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# Development of competencies for participatory evaluation of sustainability and climate emergencies through the design of educational pathways

## *Desarrollar competencias para la evaluación participativa de la sostenibilidad y la emergencia climática mediante el diseño de itinerarios educativos*

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**Abstract:**

In the context of the international climate emergency, it is essential to develop and research active and participatory learning initiatives in the university context that provide solutions based on environmental education for sustainability. This can be achieved through pedagogical approaches that integrate sustainability into the educational curriculum, with the aim of promoting the development of active, committed citizens. The main objective of this research is to promote the design of socio-educational pathways by groups of university students to help them learn to evaluate sustainability and climate emergencies in diverse contexts. The design of these paths should lead to active, participatory learning and the acquisition of competencies by the students. A mixed QUAL(quan) design was applied through a qualitative research workshop and a content analysis of the student-designed paths. The descriptive results show the profile and main characteristics of the paths designed. The qualitative analyses enabled the construction of comprehensive category systems and diagrams capable of explaining the relationships between the competencies developed and the proposals for improving sustainability on the university campus. The main conclusion is that designing environmental education paths plays a key role in helping groups of university students to learn about sustainability, to evaluate it and to come up with proposals for tackling the climate emergency on university campuses.

**Keywords:** environmental education, transversal competencies, educational paths, active learning, urban sustainability, climate emergency, competency assessment, higher education.

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**Resumen:**

En un contexto de emergencia climática internacional, se hace imprescindible desarrollar e investigar sobre iniciativas de aprendizaje activo y participativo en el contexto universitario que aporten soluciones a partir de una educación ambiental para la sostenibilidad. Esto puede realizarse a través de enfoques pedagógicos que integren la sostenibilidad en el currículo educativo con la finalidad de promover la formación de una ciudadanía activa y comprometida. Esta investigación tiene como objetivo principal promover en grupos de estudiantes universitarios el diseño de itinerarios socioeducativos, para que aprendan a evaluar la sostenibilidad y la emergencia climática en diferentes contextos. El diseño de estos itinerarios debe producir aprendizajes activos y participativos y permitir a los estudiantes adquirir competencias. Se empleó un diseño mixto CUAL(cuan) mediante un taller de investigación cualitativo y un análisis de contenido de los itinerarios diseñados por estudiantes. Los resultados descriptivos muestran el perfil y las características principales de los itinerarios diseñados. Los análisis cualitativos han conseguido construir sistemas de categorías y diagramas comprensivos capaces de explicar las relaciones entre las competencias desarrolladas y las propuestas de mejora de sostenibilidad en el campus universitario. Como principal conclusión, se pone en evidencia el papel clave del diseño de los itinerarios de educación ambiental para que los grupos de estudiantes universitarios aprendan sobre sostenibilidad, la evalúen y aporten propuestas para afrontar los desafíos de la emergencia climática en el campus universitario.

**Palabras clave:** educación ambiental, competencias transversales, itinerarios educativos, aprendizaje activo, sostenibilidad urbana, emergencia climática, evaluación de competencias, educación superior.

## 1. Introduction

In light of the urgent need to respond to the real climate emergency and to promote sustainability in urban areas, especially among university students, it is crucial to integrate environmental education and critical thinking in their learning experiences (Howlett et al., 2016; Reimers, 2024). This integration not only encourages a greater awareness of environmental challenges. It also fosters the development of a *sustainability culture* in cities and contributes to the achievement of the sustainable development goals (SDGs), especially SDG 11, "Sustainable cities and communities", and SDG 13, "Climate action" (UNESCO, 2017). Within this context, universities play a key role by promoting this sustainability culture among students and helping them develop a critical vision of their urban habitat, particularly in neighbourhoods and on university campuses.

If future generations are to build truly sustainable cities, both students and society in general must be aware of their socio-environmental impact (Díez-Gutiérrez & Palomo-Cermeño, 2022). This awareness must take the shape of specific actions that promote a more responsible and environmentally friendly lifestyle. This entails consciously reducing the consumption of natural resources, especially water and energy, and adopting practices that minimise the generation of waste and pollution.

