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Technical University of Manabi, Ecuador

*CORRESPONDENCE

M. Pilar Martínez-Agut
✉ m.pilar.martinez@uv.es

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Assessment of GreenComp learning in the training of education professionals

M. Pilar Martínez-Agut^{1*}, Anna Monzó-Martínez¹ and
Eva Ortiz-Cermeño²

¹Department of Theory of Education, Faculty of Philosophy and Educational Sciences, University of Valencia, Valencia, Spain, ²Department of Theory and History of Education, Faculty of Education, University of Murcia, Murcia, Spain

Introduction: The European Green Pact outlines various actions to promote awareness and learning about environmental sustainability. It highlights the European Framework of Competences for Sustainability (GreenComp), which is to be introduced in educational programs. Thus, students develop knowledge, skills, and attitudes that promote thinking, planning, and acting with empathy, responsibility, and care for the planet and their own health. This framework comprises 12 competencies located in four interrelated areas: “embodying sustainability values,” “assuming the complexity of sustainability,” “imagining sustainable futures,” and “acting for sustainability.” This research analyzes the competencies that undergraduate and master’s degree students at the University of Murcia and the University of Valencia claim to possess in the field of sustainable development (477 participants).

Methods: The methodology employed was descriptive-comparative and quantitative, utilizing an ad hoc questionnaire.

Results: The results show that the competencies presented by the students in the experimental and control groups differed at the end of the four months. In particular, the intervention showed a positive effect in the experimental group (EG) in terms of gender and degree taken.

Discussion: These results highlight the need to incorporate ESD from the initial training stage. The application of active techniques and the use of frameworks such as GreenComp offer specific tools that help students develop practical skills and a critical perspective on sustainability.

KEYWORDS

competences for sustainability, European union, higher education, sustainable development, quality education, professional education training

1 GreenComp. The European competence framework on sustainability

GreenComp is the reference framework for sustainability competencies in the European context. It presents an everyday basis for learning recipients and guidance for educational actors. It is intended for education and training programs for lifelong learning (European Commission, 2018), different ages and academic levels, and any formal, non-formal, or informal learning environment.

Competencies for sustainability can help recipients become systematic and critical thinkers, developing the capacity to act and establishing a knowledge base for all individuals concerned about our planet's current and future state, as well as the living things that inhabit it. GreenComp aims to develop the knowledge, skills, and attitudes necessary to think, plan, and act with empathy, responsibility, and care for our planet and the living beings that comprise it. It is a reference model for designing learning opportunities that develop sustainability competencies and assessing progress in supporting education and training for sustainability (EDS).

1.1 Problem statement

The European Commission is committed to achieving the Sustainable Development Goals (SDGs) (UNESCO, 2021a) and quality education (SDG 4) and therefore establishes the need to develop a European sustainability competence framework, the GreenComp, which responds to the European Green Pact (European Commission, 2020a,b), recommending activating education and training through capacity building and investment in learning for environmental sustainability (European Biodiversity Strategy, 2020). The European sustainability competence framework is based on a consolidated consensus established in the report (Bianchi et al., 2022), which was developed through consultation with experts from various fields (Bianchi, 2020; Churchman, 1967). Sustainable development refers to the multiple processes and pathways used to stimulate growth or achieve progress in a sustainable manner, such as the SDGs, which are global goals for all countries and sectors to work together (Molderez and Ceulemans, 2018).

The GreenComp Report defines sustainability as prioritizing the needs of all life and the planet, ensuring that human activity does not exceed planetary limits (Rockström et al., 2009). GreenComp is established for various purposes, including reviewing educational programs, designing teacher training programs, facilitating self-reflection, policy formulation, certification, assessment, monitoring, and evaluation (Bianchi et al., 2022), through competence-based education for education recipients to develop skills based on knowledge and attitudes and to promote responsible actions (Mezirow, 1997).

2 Sustainability competences

In the early 2000's, there is a shift in educational programs in several European countries from a knowledge-based approach to a competence-based approach, identifying specific sustainability competencies in higher education for students and professionals to be agents of change for sustainability (Wiek et al., 2011; Brundiers et al., 2021).

GreenComp defines a sustainability competence as one that enables people to represent sustainability values and embrace complex systems (maintaining ecosystem health, improving justice, and generating visions for sustainable futures) by developing sustainability knowledge, skills, and attitudes focused on thinking, planning, and acting in harmony with the planet. All types of

learning —formal, non-formal, and informal —are considered appropriate for lifelong development, applicable to all areas of life, both personal and collective.

The teaching and learning of sustainability competencies is based on transformative education, which aims to change our perspectives, beliefs, and behaviors through reflection (Mezirow, 1978), questioning the interpretation of our environment and our role as students, consumers, producers, professionals, activists, policy makers, neighbors, employees, teachers and trainers, organizations, communities and society in general, to change the individual and the social institution through a holistic approach.

2.1 Research gap

Therefore, the application of GreenComp to the field of initial training of education professionals represents the originality of the contribution of this research, since it is one of the first studies that implements and evaluates GreenComp in university contexts with undergraduate and master's degree students and the relevance of the study has been specified about previous gaps in the literature to strengthen its academic justification (Gayá and Martínez-Agut, 2025a,b; Martínez-Agut, 2022, 2024a; Martínez-Agut and Monzó, 2023; Pedroza and Reyes, 2023).

3 Areas and competencies of the European sustainability competence framework

GreenComp consists of four interrelated competence areas corresponding to the definition of sustainability and 12 “competencies” that constitute the sustainability competence. Each competence has a descriptor that best represents its main characteristics.

(1) Embodying sustainability values

The competence area “embodying sustainability values” promotes reflection on personal values and worldviews, from unsustainability, sustainability values, equity, and justice (Agyeman et al., 2002; Dasgupta, 2021) for current and future generations, humans being part of nature (Carolan, 2006; Jickling and Sterling, 2017; Phelan, 2004; Remington-Doucette et al., 2013; Sipos et al., 2008; Sleurs, 2008) and thus achieving transformative learning (Mezirow, 1978; Sala et al., 2020) that promotes the ability to act (OECD, 2018; Veugelers, 2000). It is composed of three competencies: 1.1. Valuing sustainability; 1.2. Supporting fairness; and 1.3. Promoting nature.

Educators need to understand sustainability in order to convey it to their students effectively. At the university level, this intervention can be exemplified by a change in pedagogical practices that promotes a comprehensive and critical understanding of environmental and social problems, which also entails changes in study materials (Gómez-Gómez and García-Lázaro, 2023).

(2) Embracing complexity in sustainability

The competence area “Embracing complexity in sustainability” promotes training in systems and critical thinking. It encourages to reflect on how to assess information better and deal with unsustainability, analyze systems by identifying their interconnections and feedback mechanisms, and contextualize challenges (sustainability problems), from the scope of a situation and the identification of the parties involved (European Environment Agency, 2019; Giangrande et al., 2019; Kearins and Springett, 2003; Wals and Benavot, 2017) from different disciplines (Flint et al., 2000), identifying and contextualizing actual or potential, simple or entrenched problems (Glasser, 2018; Pearce and Ejderyan, 2020). The following three competencies are part of this second area: 2.1. Systems thinking; 2.2. Critical thinking; and 2.3. Problem framing.

In this sense, transversality in university education is fundamental, as well as understanding the systems’ internal and external interactions to efficiently face sustainability challenges (Pearce and Ejderyan, 2020). Moreno-Pires and Fidélis (2012) examine, in a study, the use of transformative learning tactics in European university institutions and highlight that the implementation of collaborative and participatory techniques is relevant for fostering sustainable skills in students, facilitating a deeper understanding of the interrelationship between ecological and social systems.

(3) Envisioning sustainable futures

The competence domain “envisioning sustainable futures” allows visualizing future perspectives alternatives and identifying actions to achieve a sustainable future, being capable of “adaptability” processes (Barth et al., 2007) and coping with uncertainty about futures and sustainability commitments through creative (Daskolia et al., 2012) and multidisciplinary, abandoning certainties to focus on possibilities and changes (Bishop, 2019; Wahl, 2016) in a complex society (Barth et al., 2007) to which adaptive processes have to occur (Bacigalupo et al., 2016; Giovannini et al., 2020). This third domain presents three competencies: 3.1. Futures literacy; 3.2. Adaptability; and 3.3. Exploratory thinking.

University education must equip students with the skills to visualize future scenarios and design strategies to achieve them, while managing the associated uncertainty and risk. It must focus, in short, on cultivating the ability to envision sustainable futures and incorporating these skills into academic programs (UNESCO, 2017).

(4) Acting for sustainability

Acting for sustainability enhances mobilization at the individual (European Commission, 2020a; European Commission, 2021; European Environment Agency, 2021) and collective levels to shape sustainable futures, demanding actions from the people responsible for making change happen and recognizing that the transformations needed to achieve sustainability require technological, cultural and social changes, behavioral modifications and institutional reforms, from the local (Ardoín et al., 2020)

community, regional and global levels, through long-term decisions (European Commission, 2020c; UNEP, 2021). This fourth area comprises three competencies: 4.1. Political agency; 4.2. Collective action; and 4.3. Individual initiative.

To this end, it is necessary to recognize the collective action based on communities and civil society organizations, which play a fundamental role in achieving sustainability from the standpoint of critical citizenship (Breiting and Mogensen, 1999). In this context, active learning methods, which encourage students’ proactive participation in sustainable projects, gain significant relevance. This method not only aims to foster skills that enable students to participate in sustainability processes but also provides a more detailed understanding of how to operate within the political system and how to recognize and demand effective public policies for sustainability. In this context, students become catalysts of transformation, able to actively contribute to improving society and the planet (Ruiz-Bernardo and Rambla, 2024).

4 Materials and methods

This study employs a descriptive-comparative methodology and a quantitative approach. The data were collected through an *ad hoc* questionnaire addressed to undergraduate and master’s degree students in the field of education.

