

Article

Assessing Students' Self-Perceived Eco-Social Competences in Higher Education: A Rubric-Based Approach to Sustainability and Global Competence

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Abstract

This study analyses changes in university students' self-perceived eco-social competences through active methodologies linked to holistic sustainability and human rights. A multidimensional rubric based on the KNOW–CARE–DO model was applied to assess four eco-social competences: (1) critical contextualisation of knowledge in relation to social, economic, and environmental issues; (2) respect for human rights, diversity, equity, a culture of peace and participation; (3) undertaking actions for the common good and sustainable development; and (4) the application of ethical principles linked to sustainability and human rights. A pre-experimental design incorporating pre-test and post-test measurements was used. The study involved 61 students from universities in Spain, Colombia, and Italy. An open-ended question was included to complement the quantitative data. The results indicate significantly higher self-perceived competence scores at post-test than at pre-test, particularly in the critical contextualisation of knowledge. The rubric demonstrates acceptable-to-high internal consistency, although further psychometric validation is required.

Keywords: eco-social competences; higher education; education for sustainability; global competence; KNOW–CARE–DO model; service-learning (SL); project-based learning (PBL); rubric-based assessment; curriculum innovation; transformative learning

1. Introduction

Despite the growing recognition of sustainability within educational frameworks, a divide persists between its institutional formulation and its effective implementation in practice. This challenge is reflected in the “knowledge–action gap,” in which environmental knowledge does not always result in sustainable behaviour (Kollmuss & Agyeman, 2002). Although students express concern about global issues, this awareness does not always lead to transformative decisions or actions (SDSN, 2020). Likewise, teachers express motivation towards Education for Sustainable Development (ESD) and global citizenship, but highlight a lack of resources, assessment tools, and structural support (UNESCO, 2022a).

In response to this challenge, various international regulatory frameworks have stressed the need to integrate sustainability across the board into higher education. The Conference of Rectors of Spanish Universities (CRUE) highlights competences such as



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systems thinking, ethical responsibility, and civic engagement (CRUE, 2012), while Green-Comp, the European sustainability competence framework, conceives sustainability as a multidimensional competence that integrates values, an understanding of complexity, anticipation, and action (Bianchi et al., 2022). In Spain, Royal Decree 822/2021 reinforces the incorporation of competences linked to sustainability and human rights in universities (BOE, 2021). Although promoting sustainability, protecting human rights, and fostering peace are widely recognised as urgent global challenges in the Global Justice Report (Chancel et al., 2026), their recognition and promotion are not uniform across countries and governments. Given that sustainability is a complex and contested concept (Lozano, 2008), this study is grounded both in the regulatory frameworks currently in force in the countries where the research was conducted and in the Sustainable Development Goals (United Nations, 2015). Although these goals have not achieved universal acceptance, they have received broad international support and form part of the institutional and policy frameworks of the countries in which the universities included in the sample are located. However, a lack of robust tools for assessing eco-social competences in higher education persists. Assessment practices tend to focus on declarative knowledge, while the affective, ethical, and behavioural dimensions are less systematically implemented (UNESCO, 2025). This limitation hinders the monitoring of student progress, the design of coherent pedagogical approaches, and the certification of learning linked to sustainability and global citizenship (UNESCO, 2022a, 2025).

From the perspective of transformative learning, the development of eco-social competences involves not only acquiring knowledge, but also critically reviewing the frameworks that guide action (Mezirow, 2000; UNESCO, 2025). In active learning contexts, engagement with social realities can stimulate critical reflection and support the integration of understanding (KNOW) to ethical engagement (CARE) and transformative action (DO). Emotional and affective dimensions are key to promoting commitment and sustainable action (Ojala, 2012).

To address this gap, this study develops and applies a multidimensional rubric, designed within the framework of the EDUCLIMA project, to assess students' self-perceived eco-social competences in higher education. The rubric measures four key competences through 12 indicators organised in accordance with the KNOW–CARE–DO model, which integrates cognitive understanding, ethical engagement, and transformative action.

The study is based on empirical data collected at universities in Spain, Italy, and Colombia, and analyses the role of service-learning (SL) and project-based learning (PBL) in students' changes in self-perceived eco-social competences. The study addresses a central research question: To what extent do university students report changes in their self-perceived eco-social competences across the KNOW, CARE, and DO dimensions following participation in service-learning and project-based learning methodologies? To address this question, the study pursues three specific research objectives: (O1) exploring changes in students' self-perceived eco-social competences following participation in active methodologies (SL and PBL), (O2) analysing changes in these competences across the KNOW, CARE and DO dimensions, and (O3) examining the preliminary reliability and applicability of the rubric as an assessment instrument.

Overall, the study makes a twofold contribution: theoretically, it contributes to the debate on the multidimensional nature of eco-social competences, and in terms of practice, it offers a tool to strengthen the integration of sustainability and global competence into university curricula. A central question in the field is whether universities can implement socio-environmental education that is genuinely transformative rather than merely informative. This study addresses one component of this question by examining students' self-perceived changes in eco-social competences following participation in active learning

experiences. It does not, however, establish whether these changes correspond to transformative effects beyond students' self-perceptions. Having tools to assess competence development is key to moving towards transformative education in a context where higher education must respond to the eco-social crisis (SDSN, 2017, 2020; UNESCO, 2022b, 2025).

2. Theoretical Framework

2.1. ESD Competences and Global Competence in Higher Education

ESD is part of a pedagogical tradition focused on the holistic development of the individual. The four pillars of lifelong learning—learning to know, learning to do, learning to be, and learning to live together—formulated by Delors et al. (1997) remain relevant in light of the climate crisis, global interdependence, and the promotion of peace, as they link cognitive, practical, ethical, and relational dimensions.

The literature on ESD has evolved towards competence-based approaches that go beyond the mere transmission of content. Rieckmann (2018) identifies four key components: knowledge of complex socio-ecological systems, skills for sustainable action, ethical values, and behavioural readiness for change. Sustainability is thus understood as an educational field that integrates three dimensions: cognitive, socio-emotional, and behavioural competences (UNESCO, 2025).

UNESCO (2017, 2018) proposes key competences for ESD—critical thinking, systems thinking, self-awareness, integrated problem-solving, anticipatory competence, collaboration, normative competence, and strategic competence—shifting the focus from awareness-raising towards the development of individuals capable of engaging responsibly with complex sustainability challenges. In a similar vein, GreenComp (Bianchi et al., 2022) offers a European framework structured around four competence areas: embodying sustainability values, embracing complexity in sustainability, envisioning sustainable futures, and acting for sustainability, facilitating their conversion into observable learning outcomes.

The Tuning project provides a useful cross-curricular framework for university curricula through instrumental, interpersonal, and systemic competences (Tuning Project, 2003). This is in line with Wiek et al. (2011) and Rieckmann (2018) who emphasise the integrating and action-oriented nature of sustainability competences.

Global competence broadens this perspective by incorporating cultural diversity, dialogue, and global citizenship. PISA 2018 (PISA & OECD, 2018) defines it through four dimensions: investigating the world, recognising perspectives, communicating across cultures, and taking action for collective well-being and sustainable development. Similarly, Anoshkova (2022) and Boix Mansilla and Jackson (2022) emphasise the integration of knowledge, ethical dispositions, relational skills, and verifiable action, thus reinforcing the importance of multidimensional approaches to assessment.

Figure 1 illustrates the process of selecting and synthesising ESD competences and their integration with the dimensions of global competence, applied in this study, in order to develop eco-social competences.

In Spain, the Organic Law Amending the Organic Law of Education (LOMLOE) (Organic Law 3/2020) (BOE, 2020), the royal decrees on minimum educational standards for 2021–2022, and Royal Decree 822/2021 on higher education (BOE, 2021) incorporate cross-curricular references to sustainability, human rights, global citizenship, social justice, and ecological transition. The CRUE (2023) has further consolidated this integration into university curricula. In Italy, Law 92/2019 introduces compulsory civic education in primary and secondary schools, including content related to sustainable development and the 2030 Agenda, but without an equivalent requirement in higher education. However, the Italian agency for the evaluation of universities and research institutes (ANVUR, 2023) incorporates sustainability, the SDGs, and social responsibility into its evaluation processes.

This is in line with the European Green Deal, a commitment of the EU to become climate neutral by 2050, and with initiatives such as the Network of Universities for Sustainable Development (RUS), promoted by the Conference of Italian University Rectors (CRUI). In Colombia, Law 2427/2024 strengthens training in environmental sustainability, climate change, and disaster risk management in pre-school, primary, secondary, and higher education institutions (DORC, 2024).