Thus, urban sustainability becomes a primary goal. Evaluating how our daily actions affect our urban surroundings is essential in guaranteeing that our cities evolve sustainably and in harmony with the environment. In this regard, it is essential to have educational resources and strategies that facilitate a detailed evaluation. From this perspective, environmental education paths become especially relevant, as they provide a practical methodology for understanding and assessing the sustainability of urban spaces (Velasco-Martínez & Tójar-Hurtado, 2022).

### 1.1. Socio-educational pathways as a resource for evaluating urban sustainability

An urban socio-educational path is an educational tool that combines direct exploration and investigation of the urban setting with clear educational objectives. Medina et al. (2016) note that a path is a pre-set route with different stops along the way, which can take place in a natural and/or urban setting. According to Gallastegui and Rojas (2015), unlike city walks, which are primarily for leisure and tourism, socio-educational pathways are designed to promote an in-depth understanding of socio-environmental issues and urban dynamics. These authors point out that such paths are followed as a group, with a systematic, analytical approach and using observation guides and orientation by specialists in the subject matter (interpreters, instructors, etc.). They are created in a structured manner and usually include specific stops where awareness-raising activities take place, thus promoting critical reflection, environmental awareness and a commitment to sustainable urban practices (Fernández-Portela, 2017; Griffin et al., 2022). These activities are designed to actively engage the participants, promoting experiential learning that goes beyond mere observation, thus helping the students to learn behaviour that benefits the environment.

In addition, the students can actively participate in designing these socio-educational pathways, which not only boosts their relevance and effectiveness but also promotes more meaningful and committed learning (Martín-Jaime et al., 2022). By allowing the students themselves to design the paths, their educational value is enhanced, bolstering their ability to identify and address socio-environmental challenges more effectively.

In this regard, the design of socio-educational pathways plays a key role. Beyond engaging communities in the promotion of sustainable practices, they facilitate a deeper understanding of the environmental impact and the development of proactive behaviour in response to eco-social problems (Iglesias et al., 2020).

Designing socio-educational pathways is not only essential for promoting active, experiential learning but also reflects a significant step forward in the pedagogical approach (Ortega-Chinchilla et al., 2023). Originally focusing mainly on natural science, these paths now include social science, with a growing emphasis on heritage education. Furthermore, this approach now encompasses important new topics such as environmental concerns and the gender perspective. At the same time, the teaching resources used have also become more diverse, progressing from traditional tools like field notebooks and photographs to the integration of advanced digital technologies like Geographic Information Systems (GIS), augmented reality and social media, adapting to today's social and educational demands (Alcántara & Medina, 2019; Ortega-Chinchilla et al., 2023).

To design effective socio-educational pathways, it is essential to use active methodologies such as the participatory environmental diagnosis (Basulto et al., 2017). Methods like this not only enable participants to identify and manage the socio-environmental risks linked to climate change. They also encourage collaborative learning, active participation and comprehension of the socio-environmental impacts of decision-making that affects the quality of human life and the conservation of biodiversity (Basulto et al., 2017; Iglesias et al., 2020; Moncayo et al., 2023).

From this perspective, participatory environmental diagnosis fosters an understanding of the complexity and interconnection with nature through an eco-social teaching-learning process (Friend et al., 2023). It also promotes active participation in the research and decision-making processes (Bywater, 2014). Campos et al. (2020) also point out that participatory environmental diagnosis fosters the active participation of youths in identifying problems and coming up with proposals through collaborative, intercultural processes. Thus, youth engagement generates commitment and enthusiasm and ensures that the proposals respond to communities' actual needs. Moreover, efforts can be guided more effectively, harnessing the synergies among the diverse stakeholders and facilitating the participants' appropriation of the projects (Campos et al., 2020).

Another positive aspect of participatory environmental diagnosis is that it involves teamwork, autonomous learning and observation of sustainability supported by ICTs as tools for searching for information and recording quantitative and qualitative data and real images (Pedrosa et al., 2020). For example, urban paths for which mobile devices have been used as a teaching resource have shown to improve sensitivity and a pro-environmental attitude among secondary school students (Álvarez-Herrero, 2023). By participating in the design of the educational pathways, they can also learn the value of the cultural and natural heritage found in cities (Fernández & Ramos, 2015).