4.1 Participants

The participants in this study are students with different university degrees (Primary Education, Social Education, Pedagogy) and Master’s Degrees in Secondary Education at two Spanish universities (the University of Valencia and the University of Murcia). The research was structured into an experimental group and a control group, with an intervention. In addition, data collection was carried out at two different times (pretest and posttest). Table 1 presents the participants categorized by phase and group type.

Of the 477 cases that comprise the sample, 92 are part of the CG and 385 are part of the EG. Regarding sociodemographic data, 40.2% of the CG and 14.3% of the EG were men, representing 19.3% of the total sample. On the other hand, the most represented age group was 18–25 years (67.4% in CG and 87.3% in SG). The majority of the CG participants are studying for a Master’s Degree in Secondary Education (84.8%), and the EG (51.7%) is pursuing a Degree in Primary Education. Of the total sample, 41.7% are studying for a degree in Primary Education, followed by a Master’s Degree in Secondary Education (28.1%). Of the total sample, 60.6% are in the first year (83.7% in GC and 55.1% in GE).

4.2 Research design

The method used is quantitative quasi-experimental (non-random selection of cases). The design was observational since there was no manipulation by the investigator of the criterion variables; longitudinal, since it was carried out at two different times (pre- and post-intervention); and retrospective, since the analysis was performed after data collection.

TABLE 1 Participants.

Groups	Master's degree in secondary education	Degree in social education	Degree in pedagogy	Degree in primary education
Experimental pre-test	32 (UV)	35 (UM)	35 (UV)	143 (UM)
Experimental post-test	24 (UV)	18 (UV) 22 (UM)	20 (UV)	56 (UM)
Control pre-test	35 (UV)		11 (UV)	–
Control post-test	31 (UV) 12 (UM)		3 (UV)	–
Total	134	75	69	199

4.3 Instruments

An *ad hoc* questionnaire was used for data collection, in which participants were asked to assess the extent to which they possessed certain skills related to Education for Sustainable Development (a nominal polytomous scale and an ordinal scale were used, with 1 being the lowest value and 5 the highest). The questionnaire was based on the GreenComp (Bianchi et al., 2022). The linkage between the different items and the competencies and descriptors is illustrated in Table 2. A total of 179 The questionnaire was assessed by a group of experts in Education for Sustainable Development. The reliability analysis of the instrument yielded a Cronbach's alpha of 0.875, indicating a strong correlation between all items analyzed and suggesting perfect internal consistency of the instrument. On the other hand, the KMO measure of 0.873 indicates ideal sampling adequacy, implying that the data are adequate for performing an Exploratory Factor Analysis. Bartlett's test of sphericity ($p < 0.001$) confirms the presence of significant correlations between items. The responses were collected through a Google Form for subsequent analysis.

Kaiser-Meyer-Olkin measure of sampling adequacy		0.873
Bartlett's test for sphericity	Approx. Chi-square	3685.984
	df	253
	Sig.	0.0000

4.4 Methodological limitations

This study has some methodological limitations. Firstly, the absence of randomization of the sample. On the other hand, there is an imbalance between groups, as the sample was obtained based on the availability of participants. However, all of them hold degrees related to education. Finally, the study exclusively uses self-reported data and only quantitative data. These limitations are offset by the sample obtained and the results achieved.

4.5 Procedure

The research was structured in three phases. In the first phase, the pretest was administered to the participants of the

experimental and control groups. The intervention was carried out in the experimental groups in the second phase. In the third and final phase, the post-test questionnaire was applied, which consisted of the same questionnaire as the pretest, to which a question was added regarding the number of subjects taken during the four-month period that had integrated competencies for sustainable development. The study followed all ethical regulations, including obtaining informed consent from all participants. In addition, the confidentiality and anonymity of the data collected was guaranteed.

4.6 Data analysis

The analysis of the data collected was carried out using the SPSS v. 27.0 statistical package. A descriptive-comparative analysis was carried out: on the one hand, we analyzed the skills students claimed to possess concerning sustainable development. Subsequently, we examined whether these data varied according to sex, degree, and the intervention received in this area. To this end, frequency analysis was used for qualitative variables of a nominal nature. For discrete variables, measures of central tendency (mean, median) and dispersion (standard deviation, minimum, maximum) were calculated to describe the characteristics of the sample.

Cross tables and the Chi-square statistical test were used to compare frequencies to determine whether there is an association between the variables studied. In the comparison of ordinal variables under study according to classification variables (nominal), the comparison of independent groups has also been used under the non-compliance of normality and, therefore, the pertinent non-parametric tests for the case of comparison of two groups: the Mann-Whitney U test and in the case of comparison of more than two groups the Kruskal-Wallis test. The results of these comparisons were complemented with the calculation of the effect size to measure the magnitude of the differences observed between groups and within each group before and after the intervention.

5 Results

In this section, we present the descriptive and comparative analysis results. In the questionnaire, participants were asked to what extent they considered that they possessed the skills we

TABLE 2 Linking items with GreenComp.

Competence areas	Competences	Descriptor	Questionnaire item
1. Embodying sustainability values	1.1 Valuing sustainability	(1) To reflect on personal values; identify and explain how values vary among people and over time, while critically evaluating how they align with sustainability values.	4. I understand the unsustainable aspects of our society, such as climate change, poverty and economic crisis, and how they are evolving. I am aware of the urgent need for change through education.
	1.2 Supporting fairness	(2) To support equity and justice for current and future generations and learn from previous generations for sustainability.	6. Values and ethics underpin my daily actions.
	1.3 Promoting nature	(3) To acknowledge that humans are part of nature; and to respect the needs and rights of other species and of nature itself in order to restore and regenerate healthy and resilient ecosystems.	5. I am interested in my own and other people's emotions and feelings, and I value the emotional connection with the natural world. 13. I am aware of the importance of my body. Therefore, I exercise and have healthy habits.
2. Embracing complexity in sustainability	2.1 Systems thinking	(4) To approach a sustainability problem from all sides; to consider time, space and context in order to understand how elements interact within and between Systems.	1. I understand the world as an interconnected whole, I look for connections between the social and natural environment, and I take into account the consequences of my actions on people and society.
	2.2 Critical thinking	(5) To assess information and arguments, identify assumptions, challenge the <i>status quo</i> , and reflect on how personal, social and cultural backgrounds influence thinking and conclusions.	10. I critically evaluate the relevance and reliability of claims, information, sources and theories. 12. I act prudently and promptly, even in situations of uncertainty.
	2.3 Problem framing	(6) To formulate current or potential challenges as a sustainability problem in terms of difficulty, people involved, time and geographical scope, in order to identify suitable approaches to anticipating and preventing problems, and to mitigating and adapting to already existing problems.	14. I value other cultures and races positively.
3. Envisioning sustainable futures	3.1 Futures literacy	7) To envision alternative sustainable futures by imagining and developing alternative scenarios and identifying the steps needed to achieve a preferred sustainable future.	2. I explore alternatives to improve the future and reflect on how I should change my behavior to achieve my wellbeing and that of others.
	3.2 Adaptability	(8) To manage transitions and challenges in complex sustainability situations and make decisions related to the future in the face of uncertainty, ambiguity and risk.	11. I reflect on my actions; I act with transparency and responsibility.
	3.3 Exploratory thinking	(9) To adopt a relational way of thinking by exploring and linking different disciplines, using creativity and experimentation with novel ideas or methods.	8. I am curious and creative. I am interested in new challenges.
4. Acting for sustainability	4.1. Political agency	(10) To navigate the political system, identify political responsibility and accountability for unsustainable behavior, and demand effective policies for sustainability.	9. I am proactive, dynamic and with initiative.
	4.2 Collective action	(11) To act for change in collaboration with others.	7. I am flexible and I like to work collaboratively and on interdisciplinary projects.
	4.3 Individual initiative	(12) To identify own potential for sustainability and to actively contribute to improving prospects for the community and the planet.	3. I carry out actions that contribute to promoting sustainable development.

were trying to analyze, taking into account that the values of the responses ranged from 1 (the lowest value) to 5 (the highest value). In this sense, the items about which participants were asked were related to the four domains of the Greencomp (Bianchi et al., 2022), organized as highlighted in Table 2.

5.1 Competence area 1: embodying sustainability values

The first area of the Greencomp relates to sustainability values. In this regard, the research results shown in Table 3 indicate that the

TABLE 3 Competence area 1. Descriptive data of the control and experimental groups.

Valuing sustainability												
4. I understand the unsustainable aspects of our society, such as climate change, poverty and economic crisis, and how they are evolving. I am aware of the urgent need for change through education.												
	GC					GE					Control-Experimental	
	Media	SD	Median	Min.	Max.	Media	SD	Median	Min.	Max.	p	d
Pre-test	4,43	0,62	5	3	5	4,42	0,73	5	2	5	0.254	−0.068
Post-test	4,33	0,63	4	3	5	4,44	0,71	5	1	5		
Supporting fairness												
6. Values and ethics underpin my daily actions.												
Pre-test	4,00	0,79	4	3	5	4,16	0,85	4	1	5	0.175	−0.084
Post-test	4,22	0,70	4	3	5	4,29	0,67	4	3	5		
Promoting nature												
5. I am interested in my own and other people’s emotions and feelings, and I value the emotional connection with the natural world.												
Pre-test	4,24	0,79	4	2	5	4,47	0,77	5	1	5	0.005	−0.167
Post-test	4,22	0,92	4	2	5	4,51	0,68	5	2	5		
13. I am aware of the importance of my body. Therefore, I exercise and have healthy habits.												
Pre-test	3,76	0,95	4	2	5	3,68	1,04	4	1	5	0.294	−0.068
Post-test	3,57	1,17	4	1	5	4,00	0,98	4	1	5		

initial means of all participant groups are high, especially in the first three items, suggesting a similarly high level of awareness among students in the field of education regarding sustainability issues and the urgency of educational change. In the pre-posttest comparison, we can observe that the EG shows a slight increase. At the same time, the CG experiences a slight decrease, in the competencies Valuing Sustainability and Nature Promotion. Although these differences are subtle, they suggest that the intervention may have helped the EG maintain or improve their awareness of sustainability.