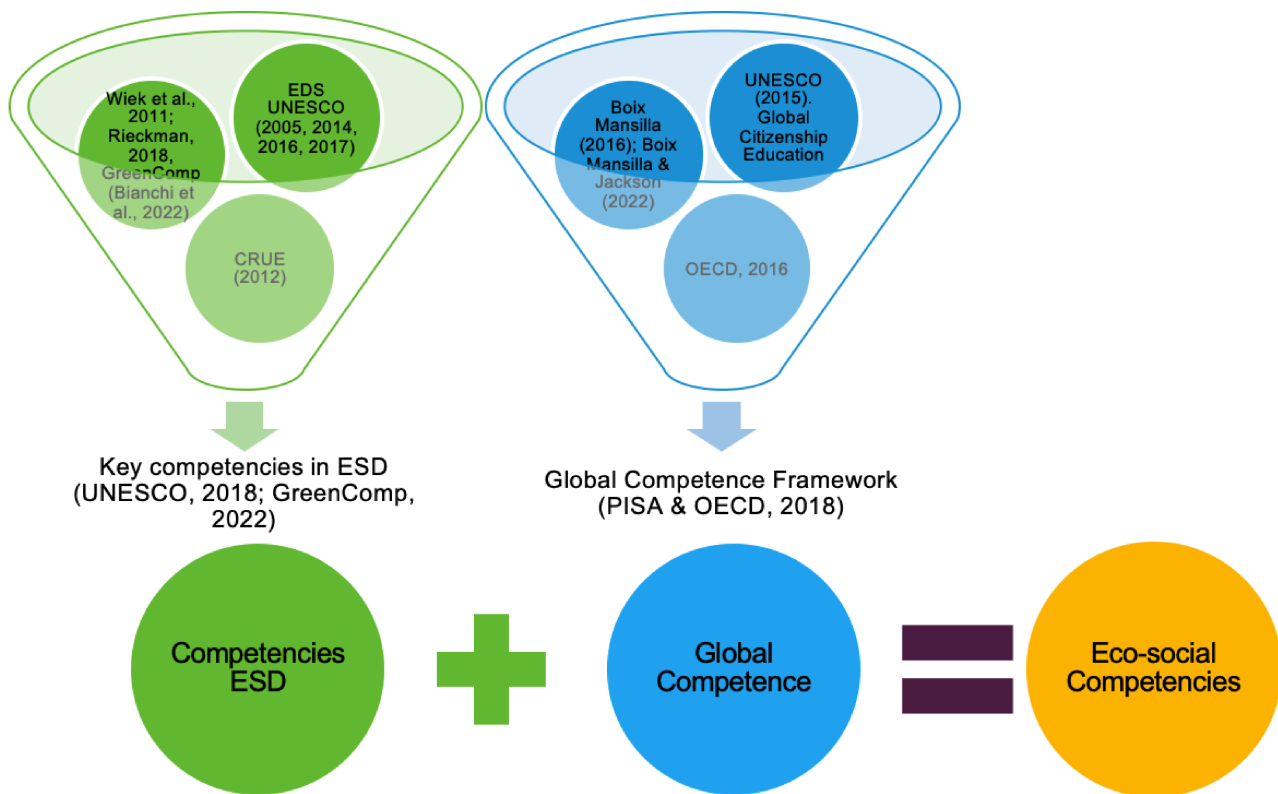


Figure 1. Synthesis of ESD competences and their integration with global competence to develop eco-social competences (Own elaboration) (Wiek et al., 2011; Rieckmann, 2018; Bianchi et al., 2022; UNESCO, 2005, 2014, 2015, 2016, 2017, 2018; CRUE, 2012; Bianchi et al., 2022; Boix Mansilla, 2016; Boix Mansilla & Jackson, 2022; OECD, 2016; PISA & OECD, 2018).

Despite these advances, a lack of standardised and validated instruments to rigorously assess competence-based learning in sustainability and global competence in higher education persists (Albareda-Tiana et al., 2024; UNESCO, 2022a). This gap justifies the use of specific tools such as the EDUCLIMA project's eco-social competence rubric (Albareda-Tiana, 2026), presented in this study.

2.2. Selection of Eco-Social Competences

Based on these frameworks, the study selects four priority generic competences: critical thinking, diversity and interculturality, initiative and entrepreneurial spirit, and ethical responsibility (see Table 1). These are personal, interpersonal, and cognitive soft skills that enable adaptation to complex contexts, collaboration, and responsible decision-making. The selection was made based on three criteria: theoretical consistency, curricular importance, and potential for implementation in terms of dimensions, descriptors, and assessable indicators.

Table 1. Conceptual alignment across frameworks.

Chosen Generic Competence	ESD Competences (International Framework)		Global Competence (International Framework)	Resulting Eco-Social Competences
Tuning Project (2003)	UNESCO (2017, 2018)	GreenComp (Bianchi et al., 2022)	PISA and OECD (2018)	Definition
Critical thinking Instrumental	Systems thinking Critical thinking	Systems thinking Critical thinking Problem framing Futures literacy	Problem-solving Critical thinking Ability to reflect on data and justify decisions	Critical contextualisation of knowledge establishing interrelationships with social, economic, and environmental issues at the local and global level
Diversity and interculturality Interpersonal	Collaboration Self-awareness	Supporting fairness Collective action	Social and emotional collaboration with others Respect for diverse perspectives Intercultural awareness	Respect for human rights, diversity, and equity of all citizens without discrimination, promoting a culture of peace and participation
Initiative and entrepreneurial spirit Systemic	Strategic competence	Problem framing Adaptability Exploratory thinking Individual initiative	Learning to learn Autonomy and initiative in problem-solving Creative and innovative thinking	Undertaking actions for the common good and sustainable development
Ethical responsibility Interpersonal	Normative competence	Valuing sustainability Promoting nature Political agency	Global competence and sustainability Awareness of social and environmental impacts Acting responsibly and ethically	Application of ethical principles related to the values of sustainability and human rights in individual and collective behaviour

Critical thinking is linked to systems thinking and an understanding of complexity as outlined in [UNESCO \(2017, 2018\)](#), [GreenComp \(Bianchi et al., 2022\)](#), and the [Tuning Project \(2003\)](#). Diversity and interculturality are related to collaboration, global competence, interpersonal skills, and the recognition of multiple perspectives. In this study, initiative and entrepreneurial spirit are not understood from a traditional business-oriented perspective but as the capacity to initiate, promote, and sustain actions that contribute to the common good and sustainable development. From this perspective, entrepreneurial competence is conceived as a form of eco-social agency that combines initiative, collaboration, responsibility, and commitment to socio-environmental transformation. This conceptualisation is consistent with the OECD Global Competence framework ([PISA & OECD, 2018](#)), UNESCO's Education for Sustainable Development approach ([Rieckmann, 2018](#)), and the GreenComp framework ([Bianchi et al., 2022](#)), all of which emphasise learners' capacity to act collaboratively and responsibly in addressing complex sustainability challenges. Ethical responsibility refers to sustainable values, social justice, active citizenship, and human rights.

Together, these competences were conceptually organised around cognitive (KNOW), ethical-affective (CARE), and behavioural (DO) dimensions of eco-social education: critical thinking problematises reality, diversity and interculturality incorporate the recognition

of the other, an entrepreneurial spirit directs learning towards social transformation, and ethical responsibility provides value-based orientation for action. Therefore, EDUCLIMA's selection of competences is based on a theoretically grounded structure that is consistent with the current demands of higher education.

Table 1 presents the conceptual alignment across frameworks used to derive integrated eco-social competences through a process of synthesis and reinterpretation.

Figure 2 illustrates the design process of eco-social competences, showing how broad generic competences are contextualized through an international framework (e.g., Green-Comp) to ultimately yield specialised, action-oriented eco-social competences.



Figure 2. Process of developing eco-social competences based on generic competences.

Leading international experts agree on a multidimensional view of eco-social competence, understood as the ability to integrate knowledge, values, and action in order to tackle global challenges as critical, responsible citizens committed to sustainability.

2.3. The KNOW–CARE–DO Pedagogical Model

To structure the assessment, the rubric adopts and adapts Okada and Gray's (2023) CARE–KNOW–DO model, which organises competence development into three interdependent dimensions: socio-emotional-affective (CARE), cognitive (KNOW), and behavioural (DO). This reordering reflects the analytical organisation adopted for the rubric and does not imply a temporal or developmental sequence. The three dimensions are therefore treated as interdependent components of eco-social competence. KNOW involves identifying concepts, analysing socio-environmental relationships, interpreting complex situations, and substantiating judgements. CARE incorporates moral sensitivity, ethical reflection, empathy, commitment, and recognition of the interdependence between people, societies, and ecosystems. DO refers to transformative action: applying learning in specific contexts, designing proposals for improvement, and participating in initiatives that benefit the common good. The KNOW–CARE–DO organisation therefore links understanding, ethical engagement, and action while retaining the interdependent character of the original CARE–KNOW–DO framework. This is particularly relevant given the difficulty of turning concern about the climate crisis and global conflicts into sustained participation. Integrating UNESCO, GreenComp, the Tuning Project, (PISA & OECD, 2018) competences and the KNOW–CARE–DO framework underpins a multidimensional, transferable, and assessable conception of eco-social competences in higher education. The EDUCLIMA rubric not only assesses knowledge of sustainability and global competence, but also the ability to adopt an ethical viewpoint, engage in intercultural relations, and address eco-social challenges.

2.4. Teaching Framework for the Development of Eco-Social Competences

In this project, active teaching methodologies such as PBL and SL were implemented because of their potential for developing eco-social competences (Albareda-Tiana et al., 2019, 2024; CRUE, 2012).