By combining participatory and transdisciplinary methodologies, educational pathways not only raise awareness about climate change and its impacts, but also guide communities toward more sustainable conduct (Tójar-Hurtado et al., 2022). For example, initiatives such as "Descarboniza! Que non é pouco" have shown that addressing specific audiences like older adults or rural women can strengthen the commitment to the eco-social transition and increase resilience in relation to the climate crisis (Iglesias et al., 2020). These focused approaches enable the participants to apply knowledge about their environmental impact and to act accordingly. In this regard, the inclusion of transdisciplinary approaches in the curriculum design improves the quality of environmental education by addressing real life scenarios and promoting integrated research (Yu & Chiang, 2017). Educational paths designed in a participatory way can foster citizen engagement leading to sustainability and a decrease in the effects of climate change because they rely on cooperative work and an analysis of reality observed and experienced through the senses (Dutta, 2022). Thus, these paths facilitate critical observation of sustainability in the immediate surroundings and promote a gratifying experience of participatory discovery, which enables students and the community to adopt sustainable daily habits and to advocate for pro-environmental governmental measures (Alcántara & Medina, 2019). In addition, educational pathways lead to life experiences that can influence the attitudes of future educational professionals when it comes to discussing the climate crisis and its effects. This idea is reinforced when the paths are designed in a collaborative way, as this promotes social interaction and joint learning about the prevention of and response to socio-environmental issues, as well as sparking an individual and collective commitment (Campos et al., 2020; Guimarães & Meira, 2020). It is also necessary for the path design to include environmental citizen fact sheets, which provide information and practical activities to raise awareness in young people about the importance of sustainability and the climate emergency (Thor & Karlsudd, 2020).

In this way, designing educational pathways is deemed to be an effective tool for developing socio-environmental competencies in university programmes, given their fundamental role in conveying skills, attitudes and values within the educational sphere (Velasco-Martínez & Tójar-Hurtado, 2022).

Therefore, implementing educational pathways as a pedagogical tool in combination with active, participatory and transdisciplinary methodologies is essential when addressing the climate crisis and bolstering university students' commitment to sustainability in urban communities.

In light of this framework of reference, this research aims to assess the effectiveness of collaborative socio-environmental path design as an educational tool to help students learn to evaluate urban sustainability. To achieve the overall goal, the following specific aims are proposed:

- To analyse the sub-themes of the paths designed for the purpose of assessing whether they properly reflect the fundamental principles and values of urban sustainability, so as to determine the students' understanding and application of these concepts.
- To evaluate the diversity and relevance of the activities proposed along the paths, seeking to understand how these activities facilitate practical learning and promote critical reflection by the students, which is essential in developing sustainability competencies.

- To identify the competencies acquired by the students in the course of the design process, in order to comprehend how this educational resource aids in the development of key skills like environmental awareness and active participation in sustainable initiatives.
- To assess proposals generated by students for improving university campus sustainability, with a view to evaluating their feasibility and potential impact, thus making it possible to analyse the students' capacity to apply their knowledge to real situations.

Accomplishing these aims will help determine how collaborative design of socio-environmental paths can serve as an effective educational tool, promoting not only the acquisition of key competencies to cope with the climate emergency but also fostering active citizenship committed to sustainability. This pedagogical approach is supported by previous research (Martín-Jaime et al., 2022; Thor & Karlsudd, 2020; Torres-Porras & Arrebola, 2018), which has highlighted the need to integrate sustainability into the educational curriculum, in order to educate students that are capable of confronting today's eco-social challenges. Thus, this study aims to contribute to the academic discussion about the effectiveness of these approaches in higher education, underscoring the importance of both meaningful and collaborative learnings as a means of empowering students and making them agents of change within their communities.