In contrast, the CG, without intervention, shows a slight decrease in their assessment. Regarding the endorsement of equanimity (item 6), the pretest results showed that the EG started with a slightly higher mean than the CG, indicating a somewhat greater initial predisposition toward endorsing values and ethics in daily actions in the EG. In the posttest, both groups showed an increase, with the EG maintaining a slight advantage over the CG. This suggests that the intervention may have influenced the EG to strengthen the integration of values and ethics in daily actions.

Regarding the significance of the differences analyzed, although in most items there is no statistically significant difference between the EG and the CG, as shown in Table 3, the mean is slightly higher in the case of CG, except for item 5 of the Promoting nature competence. In this case, the intervention had a positive effect on the EG, achieving a greater emotional connection with the natural environment and one's own and others' feelings, compared to the CG.

A comparison by sex shows differences between men and women, as shown in Table 4. In the competence of Valuing sustainability (item 4), although both men and women demonstrate a high awareness of the problems of unsustainability and the need for change through education, women show a slightly higher mean than men, with a lower standard deviation, suggesting a more homogeneous and higher perception among them. This situation is also observed in the Competence Supporting fairness, as regards item 6, although the difference is less pronounced than in the previous item. Also, in the competence Promoting Nature (item 5), although both genders show a high interest in emotional connection with nature and feelings, women present a notably higher mean and a lower standard deviation, again suggesting a more homogeneous and higher valuation. This item shows the most significant difference between genders of all the items analyzed. On the other hand, item 13 presents the lowest scores and the most significant variability in both genders. The difference between men and women is minimal, with a slight advantage for women.

As reflected in the analysis of the level of significance shown in Table 4, there are statistically significant differences between men and women in the Valuing sustainability (item 4). In contrast, the differences are not crucial concerning Supporting fairness (item 6). In the Competence Promoting nature, there are statistically significant differences between men and women regarding item 5, suggesting that women appear to show a significantly greater interest in emotions and emotional connection with the natural world. However, these differences are not significant in terms of awareness of the importance of the body and healthy habits (item 13). In short, the most notable differences between men and women are found in the items related to Valuing sustainability and emotional connection with nature, where women show significantly higher scores. Overall, the intervention has a positive

impact on the Experimental Group (EG), particularly in terms of sustainability, ethics, connection to nature, and self-care. Although the differences are insignificant, the EG showed a slight improvement compared to the control group (CG) in the posttest, indicating that the intervention strengthened these values and attitudes.

Regarding the other variable being compared, the participants' degree program, there are also differences, as shown in Table 5, assuming that the intervention was identical across all degree programs and groups involved. Social Education students consistently show the highest scores on most items, suggesting a greater sensitivity to issues of sustainability, ethics, and emotional connection. Pedagogy students tend to show the lowest scores on most items, which could indicate a need to strengthen these aspects in their training. Valuing sustainability is high in all groups, reflecting a generalized awareness of social and environmental issues in future education professionals.

More specifically, for the competence Valuing Sustainability (item 4), it is observed that Social Education students have the highest mean (4.48), followed closely by those of the Master's Degree in Secondary Education (4.43) and Primary Education (4.42). Pedagogy students have the lowest mean (4.32), although it is still high. The standard deviations are relatively low, suggesting a consistency in the responses within each group. Thus, all groups show a high appreciation of sustainability, with Social Education students leading slightly. In contrast, future pedagogues have a somewhat lower awareness of this aspect. The results are similar to those of Competence Supporting Fairness (item 6).

Additionally, the Social Education students stand out with the highest mean (4.44) and the only median of 5. The Pedagogy students also show the lowest mean (3.91), although there is more variability among them ($SD = 0.98$). Thus, there is a notable difference in how the different groups perceive the influence of values and ethics in their daily actions, such that Social Education students seem to have a more substantial commitment to these principles. In contrast, Pedagogy students show a less pronounced adherence.

Regarding the competence of promoting nature, the students of Social Education lead with the highest mean (4.59), while those of Pedagogy point to a lower mean (4.17) and higher variability ($SD = 1.01$) as regards item 5. Regarding its other item, item 13, it generally shows the lowest scores across all groups. Primary Education students have the highest mean (3.88), while Pedagogy students have the lowest (3.55). Therefore, there is a strong valuation of the emotional connection with nature in all groups, being more pronounced in Social Education and less in Pedagogy. In addition, awareness of the importance of the body and healthy habits is the least developed aspect in all groups, with considerable variability in the responses.

The data on the analysis of the level of statistical significance in the comparison based on degree are shown in Table 5. There are no significant differences between degrees in the Valuing of sustainability (item 4). On the other hand, differences are substantial to the competence Supporting fairness (item 6), so that Social Education students show the highest average rank (278.92), while Pedagogy students show the lowest (203.63). This suggests that Social Education students tend to base their actions more on values and ethics, while Pedagogy students do so to a lesser extent. Finally, for the competence Promoting nature, in item 5, although

TABLE 4 Competence area 1. Descriptive items total sample by group.

Valuing sustainability									
	Man			Woman			Total		
	Media	SD	Median	Media	SD	Median	Media	SD	Median
			N	Average range	Sum ranks	Mann-Whitney U test	p-value	d	
4. I understand the unsustainable aspects of our society, such as climate change, poverty and economic crisis, and how they are evolving. I am aware of the urgent need for change through education.	4.25	0.83	4	4.47	0.65	5	4.42	0.70	5
		M	92	211.82	19487.5	15209.5	0.03	−0.136	
		W	380	242.48	92140.5				
Supporting fairness									
6. Values and ethics underpin my daily actions.	4.10	0.84	4	4.21	0.77	4	4.19	0.78	4
		M	92	223.58	20569.0	16291.0	0.275	−0.07	
		W	380	239.63	91059.0				
Promoting nature									
5. I am interested in my own and other people's emotions and feelings, and I value the emotional connection with the natural world.	4.20	0.90	4	4.49	0.72	5	4.43	0.77	5
		M	92	203.22	18696.0	14418.0	0.333	−0.175	
		W	380	244.56	92932.0				
13. I am aware of the importance of my body. Therefore, I exercise and have healthy habits.	3.68	1.12	4	3.78	1.02	4	3.77	1.03	4
		M	92	229.15	21082.0	16804.0	0.548	−0.04	
		W	380	238.28	90546.0				

TABLE 5 Competence area 1. Comparison by sex.

Valuing sustainability																		
4. I understand the unsustainable aspects of our society, such as climate change, poverty and economic crisis, and how they are evolving. I am aware of the urgent need for change through education.																		
Degree in primary education				Master's degree in secondary education				Degree in pedagogy				Degree in social education				Total		
Med	SD	Median	Av range	Med	SD	Median	Av range	Med	SD	Median	Av range	Med	SD	Median	Av range	Med	SD	Median
4.42	0.75	5	242.38	4.43	0.68	5	239.94	4.32	0.72	4	219.57	4.48	0.62	5	246.23	4.42	0.70	5
H.K-W		2.133		p.-v		0.54		ε²		0.004								
Supporting fairness																		
6. Values and ethics underpin my daily actions.																		
4.23	0.75	4	244.04	4.13	0.74	4	227.38	3.91	0.98	4	203.63	4.44	0.64	5	278.92	4.19	0.78	4
H.K-W		13.9		p.-v		0.003		ε²		0.03								
Promoting nature																		
5. I am interested in my own and other people's emotions and feelings, and I value the emotional connection with the natural world.																		
4.49	0.70	5	244.76	4.40	0.79	5	234.84	4.17	1.01	4	209.54	4.59	0.57	5	258.27	4.43	0.77	5
H.K-W		6.51		p.-v		0.09		ε²		0.01								
13. I am aware of the importance of my body. Therefore, I exercise and have healthy habits.																		
3.88	1.03	4	254.22	3.78	1.06	4	242.39	3.55	0.88	4	204.80	3.65	1.08	4	224.03	3.77	1.03	4
H.K-W		8.13		p.-v		0.04		ε²		0.02								

it does not reach the conventional level of significance, it points to a tendency toward differences between the degrees. Social Education students show the highest average rank (258.27), while Pedagogy students show the lowest (209.54). Meanwhile, in item 13, there are significant differences between the degrees in terms of awareness of the importance of the body and healthy habits. The students of Primary Education show the highest average rank (254.22), while those of Pedagogy show the lowest (204.80).

In short, students from all degree programs show similar levels of Valuing sustainability issues and the need for change through education. However, there is evidence of improvements, in some cases significant, after the intervention in the EG, suggesting that it has an impact on the values linked to sustainability. In the comparison by sex, women, in general, seem to have a greater awareness in this area. There are also differences in how values and ethics underpin the daily actions of students, with Social Education students applying them the most and Pedagogy students applying them the least. In general, Pedagogy students tend to show the lowest average ranks in several items, which could indicate a need to reinforce these aspects in their training.

5.2 Competence area 2: embracing complexity in sustainability

The second domain of the GreenCom involves Embracing complexity of sustainability, and includes several competencies. The pre-test and post-test data collected in this research are presented in Table 6 and show an improvement in Systems thinking (item 1) for both the GE and the CG, although this improvement is greater in the case of the GE. This suggests that the intervention had a positive effect on the development of systems thinking in the SG. In contrast, for the Critical Thinking competence, as indicated in item 10, both groups demonstrate an improvement in the critical evaluation of information, with the CG showing a greater increase (from 3.67 to 4.00) compared to the SG (from 3.46 to 3.84). However, it is essential to note that the SG began with a lower initial score. In item 12 the CG shows a slight decrease in score (from 4.24 to 4.09), while the SG shows a slight improvement (from 3.87 to 3.99). This could indicate that the intervention had a positive effect on the GE in terms of acting prudently in uncertain situations. For the Problem framing competence (item 14) both groups show a slight decrease in the positive appraisal of other cultures and races, more pronounced in the case of the CG. It is worth noting that both groups started from very high initial scores, which may explain the difficulty in further improvement.