PBL, which is constructivist in nature, encourages students to design projects linked to real-world problems working in small groups (Tejedor et al., 2019). It promotes the

integration of theory and practice, critical thinking, questioning, metacognition, and active learning. It also fosters responsibility, motivation, and autonomous and lifelong learning, and teachers act as guides in the process (Holgaard et al., 2022; Terrón-López et al., 2017).

SL is based on a complex and interdependent understanding of reality as both the context and the object of learning (Culcasi, 2025). Its aim is to educate individuals capable of mobilising knowledge, skills, and attitudes in the service of the common good (Batlle Suñer, 2013). It integrates academic learning and community service into a single process, generating transformative effects on students and the community (Puig Rovira et al., 2006).

In accordance with the phases shown in Figure 3, at the start of the three courses in the three universities in three different countries analysed, the students were told they had to undertake community service, or resolve a local problem related to sustainability in the course. They carried out an initial self-assessment (pre-test) of eco-social competences, measuring their knowledge, attitudes, and skills related to the topic. In groups of up to six students, they conducted research connecting the course content with the problem addressed. Academic support was provided in two or three tutorial sessions by the faculty member responsible for each course. A minimum of two tutorial meetings were held, with additional sessions scheduled according to the needs of each student group. Instructors remained available throughout the process to support students and provide guidance on the development of their projects. Each tutorial meeting lasted approximately 15 min. Given the active nature of the methodology in which students are expected to take on a leading role in their own learning process, most of the work associated with SL or PBL was carried out autonomously by the students outside the tutorial sessions. In the first session, held at the beginning of the course, a specific and feasible problem was defined. Subsequent interim and final tutorials were held. At some universities, the projects were presented publicly and assessed by a panel of experts using the same eco-social competence rubric, although these data are not included in this study. Although incorporating these external panel assessments would provide a valuable form of methodological triangulation and further strengthen the validity of the findings, due to time constraints, these data were not included in this study to examine whether the external assessments also reflected an increase in students' eco-social competences. The students repeated a final self-assessment (post-test) of eco-social competences at the end of the respective courses.

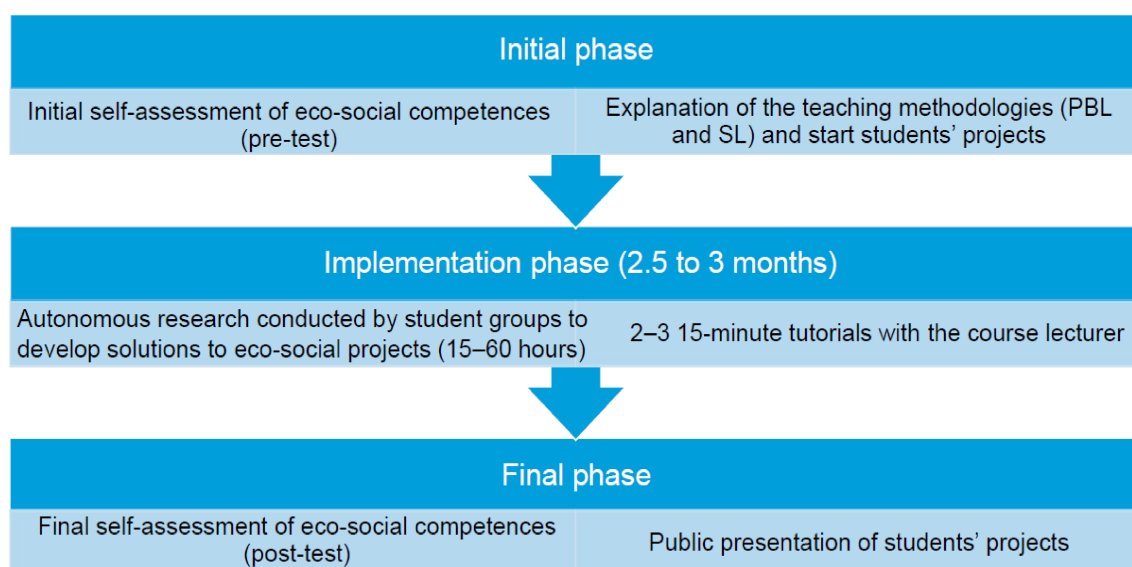


Figure 3. Initial phase, implementation phase, and final phase of the active teaching methodologies for developing eco-social competences.

3. Materials and Methods

3.1. Rubric Development

To assess students' self-perceived eco-social competences before and after participating in active learning methodologies, a multidimensional rubric was designed based on three dimensions of learning: cognitive, ethical-affective, and behavioural. This structure was based on the CARE–KNOW–DO model (Okada & Gray, 2023) and on international frameworks of education for sustainability, such as GreenComp (Bianchi et al., 2022).

The instrument was adapted to the university and intercultural context of the project, which was carried out in Spain, Italy, and Colombia. The process consisted of four stages. First, international frameworks on sustainability and eco-social competences were reviewed (UNESCO, 2017, 2018; PISA & OECD, 2018; CRUE, 2012), from which four generic competences relevant to higher education were selected: critical thinking, diversity and interculturality, initiative and entrepreneurial spirit, and ethical responsibility. Second, an existing rubric originally designed for early childhood education (Fuertes-Camacho et al., 2026) was adapted by reformulating its descriptors to suit university and community contexts, while retaining its underlying organisation around the three dimensions of KNOW, CARE, and DO. Third, teaching teams from six universities carried out a peer review to ensure cultural relevance, conceptual clarity, and consistency with the active methodologies applied. Finally, a pilot test was carried out with small groups to verify understanding of the items and refine their wording.

The rubric was applied as a self-assessment tool using a pre-test–post-test design with the aim of identifying initial levels, guiding teaching planning, and evaluating changes related to the educational experience.

3.2. Rubric Structure

The final rubric consisted of 12 items organised around four eco-social competences, each operationalised through three dimensions: KNOW, CARE and DO. The KNOW dimension corresponds to knowledge and understanding of eco-social problems; CARE refers to the reflective, ethical, and affectively oriented engagement with these problems; and DO assesses the capacity to act and bring about change in real-world contexts.

Given the multidimensional and interdependent nature of eco-social competences, some indicators may incorporate elements that overlap across KNOW, CARE and DO. In particular, certain CARE indicators may involve cognitive recognition or behavioural orientation in addition to their intended ethical-affective dimension. Therefore, the three dimensions should not be interpreted as completely distinct constructs at the level of individual indicators, but rather as analytically differentiated and interrelated dimensions of eco-social competence. This overlap is acknowledged as a limitation of the current operationalisation and should be further examined in future studies through larger samples and analyses of the empirical dimensional structure.

The four eco-social competences included were: (1) critical contextualisation of knowledge establishing interrelationships with social, economic, and environmental issues at the local and global level, (2) respect for human rights, diversity, and equity of all citizens without discrimination, promoting a culture of peace and participation, (3) undertaking actions for the common good and sustainable development, and (4) application of ethical principles related to the values of sustainability and human rights in individual and collective behaviour. Each competence was specified in three self-assessable indicators formulated in the first person, resulting in a matrix of 12 indicators.

Each eco-social competence is structured across three dimensions (KNOW–CARE–DO), organised as illustrated in Table 2.

Table 2. Dimensions and descriptors of eco-social competences.

Dimension	Further Development of Competence Mobilisation
KNOW	Cognitive dimension
CARE	Ethical-affective dimension
DO	Behavioural dimension

Three indicators were derived from the conceptual dimensions for each eco-social competence (formulated in the first person), resulting in the final matrix (Table 4).

3.3. Research Approach and Design

The study followed a pre-experimental design including quantitative pre-test–post-test measurements, complemented by a qualitative component based on an open-ended question. The quantitative component enabled analysis of changes in students’ self-assessed eco-social competences across the KNOW, CARE, and DO dimensions before and after implementing active teaching methodologies.

The qualitative component involved a deductive thematic analysis of 46 responses to the open-ended post-test question. Following [Braun and Clarke’s \(2021\)](#) typology, this corresponds to codebook thematic analysis: it maintains an interpretative focus while structuring the text through an a priori coding framework inspired by [Crabtree and Miller’s \(1999\)](#) template approach.

A code manual of this kind may be derived a priori from theory and subsequently verified against the corpus, in combination with lower-order categories developed from the data. In this study, the framework was established prior to coding based on the research objectives and the three dimensions of the eco-social competence model (KNOW, CARE, and DO). These dimensions served as predetermined organising domains rather than data-driven themes. Consequently, the analysis retained [Braun and Clarke’s \(2006\)](#) stages—familiarisation, coding, category definition, and analytical writing—while replacing inductive theme generation with the systematic verification of the predetermined framework against the corpus. Almost the entire corpus was written in Spanish, with one response in Italian. To enable analysis in a single shared language, the Italian excerpt was translated into Spanish by a native Italian-speaking co-author fluent in academic Spanish, prioritising conceptual over literal equivalence and retaining the original wording alongside the translation to ensure coding decisions remained traceable to the source text ([van Nes et al., 2010](#)). Coding was performed by two experienced qualitative researchers who were also involved in implementing the active methodologies. To limit potential insider bias, analytical decisions were documented in reflective memos, and the final categorisation was reviewed by the two co-authors who had not coded the data. After familiarising themselves with the corpus, both analysts independently segmented the responses into meaning units and assigned them to KNOW, CARE or DO (allowing multi-coding, alongside a residual category for unaligned content).