## 2. Methodology

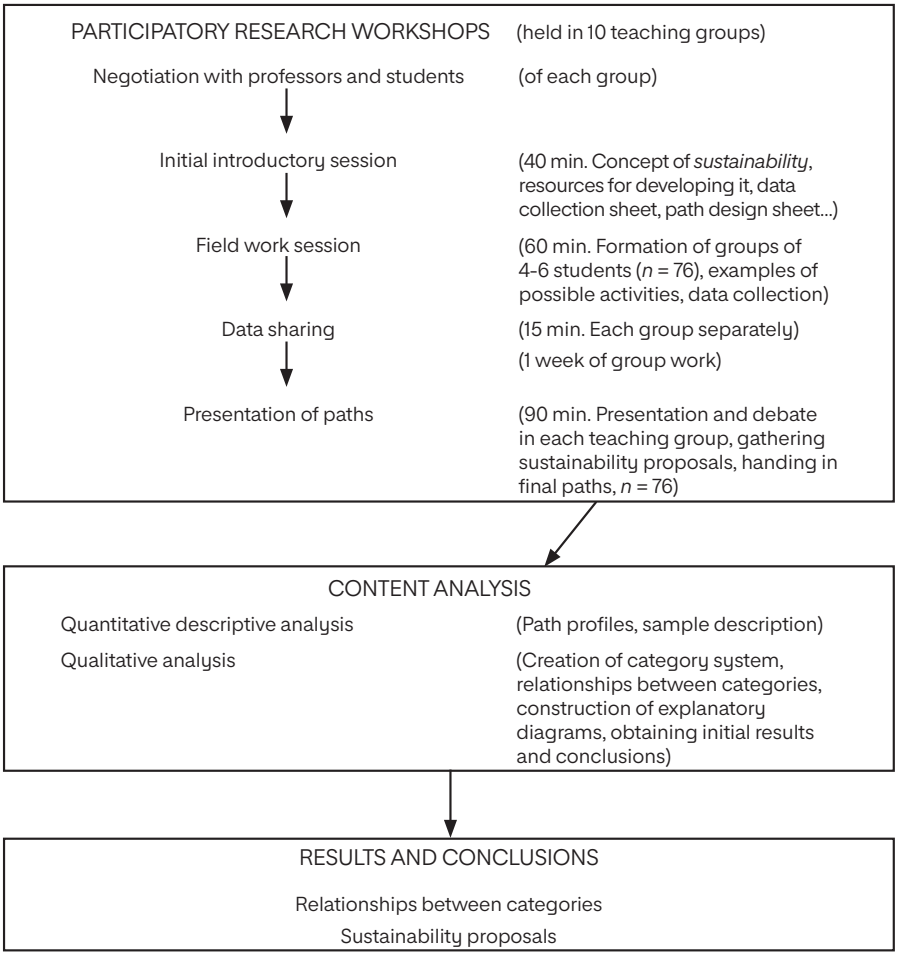
This study can be classified as a participatory action research approach (Cornish et al., 2023) in which the main methods used are the participatory research workshop (Huttunen et al., 2022) and qualitative content analysis (Mayring, 2021). Participatory research workshops are collaborative sessions that engage members of the community (in this case the educational community), researchers and other stakeholders in the research process for the purpose of tackling socio-educational problems by creating collective knowledge (Cornish et al., 2023). Qualitative content analysis is a systematic method for interpreting qualitative data, which focuses on identifying and describing the underlying meanings in texts and entails an inductive analysis of textual data to form typologies and to categorise themes (Tunison, 2023).

The research design can be classified as a mixed QUAL(quan) approach according to the classification by Creswell and Plano-Clark (2018). The quantitative part used a descriptive design that made it possible to describe the main characteristics and average profile of the paths designed. The qualitative part was present from the initial negotiation with students and professors regarding the organisation of the research workshops through to the content analysis of the paths designed by the groups of students and the public presentation thereof.