Some of these differences are statistically significant, as shown in Table 6. Specifically, there are substantial differences in the Critical thinking competence, as seen in items 10 and 12, and in the Problem framing competence (item 14). In the Critical Thinking dimensions in both items, the control group shows significantly higher scores than the experimental group. In Problem Contextualization, specifically in valuing other cultures and races, the experimental group shows significantly higher scores than the control group.

On the other hand, in this case, there are differences based on sex, as shown in Table 7. While in the Systemic thinking competence, the difference between both sexes is practically

insignificant (4.03 vs. 4.05), in the Critical thinking competence, in item 10 there is a notable difference between men and women. Men show a higher mean score (3.87) compared to women (3.58), which could suggest that men tend to evaluate information and sources more critically. In contrast, on item 12, women show a slightly higher mean score (3.99) than men (3.87), suggesting that women tend to perceive themselves as more cautious and timelier in uncertain situations. However, the difference is slight, and both groups show high scores overall. In the Problem framing competence (item 14), both groups show a high positive appraisal of other cultures and races, with females presenting a slightly higher mean score (4.60) than males (4.46). This suggests a strong attitude of openness and respect for cultural diversity in both genders, with a slightly more pronounced tendency in females.

These data are statistically relevant for some items (items 10 and 14), as shown in Table 7. For the Critical Thinking competence, in item 10 there is a statistically significant difference between men and women in this aspect of critical thinking. Males show a higher average rank (273.27) compared to females (227.60). In the Problem framing competence, in item 14, there is a statistically significant difference between males and females in the positive valuation of other cultures and races. Females show a higher average rank (241.74) compared to males (214.87).

Regarding the comparison between degrees, differences are observed along the same lines as in the previous area, as shown in Table 8. In the competence of Systemic Thinking (item 1), the students in the Master's Degree in Teaching demonstrate a more developed understanding of the world as an interconnected system, whereas the students in Pedagogy appear to have a less systemic perspective. It is interesting to note that, despite the differences in means, all degrees have a median of 4, suggesting that most students in all programs have a good understanding of systems thinking. In the Critical thinking competence, in item 10, Social Education students seem to have the most developed skills in critically evaluating information, while Pedagogy students, again, show the lowest level in this skill. In item 12, the Degree in Social Education also has the highest mean (4.03), and the Degree in Primary Education shows the lowest mean (3.93). In the Competence Problems framing (item 14), students in the Bachelor's Degree in Social Education have the highest mean (4.75), while those in the Bachelor's Degree in Pedagogy show the lowest mean (4.36). The median is 5 for all degrees, indicating a high valuation of cultural diversity across all degrees. The students of Social Education stand out with the highest score, while those of Pedagogy, although still scoring high, show the comparatively lowest valuation.

Some of these differences are statistically significant, as shown in Table 8, including the Systemic Thinking competence (item 1). In the Critical Thinking competence, on the other hand, there are significant differences in item 10, but not in item 12, related to acting prudently in uncertain situations. All degrees exhibit similar average ranges, indicating that this skill is developed comparably across all programs. There are also significant differences in the Problem framing competence (item 14).

In short, the intervention in this case has had an impact on systems thinking and problem contextualization, but not on critical thinking. On the other hand, gender differences are also evident.

TABLE 6 Competence area 1. Comparison based on sex.

Systems thinking												
1. I understand the world as an interconnected whole, I look for connections between the social and natural environment, and I take into account the consequences of my actions on people and society.												
	GC					GE					Control-Experimental	
	Media	SD	Median	Min	Max	Media	SD	Median	Min	Max	p	d
Pre-test	3.93	0.77	4	3	5	3.98	0.81	4	2	5	0.406	−0.052
Post-test	4.07	0.68	4	2	5	4.21	0.73	4	2	5		
Critical thinking												
10. I critically evaluate the relevance and reliability of claims, information, sources and theories.												
Pre-test	3.67	0.94	4	2	5	3.46	0.87	3	1	5	0.016	0.153
Post-test	4.00	0.73	4	2	5	3.84	0.82	4	2	5		
12. I act prudently and promptly, even in situations of uncertainty.												
Pre-test	4.24	0.71	4	3	5	3.87	0.84	4	2	5	0.013	0.156
Post-test	4.09	0.69	4	3	5	3.99	0.79	4	2	5		
Problem framing												
14. I value other cultures and races positively.												
Pre-test	4.48	0.66	5	3	5	4.61	0.63	5	2	5	0.002	−0.171
Post-test	4.35	0.67	4	3	5	4.59	0.69	5	2	5		

TABLE 7 Competence area 1. Comparisons of overall results based on degree.

Systems thinking									
	Man			Woman			Total		
	Media	SD	Median	Media	SD	Median	Media	SD	Median
			N	Average range	Sum ranks	U M-W	p	d	
1. I understand the world as an interconnected whole, I look for connections between the social and natural environment, and I take into account the consequences of my actions on people and society.	4.03	0.76	4	4.05	0.78	4	4.05	0.78	4
		Man	92	233.34	21467.5	17819.5	0.79	−0.017	
		Women	380	237.26	90160.5				
Critical thinking									
10. I critically evaluate the relevance and reliability of claims, information, sources and theories.	3.87	0.93	4	3.58	0.85	4	3.64	0.87	4
		M	92	237.27	25140.5	14097.5	0.002	0.194	
		W	380	227.60	86487.5				
12. I act prudently and promptly, even in situations of uncertainty.	3.87	0.81	4	3.99	0.81	4	3.96	0.80	4
		M	92	219.73	20215.5	15937.5	0.16	−0.088	
		W	380	240.56	91412.5				
Problem framing									
14. I value other cultures and races positively.	4.46	0.70	5	4.60	0.64	5	4.57	0.66	5
		M	92	214.87	19768.0	15490	0.043	−0.114	
		W	380	241.74	91860.0				

TABLE 8 Competence area 1. Degree scores.

Systems thinking																		
1. I understand the world as an interconnected whole, I look for connections between the social and natural environment, and I take into account the consequences of my actions on people and society.																		
Degree in primary education				Master's degree in secondary education				Degree in pedagogy				Degree in social education				Total		
Med	SD	Median	Av range	Med	SD	Median	Av range	Med	SD	Median	Av range	Med	SD	Median	Av range	Med	SD	Median
4.01	0.75	4	231.43	4.23	0.76	4	269.39	3.74	0.82	4	189.20	4.12	0.77	4	250.60	4.05	0.78	4
H.K-W		19.23		p.-v		0.00		ε²		0.44						H.K-W	2.133	
Critical thinking																		
10. I critically evaluate the relevance and reliability of claims, information, sources and theories.																		
3.48	0.89	3	215.91	3.85	0.75	4	269.87	3.42	0.86	3	206.88	3.89	0.89	4	274.65	3.64	0.87	4
H.K-W		23.84		p.-v		0.00		ε²		0.05								
Problem framing																		
12. I act prudently and promptly, even in situations of uncertainty.																		
3.93	0.83	4	233.45	3.97	0.77	4	240.14	3.99	0.85	4	242.39	4.03	0.75	4	248.58	3.96	0.80	4
H.K-W		0.0843		p.-v		0.84		ε²		0.002								
14. I value other cultures and races positively.																		
4.61	0.62	5	246.30	4.51	0.63	5	223.63	4.36	0.84	5	211.41	4.75	0.55	5	272.47	4.57	0.66	5
H.K-W		13.408		p.-v		0.004		ε²		0.028								

In the critical evaluation of information, men show a significantly higher tendency, which could indicate a greater willingness to question and evaluate sources of information. Women exhibit a substantially higher valuation of cultural diversity, although the magnitude of the difference is small. Finally, concerning degrees, the Master's Degree in Teaching in Secondary Education and the Bachelor's Degree in Social Education tend to show the highest average ranks on several dimensions, suggesting that these programs may be more effectively fostering these skills and attitudes. The Bachelor's Degree in Pedagogy consistently shows the lowest average ranks in the dimensions evaluated, which could indicate, again, a need to strengthen these aspects in its curriculum.

5.3 Competence area 3: envisioning a sustainable future

The third area proposed by the Greencomp is that of Envisioning sustainable future, where the intervention has also had a clear impact, as shown in Table 9. Thus, for the competence Capacity for Futures literacy (item 2), an improvement is shown in the pre-test to post-test comparison for the GE, whereas the CG presents a slight decrease. Additionally, for the competence of Adaptability (item 11), the SG experiences a slight improvement, while the CG maintains the mean at both the pretest and posttest levels. Although the difference is subtle, the intervention may have had a marginal positive effect on reflection on actions and acting with transparency and responsibility in the SG. In contrast, both groups show improvement in the Exploratory Thinking competence (item 8), although the SG maintains a slightly higher score in both the pretest and posttest.

The experimental group shows a tendency to have higher scores in all the dimensions evaluated, but not all the differences are statistically significant (Table 9). There are significant differences in the case of the Future Projection Ability competency, although this difference is marginally significant ($p = 0.052$), so no remarkable differences can be indicated. In contrast, the differences are not significant in the case of the Adaptability competence (item 11), where both groups show very similar and high means, and in the Exploratory thinking competence (item 8), where both groups show relatively high means, with the SG slightly higher. The most notable and statistically significant difference is found, therefore, in proactivity, dynamism, and initiative, where the SG shows a clear advantage over the CG.