Discrepancies were resolved through consensus discussion rather than inter-coder agreement coefficients, prioritising interpretative consistency over statistical reliability. This step confirmed the applicability of the predefined codes without requiring structural revisions. Recurrent patterns of meaning within each dimension were subsequently identified, named, and illustrated with representative excerpts. All data were managed using ATLAS.ti (version 23.3.0), fully anonymised prior to analysis and reported as verbatim quotations identified by participant code, country, and degree programme.

3.4. Population and Sample

A total of 61 university students from three universities in three different countries participated in the study: Spain, with 41 participants from Universitat Internacional de Catalunya (UIC) (67%); Colombia, with 14 participants from Universidad de La Sabana (23%); and Italy, with 6 participants from Università LUMSA (10%). The sample consisted of 16 male (26%) and 45 female students (74%) enrolled in degree programmes in medicine, education, chemical engineering, mechanical engineering, law, political science, and psychology. The original sample of students participating in the study was larger. However, the final sample was restricted to those participants for whom both pre-test and post-test data were available, as these paired data constitute the dataset analysed and reported in this paper.

The open-ended post-test question was answered by 61 students. Of these, 71.7% were female and 28.3% were male students. With regard to the different degree programmes, medicine predominated (67.4%), followed by psychology (17.4%) and chemical engineering (6.5%). The degree programmes in mechanical engineering, law, political science, and education each represented 2.2% of the qualitative responses.

At UIC, 8 PBL projects were carried out with 41 students as part of the compulsory fifth-year medicine course Epidemiology and Public Health. This methodology aimed to encourage students to reflect practically on the nexus between planetary health and human health. The projects developed were: (1) Healthy Streets: A strategy to reduce respiratory diseases on the streets of Barcelona; (2) Microplastics: A macro problem; (3) Decarbonising a hospital; (4) Childhood diseases and pollution; (5) Rapid Disaster Response Group (GIRACat-UIC); (6) Land of Fire; (7) Transforming Our Environment: Local climate action plan; and (8) Conscious and affordable nutrition for students.

Upon completing the course, students expressed satisfaction at gaining a deeper understanding of how climate change directly impacts human health and recognising the collective responsibility involved in ensuring a healthy future.

At USABANA, students enrolled in the elective course Digital Transformation and Citizenship analysed diverse socio-environmental issues using data science methodologies across six different projects. Working in small groups, students selected topics of interest, conducted preliminary literature reviews to identify different factors involved, and retrieved open-access datasets from government sources. They subsequently processed the data and synthesised their findings into visual reports detailing conclusions and recommendations, which were shared with the rest of the course participants. The student projects comprised: (1) Analysis of anabolic steroid use among university students; (2) Data analysis on the integration of former combatants from the armed conflict; (3) Analysis of vaping among university students; (4) Analysis of self-image and mental health among university students; (5) Data analysis on mental health and domestic violence; (6) The crime of being a woman: data analysis on femicide.

At LUMSA, SL and PBL were integrated into the compulsory General Didactics course within the Primary Education degree. The SL project, Volunteers for Education, implemented in collaboration with Save the Children Italy, addressed educational poverty through online tutoring provided to vulnerable children aged 9 to 16 by trained female student volunteers using inclusive digital methodologies. Concurrently, PBL projects focused on key socio-environmental topics including (1) Water in the Classroom (responsible use of water resources) and (2) Little Guardians of the Planet (school-based science activities).

Table 3 summarises the teaching methodologies applied across the different student groups and subjects, complementing Figure 3, which details the implementation phases and timeline.

Table 3. Characteristics of the educational settings and methodologies used across the participating student groups.

University, City	Degree	Course	Year	Methodology	Duration	Tutorial Hours	Instructor
Universitat Internacional de Catalunya (UIC), Barcelona	Medicine	Epidemiology and Public Health	5th	PBL	2.5 to 3 months	Minimum $2 \times \sim 15$ min; additional sessions as required	Faculty member responsible for the course
Universidad de La Sabana (USABANA), Bogotá	Various	Digital Transformation and Citizenship	1st to 4th	PBL	2.5 to 3 months	Minimum $2 \times \sim 15$ min; additional sessions as required	Faculty member responsible for the course
Università LUMSA, Rome	Primary education	General Didactics	2nd	SL and PBL	2.5 to 3 months	Minimum $2 \times \sim 15$ min; additional sessions as required	Faculty member responsible for the course

Table 4 outlines an eco-social competence rubric for higher education, consisting of 12 indicators across four core competences—Critical thinking, Diversity and interculturality, Entrepreneurial spirit, and Responsibility and sense of ethics. Each competence is structured across three functional dimensions: KNOW, CARE, and DO.

Table 4. Structure of the eco-social competence rubric in higher education (12 indicators across the KNOW–CARE–DO dimensions).

Eco-Social Competence	Competence Definition	Dimension	Specific Indicator/Descriptor
Critical thinking	Mental behaviour that involves reflecting on and questioning things, as well as being interested in the bases that give rise to one's own and other people's ideas, actions, and judgements	KNOW	I understand the functioning of natural, social, and economic systems, and the relationships between them.
		CARE	I recognise the interconnection between social, economic, and environmental issues when promoting sustainability.
		DO	I actively promote integrated sustainability, considering the interrelationships between natural, social, and economic systems.

Table 4. *Cont.*

Eco-Social Competence	Competence Definition	Dimension	Specific Indicator/Descriptor
Diversity and interculturality	Understand and respect social and cultural diversity as an enriching component at the individual and collective level that enables peaceful coexistence between people.	KNOW	I recognise the value of each person. This leads to respect for human rights, diversity, equity, citizen participation, and the development of a culture of peace.
		CARE	I know how to promote human rights, peace, and equity of all citizens in different contexts.
		DO	I act in favour of human rights, promoting equality for all, and a culture of peace, respecting social and cultural diversity.
Entrepreneurial spirit	Carry out projects on one's own initiative so as to take advantage of the opportunities provided by the context.	KNOW	I know what kind of actions contribute to the common good and to sustainable development (SD).
		CARE	I identify what kind of actions contribute to the common good and to SD in all circumstances.
		DO	I am committed, and carry out activities that contribute to the common good and to SD.
Responsibility and sense of ethics	Accept and assume the commitment that actions in the service of society and collaboration with the community represent, as well as act to achieve one's own moral good and that of others.	KNOW	I know the ethical principles that support human rights (HRs) and sustainability in individual and collective behaviour.
		CARE	I integrate sustainability ethics and respect for human rights into my actions, recognizing nature's intrinsic value and every person's dignity, while promoting education to transform human relationships with the social and cultural environment.
		DO	I act to contribute to moral good when promoting human rights and sustainability.

The indicators were formulated to operationalise the conceptual distinction between KNOW, CARE, and DO. However, the boundaries between these dimensions are not always fully distinct at the level of individual items. Some indicators, particularly within CARE, combine cognitive, ethical, and behavioural elements. This reflects the interdependent nature of eco-social competence but may also reduce the conceptual distinctiveness of the dimensions. Accordingly, the three dimensions should be interpreted as analytically related components rather than as entirely independent constructs. Further psychometric and construct-validity research is required to examine the extent to which the empirical structure of the instrument corresponds to its theoretical organisation.

3.5. Instrument

3.5.1. Structured Questionnaires (Quantitative Component)

The quantitative instrument consisted of a 12-item questionnaire derived from the eco-social competence rubric. Each item was rated on a 1–5 Likert scale, where 1 indicated a low level of development and 5 a high level. The students completed the questionnaire twice: before and after implementing the active methodologies.

The psychometric results do not provide sufficient evidence to confirm a clearly differentiated multidimensional structure of the instrument. The overall scale showed high internal consistency at both pre-test ($\alpha = 0.86$) and post-test ($\alpha = 0.90$); these coefficients should be interpreted as evidence of coherence among the 12 items rather than as support for multidimensionality. Therefore, the multidimensional structure of the instrument should be regarded as theoretically grounded rather than empirically confirmed. Further studies with larger independent samples and appropriate factorial analyses are required to establish whether the proposed dimensions represent distinct latent constructs.

Table 5. Internal consistency of the overall scale, competence subscales, and KNOW, CARE, and DO dimensions at pretest and post-test.

Scale/Subscale (N = 61)	Items	α Pretest	α Post-Test
Overall instrument	12	0.86	0.90
C1. Critical contextualisation of knowledge establishing interrelationships with social, economic, and environmental issues at the local and global level.	3	0.54	0.77
C2. Respect for human rights, diversity, and equity of all citizens without discrimination, promoting a culture of peace and participation.	3	0.70	0.84
C3. Undertaking actions for the common good and sustainable development.	3	0.68	0.74
C4. Application of ethical principles related to the values of sustainability and human rights in individual and collective behaviour	3	0.77	0.81
Overall dimensions	Items	α Pretest	α Post-Test
KNOW	4	0.63	0.67
CARE	4	0.62	0.74
DO	4	0.76	0.74

Table 6. Spearman correlations among the KNOW, CARE, and DO dimension scores at pre-test and post-test.

