed to investigate teaching sustainability competences in 15 HEIs. The survey was sent to educators of each HEI from which 668 responses were obtained. The responses were analysed in a five-step process: (1) descriptive statistics; (2) Pearson correlations; (3) PCA to check for groups; (4) Pearson correlations between the groups; and (5) regressions.

The correlations showed the interrelations within and between the two systems, with the exception of Lecturing that had the lowest correlations and was removed from further analyses.

The PCAs resulted in three distinct groups for the pedagogical approaches, Universal, Social, and Environmental, where the Social is in the middle; and three for the sustainability competences, Extrospective-social, Introspective-personal, and Cogitative-processual, where the Introspective-personal in in the middle.

The groups' correlation showed that the interrelations between the pedagogical approaches tend to be medium (except the Environmental group), the competences tend to be high, and the pedagogical approaches to the competences tend to be medium, except for the Environmental group to the Extrospective-social, which is low. The pedagogical approaches in the Environmental group are well interrelated and could develop sustainability competences. This group tends to behave in an insular, which may be due to a technocentric approach that does not address competences that are more humanistic oriented, such as empathy and tolerance. A more holistic approach may be needed for this group.

The regression analyses provide evidence for directionality and strength between the pedagogical approaches' and the competences' groups, where it can be seen that Universal and Social groups are more relevant in explaining the competences' groups than the Environmental group, which is only relevant in explaining the Cogitative-processual group.

The results served as bases to propose the STS, which showing three groups in each sub-system (pedagogical approaches and sustainability competences), their directionality, and strength. The STS provides deeper insights into the system of pedagogical approaches and sustainability competences, thus complementing previous works.

As Leonardo da Vinci postulated 'Realise that everything connects to everything else'. To improve sustainability teaching, it is necessary to understand the pedagogical approaches' groups and how they can develop the competences' groups.

Further research should be carried out on how to capitalise on the potential on the Environmental group pedagogical approaches; the reasons why Systems thinking and Anticipatory thinking tend to have lower correlations strengths than other competences; how the improve the development of sustainability competences through the pedagogical approaches' groups; and the perspective of students on the sustainability competences and pedagogical approaches.

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