Regarding the gender variable, however, some differences are evident, as shown in Table 10. In the Adaptability competence (item 11), women show a slightly higher score, as well as in the Exploratory Thinking competence (item 8), but not in the Futures literacy competence (item 2). As shown in Table 10, no statistically significant differences are observed between men and women in the Future Projections Ability (item 2) and the Exploratory Thinking competence (item 8). On the other hand, for the Adaptability competence (item 11), there is a marginally significant difference between men and women. Females show a slightly higher average rank (241.48) than males (215.91). Although the p -value does not reach the conventional level of significance (0.05), the trend suggests that women may have a slight advantage in reflecting on their actions and acting with transparency and responsibility.

TABLE 9 Competence area 2. Descriptive data of the control and experimental groups.

Futures literacy											
2. I explore alternatives to improve the future and reflect on how I should change my behavior to achieve my wellbeing and that of others.											
GC		GE				Control-Experimental					
	Media	SD	Median	Min	Max		Media	SD	Median	Min	Max
Pre-test	3.96	0.87	4	2	5		4.10	0.77	4	2	5
Post-test	3.93	0.88	4	1	5		4.22	0.78	4	2	5
Adaptability											
11. I reflect on my actions; I act with transparency and responsibility.											
Pre-test	4.30	0.59	4	3	5		4.31	0.68	4	2	5
Post-test	4.30	0.66	4	3	5		4.35	0.62	4	3	5
Exploratory thinking											
8. I am curious and creative. I am interested in new challenges.											
Pre-test	3.96	0.84	4	2	5		4.07	0.87	4	1	5
Post-test	4.13	0.78	4	2	5		4.25	0.77	4	1	5
										0.239	-0.074

TABLE 10 Competence area 2. Descriptive items total sample by group.

Futures literacy									
	Man			Woman			Total		
	Media	SD	Median	Media	SD	Median	Media	SD	Median
			N	Average range	Sum ranks	U M-W	p	d	
2. I explore alternatives to improve the future and reflect on how I should change my behavior to achieve my wellbeing and that of others.	4.11	0.84	4	4.11	0.78	4	4.10	0.79	4
		Man	92	237.88	21884.50	17189.5	0.79	−0.017	
		Women	380	236.17	89743.50				
Adaptability									
11. I reflect on my actions; I act with transparency and responsibility.	4.22	0.66	4	4.35	0.65	4	4.32	0.65	4
		M	92	215.91	19864.00	15586.0	0.074	−0.108	
		W	380	241.48	91764.00				
Exploratory thinking									
8. I am curious and creative. I am interested in new challenges.	4.09	0.82	4	4.13	0.84	4	4.12	0.84	4
		M	92	229.85	21146.00	16868.0	0.576	−0.035	
		W	380	238.11	90482.00				

Differences are again evident in the comparison by degree program, as shown in [Table 11](#). For the competence “Ability to Project the Future” (item 2), Primary Education students appear to have the most significant capacity to explore future alternatives and reflect on behavioral changes. In contrast, Pedagogy students show the lowest capacity in this regard. In the competence “Future literacy” (item 11), Social Education students stand out for their capacity for reflection and acting with transparency and responsibility. These students also show higher scores in the competence “Exploratory Thinking” (item 8), while those in Pedagogy show the lowest. These differences are significant about item 2 (Future literacy) and item 11 (Adaptability), where the difference is more marginal. In the competence “Exploratory Thinking” (item 8), however, no statistically significant differences are observed between the degrees regarding curiosity and creativity. However, the Degree in Pedagogy shows the lowest average range (206.85).

In short, across all assessed competencies, the EG shows more pronounced improvements than the CG. The ability to project the future and the endorsement of equanimity show a notable improvement in the EG, while the CG shows a slight decline. In adaptability, both groups show high scores, with a slight improvement in the EG. Exploratory thinking, encompassing both curiosity and creativity, as well as proactivity and dynamism, shows improvements in both groups, with more pronounced increases in the EG. The intervention has had a positive effect on the EG in all assessed dimensions, especially in the ability to project the future and exploratory thinking. Regarding the gender variable, both men and women show high levels of ability in all assessed competencies, suggesting a good foundation for the development of “Futures Intelligence” and the ability to project scenarios. The ability to project the future is equally high in both genders, indicating a good general disposition to anticipate and plan for future scenarios. Women tend to show slightly higher scores in adaptability and exploratory thinking.

Nevertheless, these differences are not statistically significant. Finally, when comparing the different degrees, students in Primary Education and Social Education tend to show the highest average scores in most dimensions, suggesting greater future orientation, adaptability, and proactivity. Pedagogy students consistently show the lowest average scores across all assessed dimensions. This indicates a need to reinforce these skills in their degree program. The most notable differences are observed in the ability to project into the future, suggesting that some programs (such as Primary Education) may be more effectively fostering this skill. Adaptability and exploratory thinking exhibit less pronounced differences between degrees, but these differences remain significant.

5.4 Competence area 4: acting for sustainability

The fourth and final area analyzed within the Greencomp framework was Acting for Sustainability. In this case, too, the intervention was favorable. Thus, if we examine the data presented in [Table 12](#), we observe that, while the initial scores (pretest) are similar to the Political agency competence (item 9), the EG shows a slightly higher mean, indicating a somewhat greater predisposition

TABLE 11 Competence area 2. Comparison by sex.

Futures literacy																		
2. I explore alternatives to improve the future and reflect on how I should change my behavior to achieve my wellbeing and that of others.																		
Degree in primary education				Master's degree in secondary education				Degree in pedagogy				Degree in social education				Total		
Med	SD	Median	Av range	Med	SD	Median	Av range	Med	SD	Median	Av range	Med	SD	Median	Av range	Med	SD	Median
4.25	0.73	4	262.10	4.11	0.86	4	242.79	3.62	0.79	4	162.09	4.15	0.69	4	241.69	4.10	0.79	4
H.K-W	31.83			p-v	0.00			ε ²		0.067								
Adaptability																		
11. I reflect on my actions; I act with transparency and responsibility.																		
4.34	0.66	4	242.57	4.31	0.63	4	234.72	4.16	0.72	4	211.41	4.45	0.58	4	262.57	4.32	0.65	4
H.K-W	6.415			p-v	0.09			ε ²		0.013								
Exploratory thinking																		
8. I am curious and creative. I am interested in new challenges.																		
4.16	0.84	4	245.86	4.14	0.85	4	243.53	3.91	0.89	4	206.85	4.17	0.72	4	242.27	4.12	0.84	4
H.K-W	5.093			p-v	0.165			ε ²		0.011								

to be proactive and dynamic. These differences, however, widen in the posttest, as the EG shows a more notable increase in the mean (from 3.93 to 4.18) than the CG, which experiences only a slight increase (from 3.74 to 3.83). The intervention has had a positive effect on the EG, increasing the participants' proactivity and dynamism. Similarly, in the Collective action competence (item 7), the pretest scores are high and similar, with the EG slightly higher. At post-test, the EG showed a significant increase (from 3.99 to 4.24), indicating an improvement in the willingness to work collaboratively, while the CG showed little change. The intervention also promoted flexibility and collaborative work more effectively in the EG. Finally, in the Individual initiative competence (item 3), the pre-test scores are relatively low compared to other items, with a slight advantage for the EG over the CG. At the post-test, the EG again showed a notable improvement, while the CG showed only a slight increase. Therefore, the intervention has had a positive impact on improving the EG participants' willingness to take actions that contribute to sustainable development. Regarding the level of significance of these differences, as shown in Table 12, there are significant differences in the three competencies analyzed.

Regarding the gender variable, women generally score higher, as shown in Table 13. This is true for the Political agency competence (4.02 versus 3.80), which suggests that women perceive themselves as more proactive and dynamic than men, and also for the Individual initiative competence (item 3), which indicates that women are more inclined to take action that promotes sustainable development (3.49 versus 3.26). In the Collective action competence (item 7), however, the means are almost equal, with a slight advantage for women (4.05 versus 4.02). Both scores indicate a positive attitude toward flexibility and collaboration among both men and women, with minimal differences. These differences are statistically significant in items 9 (Political agency) and 3 (Individual initiative), as shown in Table 13. In the Collective action competence (item 7), however, there is no significant difference in the perception of flexibility and collaboration between men and women. The average scores are very similar, suggesting that both genders value collaborative and interdisciplinary work equally.

Similar to the previous areas, differences also arise depending on the degree participants are pursuing, as shown in Table 14. Social Education and Primary Education students perceive themselves as the most proactive and dynamic, with means of 4.17 and 4.03, respectively, in terms of Political Agency Competence (item 9). In contrast, Pedagogy students have the lowest mean (3.68), suggesting that they feel less proactive. However, all groups show a median of 4, indicating that the general perception of proactivity is relatively high. A similar scenario arises for the Collective action competence (item 7), as Primary Education and Social Education students appear to value flexibility and collaborative work more, with a mean of 4.12. In contrast, Pedagogy students, with the lowest mean (3.78), seem to show a lower inclination toward collaboration. However, the median score of 4 across all groups suggests that collaborative work is generally highly valued. However, for the Individual initiative competence (item 3), Social Education and Pedagogy students report a greater commitment to sustainable actions, with means of 3.59 and 3.49, respectively.

In contrast, Primary Education students have the lowest mean score (3.35), suggesting that they are less inclined to pursue sustainable actions. These differences are significant for the Political

TABLE 12 Competence area 2. Comparison based on sex.

Political agency											
9. I am proactive, dynamic and with initiative.											
GC				GE				Control-Experimental			
	Media	SD	p	d	Max	Media	SD	Min	Max	p	d
Pre-test	3.74	0.91	4	2	5	3.93	0.90	1	5	0.014	-0.156
Post-test	3.83	0.90	4	2	5	4.18	0.80	1	5		
Collective action											
7. I am flexible and I like to work collaboratively and on interdisciplinary projects.											
Pre-test	3.87	0.75	4	3	5	3.99	0.90	1	5		
Post-test	3.89	0.92	4	2	5	4.24	0.74	3	5	0.029	-0.138
Individual initiative											
3. I carry out actions that contribute to promoting sustainable development.											
Pre-test	3.22	0.87	3	2	5	3.35	0.85	1	5	0.020	-0.148
Post-test	3.30	0.84	3	2	5	3.72	0.91	1	5		

TABLE 13 Competence area 2. Comparisons of overall results based on degree.