Dimensions	Pre-Test (ρ_s)	Post-Test (ρ_s)
KNOW–CARE	0.82	0.80
KNOW–DO	0.57	0.71
CARE–DO	0.57	0.79

Cronbach's alpha coefficient was recalculated for the instrument as a whole and separately for the four competency subscales and the dimensions KNOW, CARE, and DO at both measurement points. The instrument (Table 5) as a whole showed high internal consistency ($\alpha = 0.86$ at baseline and $\alpha = 0.90$ at final assessment). At the competency level, the coefficients ranged from 0.54 to 0.77 at baseline and from 0.74 to 0.84 at final assessment. For the three theoretically defined dimensions, the alpha coefficients were 0.63/0.67 for KNOW, 0.62/0.74 for CARE, and 0.76/0.74 for DO (initial/final assessment, respectively). Spearman correlations were calculated between the composite assessments of KNOW, CARE, and DO. In the initial assessment, the correlations were 0.82 for KNOW-CARE, 0.57 for KNOW-DO, and 0.57 for CARE-DO. In the final assessment, the corresponding correlations were 0.80, 0.71, and 0.79 (see Table 6). These additional analyses indicate an overlap between the theoretically defined dimensions, while also showing that this overlap is not uniform across all dimensions or all measurement occasions. These analyses are exploratory given the sample size. The subscale reliability estimates and correlations among KNOW, CARE and DO provide descriptive information about the internal coherence and empirical relatedness of the proposed dimensions, but they do not establish factorial validity. The subscale reliabilities and inter-dimension correlations reported above should therefore be interpreted as exploratory evidence.

3.5.2. Open-Ended Question (Qualitative Component)

The post-test questionnaire included an open-ended question designed to explore the students' subjective perceptions of the educational impact of the experience: "Do you consider that carrying out a project related to integrated sustainability and/or climate action has helped you develop eco-social competences? Explain why."

This question allowed gaining a deeper understanding of how the students assessed the contribution of SL and PBL experiences to the development of their eco-social competences.

3.6. Quantitative Data Analysis

Descriptive statistics were calculated for the pretest and post-test scores for the overall questionnaire, the four eco-social competences, and the three KNOW-CARE-DO dimensions. The normality of the pretest-post-test difference scores was assessed using the Shapiro-Wilk test. Because the assumptions for parametric comparison were not met, changes between pretest and post-test scores were examined using the Wilcoxon signed-rank test. Differences were calculated as post-test minus pretest, so positive values indicate higher post-test scores. The number of non-zero paired differences (n) contributing to each Wilcoxon test is reported in the corresponding tables.

Effect sizes were estimated using the matched-pairs rank-biserial correlation (Kerby, 2014). For descriptive interpretation, absolute values were classified using conventional correlation-based thresholds as negligible (<0.10), small (0.10 – 0.29), moderate (0.30 – 0.49), and large (≥ 0.50) (Tomczak & Tomczak, 2014). Ninety-five per cent confidence intervals for rank-biserial correlations were estimated using the bias-corrected and accelerated (BCa) bootstrap method with 5.000 participant-level resamples, preserving the paired pretest-post-test structure.

Statistical significance was assessed using two-tailed tests with $\alpha = 0.05$. To control the Type I error associated with multiple comparisons, Holm's sequential correction was applied separately to the four competence-level comparisons and the twelve dimension-level comparisons (KNOW, CARE, and DO within each of the four competences). The overall pretest-post-test comparison constituted a single contrast and was therefore not adjusted for multiple comparisons. Raw p -values are reported with sufficient numerical

precision in the corresponding tables to allow reconstruction of the Holm-adjusted p -values. Quantitative analyses were conducted using R version 4.5.2.

4. Results

4.1. Quantitative Results

The section below presents the quantitative data derived from the questionnaire responses of 61 students from universities in Spain (Barcelona), Colombia (Bogotá), and Italy (Rome).

Because the pre-post differences did not meet the assumption of normality (Shapiro–Wilk test, $p < 0.05$), the non-parametric Wilcoxon signed-rank test was conducted to evaluate changes between the two time-points. The analysis revealed a statistically significant increase in global post-test scores ($V = 1492$, $p = 0.000003299$ ($p < 0.001$) and $rrb = 0.71$). The null hypothesis was rejected, indicating a statistically significant difference between the post-test and pre-test scores. Given the pre-experimental design, these differences should be interpreted as observed changes rather than evidence of a direct causal effect of the intervention.

Table 7 presents the pre-test and post-test results for the four eco-social competences ($N = 61$). Using the non-parametric Wilcoxon signed-rank test, it details the changes in mean scores, standard deviations, adjusted p -values, and rank-biserial correlation effect sizes (rrb) across each competence dimension and global values.

Table 7. Pre-test and post-test results for the four eco-social competences.

Competence ($N = 61$)	Mean Pre-Test	SD	Mean Post-Test	SD	$n \neq 0$	Wilcoxon V	p	Holm- Adjusted p	Rrb [95% BCa CI]
Global	4.00	0.43	4.31	0.44	57	1492	0.000003299	—	0.71 [0.44, 0.88]
C1	3.68	0.53	4.14	0.55	48	1017.5	0.0000101333	0.0000405333	0.73 [0.47, 0.89]
C2	4.07	0.58	4.32	0.61	49	912.5	0.0027738633	0.0027738633	0.49 [0.14, 0.74]
C3	4.08	0.52	4.37	0.45	42	776.5	0.0000445262	0.0001335786	0.72 [0.39, 0.90]
C4	4.17	0.53	4.41	0.49	36	560.0	0.0003473839	0.0006947679	0.68 [0.35, 0.88]

Note. Wilcoxon signed-rank tests were calculated using the differences between the post-test and pre-test. $n \neq 0$ indicates the number of paired observations with non-zero differences contributing to the signed-rank procedure. Effect sizes are reported as rank-biserial correlations (rrb) with 95% bias-corrected and accelerated (BCa) bootstrap confidence intervals based on 5000 resamples. Holm-adjusted p -values were calculated jointly for the four competence-level comparisons. The global comparison was not adjusted as it constituted a single test.

Table 8 outlines the initial distribution of student responses across the 12 rubric indicators ($N = 61$). Categorised by competence (C1–C4) and dimension (KNOW, CARE, DO), it details response frequencies from levels 1 to 5 and highlights the combined proportion of high-level scores (levels 4–5).

The first eco-social competence, which measures the interrelation and integration among the social, environmental, and economic dimensions of sustainability, showed a large effect size (0.73). Competence had the lowest pre-test mean of the four competences, providing greater potential headroom for improvement than the competences that began at higher levels. This difference in the initial level should therefore be considered alongside the substantive interpretation of the observed increase. However, through the PBL and SL tasks they carried out, they developed an integrated understanding of these three dimensions. Overall, students reported higher levels of this competence following completion of the projects. These observed changes are consistent with the educational experiences undertaken. It should also be noted that competence 1 had the lowest pre-test mean among the four competences, providing greater headroom for improvement than the competences that started at higher levels.

Table 8. Distribution of pre-test responses across the 12 rubric indicators.

Competence	Dimension	Item	1 <i>n</i> (%)	2 <i>n</i> (%)	3 <i>n</i> (%)	4 <i>n</i> (%)	5 <i>n</i> (%)	4–5 <i>n</i> (%)
C1	KNOW	1	1 (1.6)	3 (4.9)	18 (29.5)	37 (60.7)	2 (3.3)	39 (63.9)
	CARE	2	0 (0.0)	4 (6.6)	11 (18.0)	38 (62.3)	8 (13.1)	46 (75.4)
	DO	3	1 (1.6)	4 (6.6)	16 (26.2)	36 (59.0)	4 (6.6)	40 (65.6)
C2	KNOW	4	0 (0.0)	1 (1.6)	13 (21.3)	23 (37.7)	24 (39.3)	47 (77.0)
	CARE	5	0 (0.0)	1 (1.6)	16 (26.2)	33 (54.1)	11 (18.0)	44 (72.1)
	DO	6	0 (0.0)	0 (0.0)	9 (14.8)	32 (52.5)	20 (32.8)	52 (85.2)
C3	KNOW	7	0 (0.0)	1 (1.6)	8 (13.1)	36 (59.0)	16 (26.2)	52 (85.2)
	CARE	8	0 (0.0)	1 (1.6)	5 (8.2)	35 (57.4)	20 (32.8)	55 (90.2)
	DO	9	0 (0.0)	2 (3.3)	9 (14.8)	41 (67.2)	9 (14.8)	50 (82.0)
C4	KNOW	10	0 (0.0)	2 (3.3)	6 (9.8)	38 (62.3)	15 (24.6)	53 (86.9)
	CARE	11	0 (0.0)	0 (0.0)	8 (13.1)	37 (60.7)	16 (26.2)	53 (86.9)
	DO	12	0 (0.0)	0 (0.0)	4 (6.6)	35 (57.4)	22 (36.1)	57 (93.4)

Note. *n* = number of participants selecting each response category. Percentages were calculated based on *N* = 61. The 4–5 column represents the combined frequency and percentage of responses in the two highest response categories.