As part of several subjects in the pedagogy, early childhood education, primary education and social education degree programmes at the University of Malaga, the instructors of these programmes led participatory research workshops to equip the groups of students with resources so that the latter could design paths to evaluate the sustainability of the university campus in Malaga, bearing in mind the current climate emergency situation. Each participatory research workshop held in each subject included one initial session in the classroom (40 minutes), where diverse contextualised resources were shared for the path design and data collection. One session conducted outside the classroom (60 minutes) showed an example path for the class group (divided into teams of approximately 5 members) with materials for gathering data, such as log sheets, mobile phones, etc. At this session, they were shown options in the field for developing diverse sub-themes related to sustainability (waste, energy, adapting to climate change, mobility, connection to nature, etc.), as well as certain dynamic activities for working on and evaluating a number of aspects related to sustainability. After the session outside the classroom was finished, the students were given extra time (15 minutes) to finish gathering and coordinating the data collection, in addition to one week outside of class to prepare a complete version of their own path for evaluating sustainability in one or more specific sub-themes. The

following week, in the classroom, the student groups gave participatory presentations of the paths they had designed, opening up a debate about the competencies acquired during the course of the sessions and the proposals they made for improving the university campus. A more comprehensive description of the didactic methodology used in each participatory research workshop can be found in Martín-Jaime et al. (2022). Figure 1 shows a methodological flow chart with the different phases involved in the research.

FIGURE 1. Methodological flow chart.




In the research, 405 students and 5 instructors took part, divided into 10 teaching groups of subjects included in the pedagogy, early childhood education, primary education and social education degree programmes of the Faculty of Educational Science of the University of Malaga in the 2022/23 and 2023/24 academic years. The student groups designed a total of 76 different paths, which represented the main documentary material for the development of the content analysis (*n* = 76).

Therefore, the sample considered comprises the paths designed by the student groups in the participatory research workshops (*n* = 76). These paths, and the sustainability proposals they contain, were prepared by 76 working groups (of 4 to 6 students) in 10 groups/subjects in the pedagogy, early childhood education, primary education and social education degree programmes at the University

of Malaga. The usual sampling in the participatory research workshops and in the participatory action research fits with the collaborative and community characteristics of this approach. Unlike more traditional approaches, where statistical representativeness is crucial, in participatory research the aim is to engage the people and the community in the process. In this case, it can be said that a sampling method similar to that used by Erro-Garcés and Alfaro-Tanco (2020) was applied, based on production (paths) and the sustainability improvement proposals made by the student groups.

Table 1. Main features of the sample used.

| Feature | Detail |
|---|---|
| Sectors involved (number of members) | Researchers (3), instructors (5), students (405) |
| Degrees considered (Faculty of Educational Science of the University of Malaga) | Pedagogy, early childhood education, primary education and social education degree programmes |
| Groups/subjects | 10 |
| Number of working groups (4-6 members) | 76 |
| Number of paths designed/sample size | 76 |

The SPSS statistics package v. 29 (2022) was used for the quantitative descriptive analysis. The content analysis, reduction, categorisation, study of relationships and graphing was done with Atlas.ti 23 (2023). The graphics/descriptive and comprehensive frameworks (Miles et al. 2019) were published and enhanced in Microsoft Office Professional (2021). For the purposes of transparency, and to make it possible to replicate it, all the raw data from the research was published in the RIUMA institutional repository. The file can be found under the following link: https://hdl.handle.net/10630/32551

In conducting the research and writing the manuscript, the principles of academic integrity have been observed, such as prevention of plagiarism, falsification and fabrication of data, false co-authoring and attribution of results. The research project was also given a positive assessment by the Ethics Committee of the University of Malaga for studies involving humans (CEUMA Record No. 34. Code 47-2023-H).

## 3. Results

The results are presented in two separate parts. The first contains the quantitative descriptive analyses. These analyses were conducted with direct data (number of paths, path type, etc.) and with processed data (categories constructed on the basis of qualitative inductive analysis, based on the data, for the sub-themes used, the activity typologies and the learning methodologies), which were subsequently quantified. The second part contains the qualitative analyses conducted about the students' perception of the competencies acquired and the proposals for improving the sustainability of the university campus.