Political agency									
	Man			Woman			Total		
	Media	SD	Median	Media	SD	Median	Media	SD	Median
			N	Average range	Sum ranks	U M-W	p	d	
9. I am proactive, dynamic and with initiative.	3.80	0.89	4	4.02	0.87	4	3.98	0.88	4
		Man	92	209.26	19251.50	14973.5	0.024	0.194	
		Women	380	243.10	92376.50				
Collective action									
7. I am flexible and I like to work collaboratively and on interdisciplinary projects.	4.02	0.78	4	4.05	0.87	4	4.04	0.85	4
		M	92	230.43	21199.50	16921.5	0.613	−0.032	
		W	380	237.97	90428.50				
Individual initiative									
3. I carry out actions that contribute to promoting sustainable development.	3.26	0.97	3	3.49	0.86	3	3.44	0.89	3
		M	92	210.72	19386.00	15108.0	0.032	−0.136	
		W	380	242.74	92242.00				

TABLE 14 Competence area 2. Degree scores.

Political agency																		
9. I am proactive, dynamic and with initiative.																		
Degree in primary education				Master's degree in secondary education				Degree in pedagogy				Degree in social education				Total		
Med	SD	Median	Av range	Med	SD	Median	Av range	Med	SD	Median	Av range	Med	SD	Median	Av range	Med	SD	Median
4.03	0.84	4	244.62	3.95	0.92	4	235.92	3.68	0.95	4	197.33	4.17	0.79	4	267.93	3.98	0.88	4
H.K-W		11.216		p.-v		0.011		ε²		0.024						H.K-W	2.133	
Collective action																		
7. I am flexible and I like to work collaboratively and on interdisciplinary projects.																		
4.12	0.84	4	251.10	4.01	0.82	4	233.46	3.78	0.91	4	199.64	4.12	0.87	4	253.01	4.04	0.85	4
H.K-W		9.203		p.-v		0.027		ε²		0.019								
Individual initiative																		
3. I carry out actions that contribute to promoting sustainable development.																		
3.35	0.95	3	226.21	3.47	0.88	3	241.03	3.49	0.78	4	247.91	3.59	0.82	4	261.11	3.44	0.89	3
H.K-W		4.459		p.-v		0.216		ε²		0.009								

Action competence (item 9) and the Collective Action competence (item 7). However, for the Individual Initiative competence (item 3), these differences are not significant.

In short, after assessing the results, we can observe the impact of the intervention, as evidenced by higher scores and statistically significant differences in all three competencies (Political Action, Collective action, and Individual Initiative) for the EG compared to the CG. The intervention was effective in improving proactivity, collaboration, and commitment to sustainable actions in the EG. Regarding the gender variable, women appear to be more committed to sustainable actions than men, although both groups present moderate perceptions in this regard. Finally, in the comparison by degree program, the differences are significant in the Political agency and Collective action competencies, with Social Education students showing the highest scores in both items. For the Individual initiative competence, however, no significant differences were found between degree programs, indicating that the commitment to sustainable development is fairly uniform among students, regardless of their program.

6 Discussion

Sustainable lifestyles require a change in mindset and behavior, placing equity and justice at the center together with a sense of connection with nature, thinking holistically and questioning the worldviews that underpin our current socio-economic system, and thus mobilizing individually and collectively to transform our society and shape sustainable futures for all, promoting work across various disciplines and therefore achieving systems and ethical thinking in a sustainable society (Bianchi, 2020). University education, especially that of future education professionals, must be involved in this task and oriented toward inclusive and quality training that can improve social and environmental conditions.

Although this study has focused exclusively on self-reported data, which may contain a social desirability bias that could influence responses on ethical and sustainability competencies and affect the validity of the results, it provides a first approximation to the functionality of GreenComp to improve sustainability competencies for university students. It should be kept in mind, therefore, that the results provided may point to a higher level of competence than exists.

The GreenComp, adopted by the European Commission, serves as a guide to learning for sustainability by adapting to the needs and situations of recipients and their context, considering the impact of digital technologies on sustainability, learning based on experience and daily activities, and the relationship between disciplines. These competencies, as noted, are organized into four fundamental areas, which must be present in the training of future education professionals.

The first area is related to embodying sustainability values. The inclination of these values in higher education teaching-learning processes is vital to training professionals with a broad vision of life and a commitment to sustainable development. Different investigations have confirmed the need for higher education institutions to adapt their study plans to promote what is known as sustainable education, ensuring that students can address current environmental and social challenges (Bedoya and Muñoz, 2022).

Despite the aforementioned limitations of this study and the need for further studies, the results suggest that, while undergraduate and master's students in the field of education start with a high level of awareness, the intervention contributes to strengthening these values and attitudes, significantly in some cases, such as those related to the nature promotion competency. Training in sustainable values not only ensures committed environmental citizenship but also impacts reflection on personal values and sustainability, which is essential for intergenerational equity and justice, in addition to fostering a greater understanding of the interdependence between humanity and nature (Bianchi et al., 2022).

Another area highlighted in GreenComp is assuming the complexity of sustainability, which is necessary to train professionals capable of facing current environmental and social challenges. In this study, the intervention has been shown to have an impact on the improvement of skills related to systems thinking and to alleviate disaffection in aspects related to the positive valuation of other cultures and races. It should be noted that this training is influenced by teachers' views on Education for Sustainable Development since this impacts their teaching methods and the impact of their training on implementing the Sustainable Development Goals (SDGs) (Zúñiga et al., 2022).

Other studies, such as that of Gonzalo et al. (2017), have highlighted the importance of addressing sustainability issues from a comprehensive approach, considering the interrelations within and between systems, critically analyzing information, and questioning the *status quo* to pose present or future challenges as sustainability problems. To this end, soft skills, i.e., interpersonal, cognitive, and emotional capacities, such as empathy, effective communication, collaborative work, and critical reasoning, are essential to facing global sustainability challenges. These skills enable students to understand environmental, social, and economic problems and to become catalysts for change, capable of creating innovative and ethical solutions in their respective areas (Aguado, 2025).

In addition, it is essential that future education professionals can anticipate future needs. The projection and organization of sustainable futures, the third of the areas analyzed, is also linked to the need to train students in the generation of alternative scenarios, recognizing the steps required to achieve desired futures and managing transitions in complicated environments, highlighting the importance of making informed decisions in the face of the uncertainty and danger intrinsic to these procedures (Olondriz and Botines, 2023).

The research highlights how intervention in the university environment can improve the skills linked to this projection, especially regarding proactivity, dynamism, and initiative, which are crucial for the ability to project and adapt to future scenarios. Exploratory thinking, which includes curiosity and creativity, also shows a positive trend, although it does not reach conventional statistical significance.

These results reinforce the importance of higher education institutions incorporating skills to foresee and plan sustainable futures in their study programs. By equipping students with these skills, the education of professionals capable of proactively addressing sustainability challenges is promoted, projecting and building promising futures in a world marked by uncertainty

and continuous transformation (EDS). Although many institutions recognize their relevance, incorporating these skills into the university environment remains limited in many study programs (Lozano et al., 2017).

Interest in incorporating sustainability into university education has been reflected in several studies examining the application of active learning techniques and innovative educational models within the framework of sustainability. These are linked to the fourth area of the GreenComp, i.e., acting in favor of sustainability. The data from our study reveal that the intervention in this area has had a positive effect, increasing participants' proactivity, dynamism, willingness to work collaboratively, and flexibility. It should be clarified, however, that about the critical thinking competency, the CG obtained better results than the CG, even though it did not have a specific intervention. Although it may seem a contradiction, the CG started from a higher index than the CG, and both have improved. This may suggest that progress in their academic training may influence the improvement of this competence in all students, and that having better starting skills may have a positive influence on their development. This aspect would require further analysis due to its pedagogical importance.

On the other hand, the difference between the degrees, which have been pointed out in all the areas analyzed, suggests that aspects such as curricular content, as well as the professional orientation of the different types of study, can also have an impact on the development of competencies in sustainability. Thus, in a degree such as Social Education, linked to socio-educational intervention aimed at greater personal and social development, and integration and participation in different social spheres, its students stand out in all the dimensions analyzed, especially in greater sensitivity to sustainability, ethics, and emotional connection, and in action in favor of sustainability. On the other hand, in the dimension related to the assumption of complexity, critical thinking, and contextualization of problems, the students of the master's degree in Secondary Education also stand out. It should be taken into account that these students already have a university degree; therefore, they are more educated students. Finally, in terms of projecting sustainable futures, adaptability, and exploratory thinking, teacher training students also stand out. These skills are essential for future teachers. On the other hand, the Pedagogy degree, within the education studies, seems to be the least prepared concerning the competences to move toward a more sustainable development. For this reason, it is recommended that a review of these skills be carried out.

Studies such as that by Cantillo et al. (2024) examine the challenges and possibilities that university education faces in integrating the principles of Sustainable Development into its educational programs, highlighting the importance of an innovative pedagogical methodology that addresses current global challenges and emphasizing that university institutions play an essential role in building responsible and sustainable attitudes in students. In this sense, applying participatory and dialogical models in tutoring generates an environment where students acquire knowledge about sustainability and become leaders dedicated to the community, making it a highly relevant intervention (Villarrubia et al., 2024).