The second eco-social competence, corresponding to respect for human rights, diversity, and equity for all citizens, presented a moderate effect size (0.49). Students already demonstrated a high initial level (mean score in the pre-test = 4.07). Nevertheless, in light of the dimensional definitions, these results can be interpreted as an increase in participants' interest in learning about and promoting human rights.

The third eco-social competence, which measures contributions to actions for the common good and sustainable development, demonstrated a large effect size (0.72). These findings suggest that participants perceived themselves as more committed to taking action after completing the projects.

The fourth eco-social competence, corresponding to the “application of ethical principles related to sustainability values and human rights in individual and collective behaviours,” exhibited a large effect size (0.68). This pattern is likely related to students starting at a high initial level while the projects themselves were oriented towards themes focused on human rights, sustainability, and the promotion of peace.

Table 9 presents the statistical results for each dimension by competence. It displays the statistical values, including effect sizes and Wilcoxon signed-rank test results using Holm's correction to control for multiple comparison errors. This adjusted *p*-value prevents false-positive interpretations (Type I errors) in the results.

For eco-social competence 1, the analysis across all three dimensions (KNOW, CARE, and DO) indicates statistically significant improvements from pre-test to post-test (Holm-adjusted *p* < 0.05). Furthermore, all three dimensions registered large effect sizes (ranging from 0.58 to 0.70), demonstrating that meaningful changes were observed in students' self-perceived critical knowledge, eco-social values and attitudes, and the capacity to act coherently in response to social and environmental challenges. The KNOW dimension showed the greatest improvement and the largest effect size, followed by DO. Although CARE also improved significantly, it showed the smallest effect size among the three dimensions. This pattern highlights that, while all three dimensions experienced statistically significant growth, they evolved at different rates.

Table 9. Pre-test and post-test results for the four eco-social competences by dimension.

Competence	Dimension	Mean Pre-Test	SD	Mean Post-Test	SD	$n \neq 0$	V	p	Holm-Adjusted p	rrb [95% BCa CI]
C1	KNOW	3.59	0.72	4.13	0.67	36	567.5	0.000109	0.001304	0.70 [0.37, 0.89]
	CARE	3.82	0.74	4.23	0.62	35	497.0	0.001450	0.013051	0.58 [0.19, 0.80]
	DO	3.62	0.78	4.05	0.72	33	463.0	0.000467	0.004668	0.65 [0.33, 0.85]
C2	KNOW	4.15	0.81	4.41	0.72	36	460.0	0.032790	0.098371	0.38 [0.00, 0.69]
	CARE	3.88	0.71	4.23	0.74	35	475.0	0.004779	0.028676	0.51 [0.12, 0.77]
	DO	4.18	0.67	4.33	0.68	26	229.0	0.137363	0.221932	0.30 [−0.17, 0.66]
C3	KNOW	4.10	0.68	4.41	0.50	24	250.0	0.002343	0.018745	0.67 [0.25, 0.88]
	CARE	4.21	0.66	4.38	0.58	25	218.0	0.110966	0.221932	0.34 [−0.08, 0.68]
	DO	3.93	0.65	4.31	0.59	29	368.5	0.000390	0.004289	0.69 [0.28, 0.93]
C4	KNOW	4.08	0.69	4.34	0.60	23	216.0	0.010872	0.054359	0.57 [0.14, 0.84]
	CARE	4.13	0.62	4.38	0.58	19	163.0	0.002741	0.019189	0.72 [0.25, 0.93]
	DO	4.30	0.59	4.52	0.57	21	182.5	0.011690	0.054359	0.58 [0.07, 0.88]

Note. N = 61. Wilcoxon signed-rank tests were based on post-test minus pretest differences. $n \neq 0$ indicates the number of paired observations with non-zero differences contributing to the signed-rank procedure. Holm-adjusted p -values were calculated jointly across the 12 dimension-level comparisons. Effect sizes are reported as matched-pairs rank-biserial correlations (rrb) with 95% bias-corrected and accelerated (BCa) bootstrap confidence intervals based on 5000 participant-level resamples.

For eco-social competence 2, which relates to respect for human rights, diversity, and equity, only the CARE dimension presented a significant improvement following the intervention (Holm-adjusted $p = 0.029$) accompanied by a large effect size (0.51). Conversely, while the KNOW and DO dimensions showed increases in moderate scores and effect sizes (0.38 and 0.30, respectively), these differences ceased to be statistically significant after applying Holm's correction.

For eco-social competence 3, focused on taking action for the common good and sustainable development, results indicate significant improvements in the KNOW and DO dimensions. Significant improvements were observed following participation in the learning experiences both in understanding principles associated with the common good and sustainability, and in translating that knowledge into concrete action. In contrast, the CARE dimension showed no statistically significant difference despite an increase in mean scores and a moderate effect size. This outcome may also be attributable to a ceiling effect, as students started with a high initial score (mean score in the pre-test = 4.21), thereby limiting the scope for further improvement in sustainability-related attitudes and values.

Finally, for eco-social competence 4, regarding the application of ethical principles linked to sustainability values and human rights, the largest observed changes concentrated in the CARE dimension—the only dimension to maintain a statistically significant improvement and demonstrate the largest effect size (0.72). The KNOW and DO dimensions showed increases in mean scores and large effect sizes. However, their Holm-adjusted p -values were not statistically significant. All three dimensions within this competence had high initial pre-test means (4.08, 4.13, and 4.30) suggesting limited room for further improvement.

This pattern suggests differentiated effects depending on the nature of each competence. While the development of critical thinking regarding eco-social problems (competence 1) was comprehensively strengthened across all three dimensions, competences related to human rights and ethics (competences 2 and 4) demonstrated a greater impact on the attitudinal dimension (CARE). Meanwhile, the competence oriented towards action for

the common good (competence 3) primarily showed enhancement in knowledge (KNOW) and action (DO).

4.2. Qualitative Results

With regard to the qualitative analysis, the open-ended responses overall show that SL and PBL projects linked to integrated sustainability contributed especially to strengthening eco-social competence 1 (critical contextualisation of knowledge establishing interrelationships with social, economic, and environmental issues at the local and global level), particularly in its cognitive dimension KNOW. Understanding of the interdependence between local and/or global environmental, social, economic, and health systems was broadened. Numerous students pointed out that the experience enabled them to “better understand what sustainability goals entail and the importance of promoting them” (Student 1, female) or “grasp the complexity of climate change and the urgent need for action” (Student 4, female). This generates a more sophisticated contextualisation of eco-social issues and a greater awareness of their seriousness. At the same time, relevant components of the CARE dimension emerged, associated with empathy and recognising vulnerability of certain groups of people. Examples are when the participants state that children “are highly vulnerable to environmental pollution” and that adults have a responsibility to “fight for them” (Student 13, female). Awareness of the ethical implications of sustainability for public health was also heightened: “working on a project related to sustainability or climate action helps understand how environmental factors directly influence the health of populations, especially in vulnerable contexts [...] strengthening the ethical and professional commitment to equity and collective well-being” (Student 25, male).

The DO dimension appears in a more situated and specific manner, linked both to changes in personal habits and to proposals for collective action, in line with competence 3 (undertaking actions for the common good and sustainable development) and, to a lesser extent, with competence 4 (application of ethical principles related to the values of sustainability and human rights in individual and collective behaviour). Some students describe changes in their daily behaviour—for instance, “avoiding heating plastic containers to reduce exposure to microplastics” (Student 9, female)—while others highlight the design of community activities, such as “awareness campaigns, local solutions, reducing individual environmental impact” (Student 17, female), or proposals for “healthy streets, incorporating criteria of public health and urban sustainability” (Student 26, female). In this regard, the experience was associated not only with students reporting greater declarative knowledge but also with describing an increased ability to imagine and plan specific actions oriented towards the common good. This provides qualitative evidence of how students described connections among understanding, ethical engagement, and action, consistent with the analytical structure of the KNOW–CARE–DO framework.

In terms of gender, both female and male students show progress across the three KNOW–CARE–DO dimensions, but with nuances in the discursive emphasis. Female students more frequently referred to vulnerability, care, and the relational dimension of problems. For instance, they referred to the need to “care for women of all ages” in response to femicide (Student 35, female) or acknowledged the impact of domestic violence on mental health. They also stressed the importance of assuming “social responsibility” when addressing these realities (Student 37, female). These observations concern differences in discursive emphasis rather than statistically tested differences in competence scores.

Among male students, however, the cognitive dimension of competence 1 was particularly prominent, with an emphasis on the analysis of social and environmental determinants of health, the understanding of complex systems, and the development of a “broader vision” that integrates social and environmental equity into the professional role (Student 2, male;

Student 25, male). This pattern is interpreted here as a difference in narrative emphasis rather than as evidence of a gender difference in competence scores.

Figure 4 illustrates the flow from gender groups (female/male) to four eco-social competences (1–4) and their corresponding KNOW, CARE, and DO dimensions.