### 3.1. Quantitative descriptive analysis

A total of 76 paths designed by different small student groups were considered. Of these, 64.9% were linear paths, while the remaining 35.1% were circular. Circular paths are routes that begin and end at the same point, which facilitates integration of different stages of the journey into a single trail. Linear paths, on the other hand, have a starting point that differs from the final destination, which makes it possible to explore larger areas without having to return to the point of origin. Both path options were proposed to provide a variety of spatial and didactic experiences for the students. The groups were composed of 4 to 6 members in most cases

(mean = 5.3). The creation of groups of 4 to 6 students responds to the need for teams that were small enough to foster active participation by all the members but at the same time large enough to generate enriching discussions. Furthermore, the group size was designed to ensure fluid dynamics in the field work, enabling each student to play different roles within the team. The sub-themes addressed most often are shown in Table 2. As illustrated, the most commonly addressed themes are the connection to nature and sorting waste (72.6%). The activities in 41.1% of the paths touched on themes related to healthy spaces and low levels of pollution (air, noise, light, etc.). Recreation and community well-being (improved co-existence) figure prominently, being mentioned in 34.2% of the paths designed. Other relevant issues are mobility (31.5%), inclusiveness (27.4%) and responsible consumption (27.4%). This latter theme would become more relevant if linked to other paths dealing with the local economy and responsible trade (4.1% more). Other sub-themes represented in more than 10% of the paths (specifically 12.3%) are renewable resources and energy, urban planning and sustainable architecture.

Table 2. Sub-themes most commonly addressed by the student groups in the paths designed.

| Sub-theme | Frequency | Percentage |
|---|---|---|
| Connection to nature | 53 | 72.6 |
| Sorting waste | 53 | 72.6 |
| Healthy spaces: low levels of environmental pollution (air, noise, light, etc.) | 30 | 41.1 |
| Recreation and community well-being (improved co-existence, health, etc.) | 25 | 34.2 |
| Mobility | 23 | 31.5 |
| Responsible consumption | 20 | 27.4 |
| Inclusiveness (disabilities, accessibility: urban barriers, adaptation of public infrastructure, etc.) | 20 | 27.4 |
| Adapting to climate change (climate shelters, shaded areas, green spaces and corridors, etc.) | 14 | 19.2 |
| Renewable resources and energy (solar panels, battery charging, etc.) | 9 | 12.3 |
| Urban planning and sustainable architecture | 9 | 12.3 |
| Recreation and community well-being (improved co-existence, health, etc.) | 9 | 12.3 |
| Citizen engagement and local governance | 4 | 5.5 |
| Art and preservation of historical and architectural heritage | 4 | 5.5 |
| Resilience and urban recovery capabilities | 4 | 5.5 |
| Local economy and responsible trade | 3 | 4.1 |
| Others (leisure, complexity, isolation) | 3 | 4.1 |

Note: the percentages do not come to a total of 100, and the frequencies are not equal to the total number of paths ($n$ = 76) because several sub-themes may be addressed in a single path.

The paths designed by the student groups in a participatory manner had an average duration of 169 minutes (approximately 2 hours and 49 minutes). Sketches of the route and scheduled stops were often presented (63.9%), detailed information of interest was furnished along with key concepts to be developed at each milestone (81.4%), in addition to topics for reflecting on sustainability and encouraging participation (85.9%). For the most part, the paths consisted of 4 to 5 stops or milestones where a wide range of activities was proposed, taking advantage of the resources offered in each location. The most frequent activity typologies are shown in Table 3. Cooperative or group dynamic games ranked above all other types of activities (73.7%). Activities involving the identification of flora or fauna species are also predominant (43.4%). Other types of activities commonly used in the paths designed by the students were games that trigger the senses and evaluation and closure activities (30.35% each).