Likewise, incorporating and promoting the SDGs enhances the education of students capable of facing global challenges and actively contributing to sustainable development in their respective disciplines (Ramos, 2020). Aranda et al. (2024) analyzed the inclusion of sustainability in the curricula of universities in Andalusia, assessing how sustainability principles are integrated into university education. These investigations agree that sustainability should be a fundamental pillar in the education of higher education students, not only as an area of study but as a commitment to proactive action in all facets of work and personal life.

In this sense, incorporating the GreenComp framework in university education enables students to face environmental challenges in a practical and committed way, promoting, beyond personal skills, group collaboration to promote sustainable policies (Olondriz and Botines, 2023). In this context, the GreenComp framework emerges as an essential instrument for educating people with the ability to proactively intervene in their environment, promoting sustainability in all strata of society.

7 Conclusion

Higher education can contribute to building a more equitable and environmentally responsible society. Adapting curricula, teacher training, and promoting sustainable values in the university environment are essential strategies to strengthen the training of individuals with a systemic vision and an active commitment to sustainability. In this way, higher education can become a driving force for change that drives the social and environmental transformation necessary for a sustainable future.

This study has demonstrated how incorporating content designed to develop the competencies outlined in the GreenComp framework within the university environment can enhance the training of future education professionals. Integrating skills linked to sustainability, actively engaging in social and environmental projects, and establishing spaces for dialogue and interdisciplinary cooperation to promote educational leadership committed to sustainable progress are essential (Merma-Molina et al., 2022).

Applying active techniques and frameworks, such as GreenComp, offers specific instruments that facilitate the development of practical competencies and a critical perspective on sustainability in students. At the same time, academic mentoring programs and cutting-edge pedagogical tactics reinforce the notion that sustainability must be incorporated into every aspect of the teaching process.

Therefore, the contributions of this study are that it implements and evaluates the GreenComp in university contexts with undergraduate and master's students, the instrument used has been developed, and the relevance of the study has been specified about aspects not addressed in the literature, justifying its academic inclusion (Vargas and Aragón, 2021).

One of the strengths of this study lies in the relevance of the research topic, which aligns with the educational policies of the European Green Deal, and its direct connection to key competences in sustainability.

This intervention distinguishes itself from previous ESD experiences, highlighting its methodological innovation and specific Contribution To The Field ([Appendix 1](#)). These results can inform teacher training programs in broader or international contexts, extending beyond the context where the educational intervention was initially carried out ([UNESCO, 2021b](#)).

Data availability statement

The original contributions presented in this study are included in this article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical approval was not required for the studies involving humans because it is not necessary in both universities. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

MM-A: Formal analysis, Writing – review & editing, Resources, Visualization, Data curation, Validation, Investigation, Software, Project administration, Supervision, Funding acquisition, Methodology, Writing – original draft, Conceptualization. AM-M: Data curation, Visualization, Software, Resources, Conceptualization, Writing – original draft, Project administration, Funding acquisition, Validation, Methodology, Investigation, Writing – review & editing, Formal analysis, Supervision. EO-C: Software, Writing – original draft, Visualization, Resources, Writing – review & editing, Investigation, Funding acquisition, Validation, Formal analysis, Methodology, Conceptualization, Supervision, Data curation, Project administration.

References

- Aguado, N. M. (2025). Competencias blandas para el desarrollo sostenible en la educación superior. *Rev. Invecom* 5, 1–12. doi: 10.5281/zenodo.14212747
- Agyeman, J., Bullard, R. D., and Evans, B. (2002). Exploring the nexus: Bringing together sustainability, environmental justice and equity. *Space Polity* 6, 77–90. doi: 10.1080/13562570220137907
- Aranda, L., Rumiche, R. P., Ríos-Ariza, J. M., and Mena-Rodríguez, E. (2024). Sustainability in undergraduate course curricula at Andalusian universities: A comparative analysis. *Front. Educ.* 9:1352959. doi: 10.3389/feduc.2024.1352959
- Ardoín, N. M., Bowers, A. W., and Gaillard, E. (2020). Environmental education outcomes for conservation: A systematic review. *Biol. Conserv.* 241:108224. doi: 10.1016/j.biocon.2019.108224
- Bacigalupo, M., Kampylis, P., Punie, Y., and Van den Brande, G. (2016). *EntreComp: The entrepreneurship competence framework*. Brussels: Joint Research Centre, European Commission.
- Barth, M., Godemann, J., Rieckmann, M., and Stoltenberg, U. (2007). Developing key competencies for sustainable development in higher education. *Int. J. sustain. High. Educ.* 8, 416–430. doi: 10.1108/14676370710823582
- Bedoya, M. C. M., and Muñoz, J. (2022). La enseñanza de la sostenibilidad en la educación superior como estrategia pedagógica para una profesión integral. *Rev. Interam. Invest. Educ. Pedag.* 15, 235–260. doi: 10.15332/25005421.6681
- Bianchi, G. (2020). *Sustainability competences*. Brussels: Joint Research Centre, European Commission.