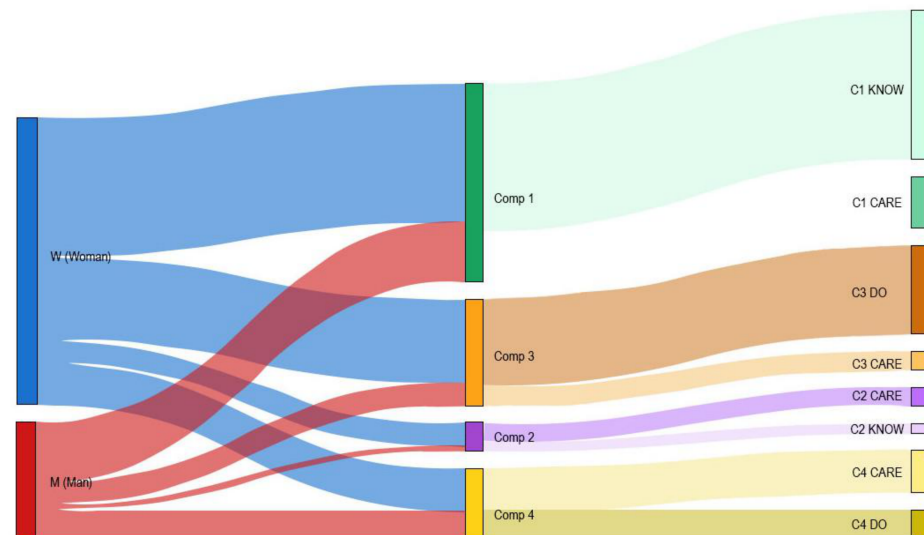


Figure 4. Eco-social competences and KNOW-CARE-DO dimensions by gender (N = 46).

5. Discussion

Overall, the findings indicate that students reported higher self-perceived eco-social competence at post-test than at pre-test following participation in active learning experiences. The quantitative and qualitative results point to changes across cognitive, ethical-affective, and action-oriented aspects of eco-social competence, although these patterns should be interpreted within the limitations of a pre-experimental self-report design.

With respect to the first objective (O1), the findings indicate that implementing active methodologies—specifically SL and PBL—was associated with improvements in students' self-perceived eco-social competences. Although the observed increase in post-test scores aligns with the expected pedagogical impact, these changes should be interpreted cautiously. They may also reflect confounding factors typical of pre-post self-assessment designs, such as response shift bias, social desirability, participant maturation, or concurrent learning experiences. Nevertheless, these results align with existing literature showing that active, experiential pedagogies foster sustainability-related competences by grounding knowledge in authentic contexts, critical reflection, and civic engagement (Brundiers et al., 2021; Rieckmann, 2018; UNESCO, 2022c). Accordingly, the present data should be viewed as evidence compatible with this broader framework rather than definitive proof of a direct causal relationship. Beyond competence gains, the results suggest that these methodologies may help students contextualise complex issues related to the Sustainable Development Goals (SDGs) within university curricula. This pedagogical approach appears to facilitate a transition from a reductionist view of sustainability towards a more integrated, holistic perspective, a shift consistent with systemic thinking approaches promoted in education for sustainability (Sterling, 2011; Rieckmann, 2018), with the GreenComp framework (Bianchi et al., 2022), and with the 2030 Agenda (United Nations, 2015), which stress the need to understand the interdependence between social, environmental, and economic dimensions.

The stronger increase observed in the KNOW dimension is consistent with the theoretical emphasis placed on understanding complex eco-social problems as an important component of comprehensive eco-social competence. However, the present design does not

establish KNOW as a necessary causal condition for the development of other dimensions. The particularly significant improvement observed in the competence of critical contextualisation of knowledge reinforces the idea that an informed understanding of problems constitutes the starting point for the mobilisation of values and transformative action.

The results of the study show that participating in SL and PBL projects addressing integrated sustainability is linked to an overall increase in students' self-perceived eco-social competences, with a particularly significant effect on eco-social competence 1, which is related to the interrelationships between social, economic, and environmental issues, especially in the KNOW dimension. The increase observed in this competence suggests that the observed pattern is consistent with students developing a more complex and refined understanding of the interrelationships between environmental, social, economic and health systems, shifting the focus from general awareness towards deeper and more grounded forms of structural analysis.

Regarding the second objective (O2), the study identifies changes in students' self-perceived eco-social competences across the KNOW, CARE, and DO dimensions, providing a more in-depth understanding of the educational process.

First of all, consistent progress is observed in the KNOW dimension. These findings are consistent with previous research suggesting that active methodologies can support critical thinking, problematisation, and understanding of complexity (UNESCO, 2017, 2018), with a particularly significant effect on eco-social competence 1, particularly in the KNOW dimension. Secondly, several CARE-related indicators showed increases, particularly in relation to human rights, social responsibility, and engagement with real-world social issues. These findings should nevertheless be interpreted cautiously because some CARE indicators include cognitive or behavioural content and therefore may not represent a distinct affective construct. The qualitative responses provide complementary evidence of students expressing ethical concern, empathy, social responsibility, and awareness of vulnerability, but these narratives should not be taken as psychometric validation of the CARE dimension. The convergence between the quantitative and qualitative results highlights that the students not only expand their knowledge of sustainability, but also develop ethical and relational sensitivity, expressed in terms of empathy, social responsibility, and awareness of vulnerability. This is in agreement with studies on transformative learning (Mezirow, 2000; Boix Mansilla & Jackson, 2022).

The analysis by competences enables examining these results in greater depth. Eco-social competence 2 shows particularly significant progress in the CARE dimension, accompanied by narratives that emphasise human rights, equity, and the recognition of vulnerable groups. Eco-social competence 3, linked to an entrepreneurial spirit oriented towards the common good, shows a notable increase in the DO dimension, suggesting a greater willingness among students to transform knowledge and ethical concern into proposals for specific action, both in everyday life and in social impact initiatives.

The DO dimension remains the most variable and least established, consistent with the documented gap between knowledge, attitude, and action (Kollmuss & Agyeman, 2002; UNESCO, 2022a). The observed pattern also suggests that the expression of DO may depend not only on students' self-perceived competence but on the pedagogical and institutional conditions available for action. Opportunities to enact eco-social commitments, access to resources, institutional support, and the design of learning activities may therefore influence the extent to which students report action-oriented competence. This finding is consistent with Pantazidis' (2026) argument that pre-service teachers often develop anticipatory imaginaries about transformative education while remaining influenced by a schoolised mind, which may constrain the translation of critical understanding and ethical commitment into sustained educational practice. In line with this perspective,

strengthening the DO dimension may require not only competence development but also pedagogical and institutional conditions that enable students to enact their emerging eco-social commitments.

As with any competence framework, the rubric reflects predefined educational priorities regarding the forms of civic engagement it seeks to assess. Consequently, it may not fully capture alternative expressions of civic agency, such as protest, institutional critique, or other non-formal forms of participation (Andreotti, 2014).

The findings suggest that, although the rubric was analytically organised as KNOW–CARE–DO for assessment purposes, competence development does not appear to follow a rigid linear sequence. Rather, the three dimensions seem to interact dynamically throughout the learning process. This interpretation is consistent with the assessment-oriented adaptation of the original CARE–KNOW–DO framework adopted in this study, intended to organise the evaluation of learning rather than to propose a universal developmental sequence.

A particularly important aspect is the difference in narrative emphasis by gender in the way eco-social competences are developed and expressed. From a qualitative perspective, male students more frequently emphasised aspects of eco-social critical thinking related to understanding complex systems, analysing social and environmental determinants of health, and integrating social and environmental equity into their professional roles. However, the qualitative analysis moderates this difference, showing that female students tend to place greater emphasis on dimensions related to care, vulnerability, and social responsibility, particularly with regard to issues such as inequality, mental health, or gender-based violence. Far from revealing a divide in terms of competence development, these results suggest distinct—and potentially complementary—ways of engaging with the eco-social framework. The findings suggest avoiding oversimplified interpretations and promoting curriculum designs that integrate the cognitive, ethical, and practical dimensions of learning in a balanced manner.

Eco-social competence 4 is especially noteworthy when comparing quantitative and qualitative results. Although the improvement in scores is moderate, the qualitative analysis reveals a strong presence of values, ethical concern, and a sense of responsibility. This apparent divergence suggests that scale-based instruments may underestimate deeper processes of moral internalisation, which do not always immediately translate into observable practices. In this respect, ethics can be interpreted as a dimension in the process of consolidation, which precedes or accompanies action, rather than as a fully stabilised outcome.

Regarding the third research objective (O3), the study presents a theoretically grounded instrument that addresses the growing demand for robust frameworks to assess eco-social competences in higher education settings. The rubric provides a theoretically grounded framework for organising students' self-perceptions of eco-social competence across four competence areas and three analytically related dimensions. The internal consistency results provide preliminary evidence regarding the coherence of the instrument, but they do not establish its factorial or multidimensional validity. The subscale reliabilities and inter-dimension correlations reported above should therefore be interpreted as exploratory evidence that can inform further instrument development. Larger samples and additional forms of validity evidence are needed before the rubric can be considered a validated measure of distinct KNOW, CARE, and DO constructs. This addresses one of the main shortcomings identified in the literature on education for sustainability and global competence, namely the lack of operational instruments that integrate cognitive, ethical, and practical dimensions (UNESCO, 2022a; Rieckmann, 2018).