Table 3. Activity typologies included in the paths designed by the students.

| **Activity typology** | **Frequency** | **Percentage** |
|---|---|---|
| Cooperative or group dynamic games | 56 | 73.7 |
| Species identification (flora and fauna) | 33 | 43.4 |
| Game to trigger the senses (observing, listening, smelling, touching, etc.) | 23 | 30.3 |
| Evaluation or closure activities | 23 | 30.3 |
| Creative activities (decorating, painting, designs like bracelets, flowerpots, toys, etc. using recyclable materials) | 22 | 28.9 |
| Workshops (soap, composting, food, responsible consumption, road safety, etc.) | 20 | 26.3 |
| Urban recovery, repair or redesign (drawing the bike lane lines, planting, etc.) | 17 | 27.4 |
| Guided exploration activities (orientation games, obstacle courses, escape room, etc.) | 16 | 21.1 |
| Collaborative cleaning and waste identification/collection | 14 | 18.4 |
| Introduction dynamics | 11 | 14.5 |
| Use of mobile applications | 10 | 13.2 |
| Demonstrations and experiments (e.g., footprint measurement, compost testing, building small habitats for wildlife such as insects or birds, water filtering, making recycled paper, etc.) | 9 | 11.8 |
| Creating informative materials and channels (posters, networks, etc.) | 7 | 9.2 |
| Debates or round tables | 6 | 7.9 |
| Bicycle/scooter tours | 6 | 7.9 |
| Others | < 6 | < 7 |

Note: the percentages do not come to a total of 100, and the activity frequencies are not equal to the total number of paths ($n$ =76) because several types of activities may take place in a single path.

The most common didactic methodology is cooperative and collaborative learning (90.9%). In second place, game-based learning/gamification was used (58.45%), followed by learning based on workshops (49.4%). Ranked from highest to lowest, the master class/lecture comes in fourth place (20%), with other, more innovative, methodologies reaching percentages of less than 20%: discovery learning (14.3%), problem-based learning (e.g., researching and proposing solutions for reducing noise pollution at key points on campus) (13%), dialogic learning (e.g., discussing different approaches for dealing with environmental problems) (10.4%), movement-based learning (e.g., jumping games, running, bike races) (10.4%) and transformative learning (9.1%). The other methodologies did not reach 8% (fewer than 7 paths included them).

## 3.2. Qualitative content analysis

After designing the paths, the student groups reflected on what they had learnt and the competencies acquired. They also drew up proposals for improving campus sustainability based on the learning activity they had done. A qualitative content analysis was conducted of these contributions, in addition to the design of a path to evaluate the sustainability and climate emergency on the university campus. This process involved establishing preliminary categories based on the texts prepared (paths) by the student groups. These initial categories were then refined and redefined in recurring verification processes and, at the same time, relationships between them were established without losing sight of the students' literal expressions.

The process and results obtained in relation to the competencies acquired are summarised below, in addition to the proposals for improving campus sustainability.

### 3.2.1. Competencies acquired and learning

The process of categorising the competencies acquired led to 5 main categories:

- Environmental awareness and education (EAE): awareness about environmental damage and the interconnectedness of all life forms, recognising natural resources and the impact on the city centre, importance of social and environmental education, spotlighting biodiversity in urban settings, and awareness about the energy crisis and climate emergency.
- Personal and collective engagement (PCE): participation and importance of awareness and shared responsibility, citizen collaboration and smart urban planning, environmental impact of industry and multinationals, and assessment of individual actions for improving the planet.
- Sustainable practices and life habits (SPLH): activities such as reducing, reusing and recycling waste; water and energy savings; use of public transport and sustainable mobility; responsible and local consumption (km 0), and the importance of teamwork and cooperation.
- Urban environmental care and management (UECM): care for and maintenance of public spaces, importance of green areas and natural spaces in the city, urban renaturing and creation of urban gardens, proper waste management and use of organic fertilisers, and encouraging accessibility and healthy spaces.
- Sustainable development goals (SDGs): SDGs and protecting the planet; ending poverty and developing inclusive, safe, resilient and sustainable cities; and lifelong education and the achievement of a just society for present and future generations.