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Conflict of interest

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- Bianchi, G., Pisiotis, U., and Cabrera, M. (2022). *GreenComp The European sustainability competence framework*. Luxembourg: Publications Office of the European Union, doi: 10.2760/13286
- Bishop, P. (2019). "Handbook of anticipation," in *Anticipation: Teaching the future*, ed. R. Poli (Cham: Springer).
- Breiting, S., and Mogensen, F. (1999). Action competence and environmental education. *Cambridge J. Educ.* 29, 349–353. doi: 10.1080/0305764990290305
- Brundiers, K., Barth, M., Cebrián, G., Cohen, M., Diaz, L., Doucette-Remington, S., et al. (2021). Key competencies in sustainability in higher education—toward an agreed-upon reference framework. *Sustain. Sci.* 16, 13–29. doi: 10.1007/s11625-020-00838-2
- Cantillo, J. C., Pacheco, M. C. A., and Torres, J. M. (2024). Desarrollo sostenible en la educación universitaria: Retos y oportunidades. *Rev. Invest. Ciencias Educ.* 1, 79–92. doi: 10.70262/riesafd.v1i3.2024.27
- Carolan, M. S. (2006). Scientific knowledge and environmental policy: Why science needs values. *Environ. Sci.* 3, 229–237. doi: 10.1080/15693430601058224
- Churchman, C. W. (1967). Wicked problems. *Manag. Sci.* 14, 141–142. doi: 10.1007/978-1-4419-1153-7_200919
- Dasgupta, P. (2021). *The economics of biodiversity: The Dasgupta review*. London: HM Treasury.
- Daskolia, M., Dimos, A., and Kampylis, P. G. (2012). Secondary teachers' conceptions of creative thinking within the context of environmental education. *Int. J. Environ. Sci. Educ.* 7, 269–290.
- European Biodiversity Strategy (2020). *Bringing nature back into our lives*. Brussels: European Biodiversity Strategy.
- European Commission (2018). *Council recommendation of 22 May 2018 on key competences for lifelong learning*. Brussels: European Commission.
- European Commission (2020a). *Communication from the commission to the european parliament, the council, the European economic and social committee and the committee of the regions on achieving the european education area by 2025*. Brussels: European Commission.
- European Commission (2020b). *European skills agenda for sustainable competitiveness, social fairness and resilience*. Brussels: European Commission.
- European Commission (2020c). *Circular economy action plan: For a cleaner and more competitive Europe*. Brussels: European Commission.
- European Commission (2021). *Special eurobarometer 513 – climate change*. Brussels: European Commission.
- European Environment Agency (2019). *The European environment—state and outlook 2020. knowledge for transition to a sustainable Europe*. Copenhagen: European Environment Agency.
- European Environment Agency (2021). *With people and for people: Innovating for sustainability*. Copenhagen: European Environment Agency.
- Flint, R. W., McCarter, W., and Bonniwell, T. (2000). Interdisciplinary education in sustainability: Links in secondary and higher education. The Northampton Legacy Program. *Int. J. Sustain. High. Educ.* 1, 191–202. doi: 10.1108/1467630010328261
- Gayá, M. A., and Martínez-Agut, M. P. (2025a). Análisis de las metodologías docentes en educación para el desarrollo sostenible. *Rev. Estilos Aprendiz.* 18, 59–76. doi: 10.55777/rea.v18i35.7104
- Gayá, M. A., and Martínez-Agut, M. P. (2025b). Conocimientos del profesorado sobre el marco legal y curricular de educación para el desarrollo sostenible. *Rev. Educ. Derecho* 31, 1–30. doi: 10.1344/REYD2025.31.46315
- Giangrande, N., White, R. M., East, M., Jackson, R., Clarke, T., Saloff Coste, M., et al. (2019). A competency framework to assess and activate education for sustainable development. Addressing the UN sustainable development goals 4.7 challenge. *Sustainability* 11:2832. doi: 10.3390/su11102832
- Giovannini, E., Benczur, P., Campolongo, F., Cariboni, J., and Manca, A. R. (2020). *Time for transformative resilience: The COVID-19 emergency*. Brussels: Joint Research Centre, European Commission.
- Glasser, H. (2018). *Toward robust foundations for sustainable well-being societies: Learning to change by changing how we learn. Sustainability, human well-being, and the future of education*. London: Palgrave Macmillan.
- Gómez-Gómez, M., and García-Lázaro, D. (2023). Concienciación y conocimientos sobre los objetivos de desarrollo sostenible en la formación del profesorado. *Profes., Rev. Currículum Form. Profes.* 27, 243–264. doi: 10.30827/profesorado.v27i3.27948
- Gonzalo, V., Sobrino, M. R., Benítez, L., and Coronado, A. (2017). Revisión sistemática sobre competencias en desarrollo sostenible en educación superior. *Rev. Iberoam. Educ.* 73, 85–108. doi: 10.35362/rie730289
- Jickling, B., and Sterling, S. (2017). *Post-sustainability and environmental education: Remaking education for the future*. Berlin: Springer.
- Kearins, K., and Springett, D. (2003). Educating for sustainability: Developing critical skills. *J. Manag. Educ.* 27, 188–204. doi: 10.1177/1052562903251411
- López, C. (2022). *Los ODS. Avanzando hacia una educación sostenible*. Salamanca: Ediciones Universidad de Salamanca.
- Lozano, R., Merrill, M. Y., Sammalisto, K., Ceulemans, K., and Lozano, F. J. (2017). Connecting competences and pedagogical approaches for sustainable development in higher education: A literature review and framework proposal. *Sustainability* 9:1889. doi: 10.3390/su9101889
- Martínez-Agut, M. P. (2022). La educación para el desarrollo y la ciudadanía global en el marco de la cooperación al desarrollo y los objetivos de desarrollo sostenible (ODS). *Quaderns Anim. Educ. Soc.* 35, 1–45.
- Martínez-Agut, M. P. (2024a). "La innovación educativa desde las universidades para potenciar la equidad, la inclusión y el compromiso con la sostenibilidad," in *Proceedings of the conference: REDINE, edunovatic*, (Eindhoven: Adaya Press), 483–489.
- Martínez-Agut, M. P. (2024b). "Las metodologías activas y las metodologías para la acción en el compromiso hacia la sostenibilidad y la ciudadanía mundial," in *Proceedings of the conference: REDINE, edunovatic*, (Eindhoven: Adaya Press), 131–137.
- Martínez-Agut, M. P. (2025). Iniciatives d'aprenentatge servei: Difusió i participació dels usuaris a les xarxes socials amb la temàtica dels objectius de desenvolupament sostenible. *Rev. Iberoam. Aprendiz. Serv.* 19, 112–121. doi: 10.1344/RIDAS2025.19.8
- Martínez-Agut, M. P., and Jiménez, J. (2023). "Diversidad funcional, sostenibilidad y aprendizaje servicio en un centro de secundaria," in *Proceedings of the actas del XI Congreso internacional de psicología y educación: Bienestar psicológico y digitalización: El gran reto de la psicología hoy*, ed. F. Alcantud (Cham: Springer), 1857–1865.
- Martínez-Agut, M. P., and Monzó, A. (2023). "Compromiso con la educación de los docentes: Identidad y ciudadanía mundial desde los Objetivos de Desarrollo Sostenible (ODS)," in *Desarrollo de la identidad y el buen carácter en el siglo XXI*, ed. C. Naval (Madrid: Dykinson), 324–333.
- Martínez-Agut, M. P., Gayá, M. A., and Monzó, A. (2024b). "Estudios universitarios y profesiones. Proceso de enseñanza-aprendizaje entre estudiantes de Grado y Educación Primaria desde la orientación educativa y profesional," in *Promoción de derechos, buen trato y participación de la infancia y la adolescencia en los centros de educación superior*, ed. A. Jiménez (Madrid: Dykinson), 67–80.
- Martínez-Agut, M. P., Gayá, M. A., Gallardo, I. M., and Monzó, A. (2024a). "Los Derechos de la Infancia. Su enseñanza-aprendizaje mediante metodologías activas," in *Proceedings of the CIMIE 24. Ciencia, educación y diálogos culturales: Cerrando brechas, construyendo puentes*, (Bhubaneswar: CIMIE), 293–296.
- Merma-Molina, G., Gavilán-Martín, D., Baena-Morales, S., and Urrea-Solano, M. (2022). Critical thinking and effective personality in the framework of education for sustainable development. *Educ. Sci.* 12:28. doi: 10.3390/educsci12010028
- Mezirow, J. (1978). Perspective transformation. *Adult Educ.* 28, 100–110. doi: 10.1177/074171367802800202
- Mezirow, J. (1997). Transformative learning: Theory to practice. *New Dir. Adult Contin. Educ.* 74, 5–12. doi: 10.1002/ace.7401
- Molderez, I., and Ceulemans, K. (2018). The power of art to foster systems thinking, one of the key competencies of education for sustainable development. *J. Clean. Prod.* 186, 758–770. doi: 10.1016/j.jclepro.2018.03.120
- Moreno-Pires, S., and Fidélis, T. (2012). A proposal to explore the role of sustainability indicators in local governance contexts: The case of Palmela, Portugal. *Environ. Impact Assess. Rev.* 32, 13–21. doi: 10.1016/j.econind.2012.05.003
- OECD (2018). *The future of education and skills: Education 2030. OECD education working papers*. Paris: OECD.
- Olondriz, A., and Botines, I. (2023). "Competencias en sostenibilidad: GreenComp y Educación Superior," in *Construyendo un mundo sostenible: ODS clave para el cambio*, eds A. Ramos-Play and A. Olondriz Valverde (Madrid: Dykinson), 25–39.
- Pearce, B. J., and Ejderyan, O. (2020). Joint problem framing as reflexive practice: Honing a transdisciplinary skill. *Sustain. Sci.* 15, 683–698. doi: 10.1007/s11625-019-00744-2
- Pedroza, R., and Reyes, A. M. (2023). *Ecologías del aprendizaje en la educación para el desarrollo sostenible. Modelo abeja digital*. Madrid: Octaedro.
- Phelan, A. M. (2004). Rationalism, complexity science and curriculum: A cautionary tale. *Compl. Int. J. Complex. Educ.* 1, 9–17. doi: 10.29173/cmplct8712
- Ramos, D. I. (2020). Contribución de la educación superior a los objetivos de desarrollo sostenible desde la docencia. *Rev. Esp. Educ. Comp.* 37, 89–110. doi: 10.5944/reec.37.2021.27763
- Remington-Doucette, S. M., Connell, K. Y. H., Armstrong, C. M., and Musgrove, S. L. (2013). Assessing sustainability education in a transdisciplinary undergraduate course focused on real-world problem solving: A case for disciplinary grounding. *Int. J. Sustain. High. Educ.* 14, 404–433. doi: 10.1108/IJSHE-01-2012-0001
- Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, I. I. I., Lambin, E. F., et al. (2009). A safe operating space for humanity. *Nature* 461, 472–475. doi: 10.1038/461472a
- Ruiz-Bernardo, M. P., and Rambla, J. L. (2024). "Cocreación de la ruta de los ODS en la UJI," in *Proceedings of the Actes 2nd international congress: Education and knowledge*, eds R. Roig-Vila, F. Sirignano, and J. M. Antolí Martínez (Barcelona: Octaedro), 501.

- Sala, A., Punie, Y., Garkov, V., and Cabrera Giraldez, M. (2020). *LifeComp: The European framework for personal, social and learning to learn key competence*. Brussels: Joint Research Centre, European Commission.
- Sipos, Y., Battisti, B., and Grimm, K. (2008). Achieving transformative sustainability learning: Engaging head, hands and heart. *Int. J. Sustain. High. Educ.* 9, 68–86. doi: 10.1108/14676370810842193
- Sleurs, W. (2008). *Competencies for ESD teachers. A framework to integrate ESD in the curriculum of teacher training institutes –Comenius 2.1 project 118277-CP-1-2004-BE-Comenius-C2.1*. Calgary, AB: CSCT.
- UNEP (2021). *GEO-6 for youth*. Nairobi: UNEP.
- UNESCO (2017). *Education for sustainable development goals: Learning objectives*. Paris: UNESCO.
- UNESCO (2021a). *Learn for our planet*. Paris: UNESCO.
- UNESCO (2021b). *Reimagining our futures together: A new social contract for education*. Paris: UNESCO.
- Urrea-Solano, M., Hernández-Amorós, M. J., Merma-Molina, G., and Baena-Morales, S. (2021). The learning of e-sustainability competences: A comparative study between future early childhood and primary school teachers. *Educ. Sci.* 11:644. doi: 10.3390/educsci11100644
- Vargas, M., and Aragón, L. (2021). *Los objetivos de desarrollo sostenible: Hoja de ruta en la educación del siglo XXI*. Barcelona: Octaedro.
- Veugelers, W. (2000). Different ways of teaching values. *Educ. Rev.* 52, 37–46. doi: 10.1080/00131910097397
- Villarrubia, M. S., Ortiz-Jiménez, M., González, P., and Suárez-Campos, L. (2024). Evaluation of sustainability in university tutoring programs for educational leadership: A case study. *Front. Educ.* 9:1416666. doi: 10.3389/feduc.2024.1416666
- Wahl, D. (2016). *Designing regenerative cultures*. Charmouth: Triarchy Press.
- Wals, A. E., and Benavot, A. (2017). Can we meet the sustainability challenges? The role of education and lifelong learning. *Eur. J. Educ.* 52, 404–413. doi: 10.1111/ejed.12250
- Wiek, A., Withycombe, L., and Redman, C. L. (2011). Key competencies in sustainability: A reference framework for academic program development. *Sustain. Sci.* 6, 203–218. doi: 10.1007/s11625-011-0132-6
- Zúñiga, O., Marúm, E., and Rodríguez, C. E. (2022). La educación para el desarrollo sostenible en la educación superior: El efecto de las áreas del conocimiento en las concepciones del profesorado universitario. *Rev. Mex. Investig. Educ.* 30, 1–28. doi: 10.24320/remie.2022.30.157.4970

Appendix 1

The text describes the pedagogical intervention, but an appendix is included with specific examples of the activities implemented in the classroom, which can enhance the replicability of the study.

Active methodologies were used: case studies, selecting situations that have been worked on in the classroom, Problem-Based Learning (PBL), and Challenge-Based Learning (CBL) with the theme of sustainability (López, 2022; Martínez-Agut, 2024a; Urrea-Solano et al., 2021); simulations of situations linked to Education for Sustainable Development (ESD) were conducted (Martínez-Agut et al., 2024a,b); integrative projects were developed that compile proposals for the Sustainable Development Goals in specific contexts (Martínez-Agut, 2024b); As methodologies for action, Service-Learning Projects have been designed and implemented for particular communities and entities, analyzing the results and establishing conclusions that have been shared with students in the classroom (Martínez-Agut and Jiménez, 2023; Martínez-Agut, 2025).