However, the validity of the instrument should be considered preliminary. As noted by DeVellis and Thorpe (2021) and Boateng et al. (2018), further robust psychometric analyses and application in diverse contexts are necessary to consolidate its validity. Overall, the findings stress the crucial role of higher education in equipping future professionals to navigate the eco-social crisis from a critical, ethical, and transformative perspective (UNESCO, 2022b; SDSN, 2020). While the results must be interpreted within the study's methodological limits, they align with the consensus that fulfilling this role requires more than simply adding sustainability-related content to curricula. It demands a fundamental transformation of teaching practices, assessment frameworks, and institutional structures. Ultimately, these findings suggest the value of learning experiences that connect understanding, ethical engagement, and action, while providing opportunities for students to apply their learning to real-world eco-social challenges.

6. Limitations and Future Research

Despite the results obtained, the study has limitations that must be considered when interpreting the findings. First of all, the pre-experimental pre-test and post-test design, combined with a relatively small number of participants and purposive sampling, limits the possibility of generalising the results beyond the three university contexts analysed. Furthermore, the absence of a comparison group and random allocation limits the possibility of establishing strict causal relationships between participation in SL and PBL experiences and changes in students' self-perceived eco-social competences. However, given that both approaches share an active learning focus, the results enable identifying consistent associations within the framework of these types of methodologies. Secondly, both the quantitative measures and the open-ended question are based on self-report data, which may introduce social desirability bias, particularly in relation to topics carrying a normative weight, such as sustainability and social justice. These types of tools provide access to dimensions that are difficult to observe directly.

As for future lines of research, it is appropriate to move towards longitudinal designs that allow for the analysis of the development of eco-social competences throughout the entire educational pathway, as well as towards comparative studies across different disciplines and institutional contexts. Future studies should also triangulate students' self-perceived levels of eco-social competence with external assessments conducted by expert panels, enabling comparison between perceived competence development and independently evaluated performance. It would provide a more robust assessment of changes in eco-social competences.

It would also be worthwhile to further analyse intersections with other variables such as gender, geographical origin, field of study, etc. Similarly, future research could further examine the possible mediating role of the CARE dimension between KNOW and DO, using specific designs and techniques, as well as explore assessment approaches that integrate standardised scales with biographical, narrative, and participatory methodologies.

In addition, the alignment between individual indicators and the KNOW–CARE–DO dimensions is not fully homogeneous, particularly for some CARE indicators, which may also involve cognitive or behavioural elements. This overlap should be considered when interpreting dimension-specific findings.

7. Conclusions

The findings indicate changes in students' self-perceived eco-social competences following their participation in active learning methodologies in higher education. The observed improvements across the KNOW, CARE and DO dimensions are consistent with the potential of these methodologies to support learning processes that integrate cognitive

understanding, ethical engagement and action-oriented dispositions. However, given the pre-experimental design and reliance on self-reported measures, these results should be interpreted as compatible with the educational intervention rather than as evidence of a direct causal relationship.

Beyond demonstrating positive educational outcomes, the study contributes to the field by integrating an empirically informed competence framework, active methodologies, and an assessment rubric within a single analytical model. This combination provides a practical and theoretically informed approach that can support curriculum development and future research on eco-social competence in higher education.

Although the findings should not be interpreted as demonstrating direct causality, they provide consistent evidence that universities may support changes in students' self-perceived competences through well-designed experiential pedagogies guided by multidimensional models such as KNOW–CARE–DO. Overall, the findings yield concrete policy, institutional, educational, and practical implications for higher education.

7.1. Policy and Institutional Implications

The complexity of contemporary socio-environmental challenges, including climate change, increasing social polarisation, and armed conflict, requires higher education institutions to develop cross-curricular competences that empower students to navigate systemic problems and contribute to transformative solutions (UNESCO, 2025). As key agents in educating future citizens and professionals, universities play a key role in integrating sustainability, human rights, peace, and climate action into degree programmes through strategic collaboration among academic leaders, teaching staff, students, and external stakeholders (BOE, 2021; CRUE, 2023; SDSN, 2020).

Consequently, these findings support the systematic integration of eco-social competences across undergraduate and postgraduate degree programmes. Curriculum managers and higher education policymakers can embed these competences into programme learning outcomes, course syllabi, teaching activities, and assessment frameworks. At the institutional level, universities should establish dedicated coordination structures to support pedagogical implementation, monitor progress, and align curricular goals with institutional sustainability strategies and international policy frameworks.

7.2. Educational Implications

This study helps bridge the gap between theoretical frameworks in Education for Sustainable Development (ESD) and their practical application in university classrooms. The findings indicate that students reported higher self-perceived sustainability competences following participation in active teaching methodologies by engaging in real-world inquiries, multi-perspective analyses, collaborative problem-solving, and actionable design.

When structured effectively, these methodologies provide opportunities for students to engage with integrated knowledge, ethical attitudes and values, and action-oriented skills related to sustainability, human rights, and social responsibility. However, their effectiveness relies on explicit alignment with learning outcomes and assessment criteria, rather than on isolated ad-hoc teaching activities.

7.3. Practical Implications for Curriculum Implementation and Assessment

The research presents a theoretically grounded and practically applicable rubric for organising and exploring students' self-perceived eco-social competences in higher education. The 12-indicator matrix and the eco-social competence rubric (Table 4) offer a practical framework for exploring changes in students' self-perceived competence across the KNOW, CARE, and DO dimensions.

Institutions can replicate and adapt this model without requiring dedicated grant funding or external project infrastructure. Implementation can follow a phased, institutional process:

Curricular mapping: Align the 12 indicators with existing course and degree programme learning outcomes.

Course selection: Identify target courses in which eco-social competences are already present or easily integrated without full curriculum redesign.

Teacher training: Provide targeted training on the competence framework, active methodologies, and rubric-based assessment.

Pilot testing: Conduct an initial pilot test across a representative sample of courses from diverse disciplines.

Pre-post students' self-perceived assessment: Apply the rubric at the beginning and end of the selected courses to identify changes across the KNOW, CARE, and DO dimensions.

Iterative refinement: Collectively analyse assessment data to refine teaching strategies, assessment criteria, and programme learning outcomes.

Institutional scaling: Progressively scale the model to other courses and programmes through existing quality assurance and curriculum review processes.

This process can be coordinated by existing university structures, such as academic quality offices, curriculum development centres, or sustainability committees. A designated coordinator and a small interdisciplinary group of teachers can adapt the descriptors to the institutional context, oversee data collection, and evaluate outcomes. The matrix should serve as a flexible framework: universities are encouraged to contextualise specific descriptors while retaining the core three-dimensional structure to maintain comparative validity.

7.4. Implications for Youth Empowerment and Mobilisation

By linking knowledge with ethical values and practical action, the proposed approach can provide opportunities for students to develop and exercise agency in sustainability initiatives and to engage with socio-environmental challenges. Integrating eco-social learning into core curricula is particularly important because it democratises ESD, moving beyond voluntary or extracurricular activities and reaching a broader, more diverse student population.

Ultimately, this model is adaptable across varied higher education contexts when supported by curricular alignment, staff training, institutional coordination, and systematic assessment. As such, the matrix offers universities a scalable, evidence-grounded framework for translating general commitments to the SDGs into systematic assessment and support of students' self-perceived eco-social competences.

Overall, the study underscores that transformative sustainability education requires an integrated approach that addresses what students know, what they care about, and what they do. The findings contribute to the growing body of evidence indicating that higher education has the potential to play a crucial role in enabling students to understand the complexity of contemporary eco-social challenges and to respond to them through ethical commitment and transformative action. Future research should explore the long-term retention of these competencies and the institutional conditions required to scale active learning methodologies across diverse academic disciplines.

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Abbreviations

The following abbreviations are used in this manuscript:

ANVUR	Italian National Agency for the Evaluation of Universities and Research Institutes
BOE	Boletín Oficial del Estado (Official State Gazette, in English)
CRUE	Conferencia de Rectores de las Universidades Españolas (Conference of Rectors of Spanish Universities, in English)
CRUI	Conference of Italian University Rectors
DORC	Diario Oficial de la República de Colombia (Official Gazette of the Republic of Colombia, in English)
ESD	Education for Sustainable Development
EU	European Union
HRs	Human Rights
LOMLOE	Organic Law Amending the Organic Law of Education
LUMSA	Libera Università Maria Santissima Assunta
N	Sample size
O1, O2, O3	Objective 1, Objective 2, and Objective 3 of the study
OECD	Organisation for Economic Co-operation and Development
PISA	Programme for International Student Assessment
SDGs	Sustainable Development Goals
SDSN	Sustainable Development Solutions Network
PBL	Project-Based Learning
RUS	Rete delle Università per lo Sviluppo Sostenibile
SL	Service-Learning
UIC	Universitat Internacional de Catalunya
USABANA	Universidad de la Sabana
UNESCO	United Nations Educational, Scientific and Cultural Organisation

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