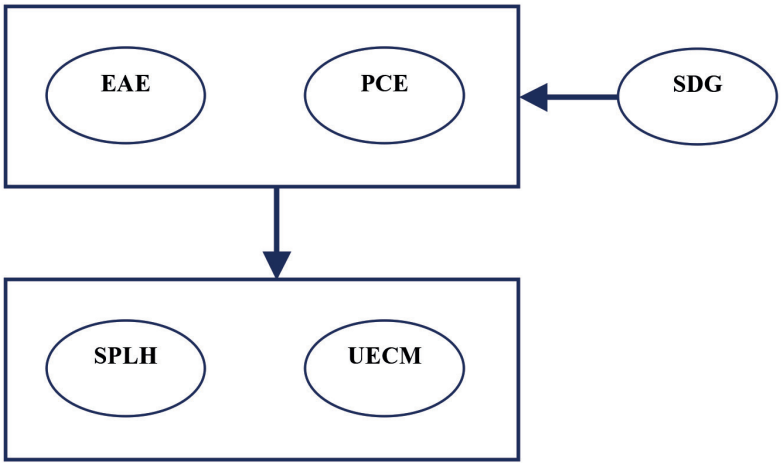
Table 4 shows these 5 categories related to learning outcomes and the competencies developed (each with the corresponding code), their definitions (in the second column) and some examples of literal statements made by the groups, based on which they were constructed.

TABLE 4. Categories constructed on the basis of the competencies acquired and learning outcomes after designing the paths for evaluating sustainability.

| Category (code) | Definition | Literal statements [coding] |
|---|---|---|
| Environmental awareness and education (EAE) | Understanding the negative impact of our actions, recognising natural resources required for urban life, and environmental education as a key tool for change. | "Human beings are capable of transforming the environment; in this process, we often harm nature and overuse its resources." [IJC19:01]; "Thanks to what we have learnt, we can become more aware of the need to help care for the environment and to change certain structures." [IJJ00:02] |
| Personal and collective engagement (PCE) | Taking on shared responsibility and citizen collaboration to achieve sustainability. | "We believe the public [students, in this case] should be educated in this area because this is a collective commitment." [IJC18:02]; "Importance of personal engagement in solving problems." [IJJ14:01] |
| Sustainable practices and life habits (SPLH) | Performing actions like recycling, reuse, sustainable mobility and responsible consumption. | "Reusing vs recycling." [ILV00:01]; "Importance of sustainable mobility." [IJJ29:01] |
| Urban environmental care and management (UECM) | Maintaining and enhancing green spaces, properly managing waste and ensuring accessibility and health in urban spaces. | "Importance of trees in the city, accessibility, urban infrastructure." [IJJ04:01]; "Care for public spaces, reducing and sorting waste, urban renaturing and accessibility." [IJC00:01] |
| Sustainable development goals (SDG) | Relating urban sustainability to the SDGs, focusing on protecting the planet, creating resilient, inclusive cities and lifelong education for a just society. | "It should be noted that this is related to the SDGs [sustainable development goals], given that these goals help protect the planet and ensure that it prospers, as well as ending poverty." [ILV11:03]; "Going through these dynamics, we have learnt in a highly visual and entertaining way how to put many of the sustainable development goals [SDGs] into practice at our own university." [IJC14:01] |

The competencies developed throughout the course of the research workshop process (including the path design by student groups aimed at evaluating university campus sustainability), which are represented by the 5 categories above, were arranged into an explanatory diagram that helped to understand the relationships between categories and macro-categories. Thus (see Figure 2), educational and environmental values (categories EAE and PCE), awareness and engagement, along with knowledge (in this case, conceptualised as SDGs), are what spark certain individual and collective activities (categories SPLH and UECM), sustainable practices, life habits, urban environmental care and management.

FIGURE 2. Relationships between categories: competencies acquired.




### 3.2.2. Proposals for university campus sustainability

The process of categorising the proposals for university campus sustainability within a climate emergency setting provided 8 main categories:

- Sustainable mobility (SM): increasing bicycle and scooter parking spaces, improving and maintaining bike lanes and promoting the use of public transport and vehicle sharing.
- Waste management (WM): increasing the number of recycling bins on campus and in the classrooms; including accessible bins with information in Braille; creating a specific bin in the cafeteria for composting and promoting the use of products with less packaging and greater proximity and more organic products.
- Renewable energy (RE): increase in solar panels, lighting powered by solar energy and USB charging stations with solar panels.
- Green spaces and biodiversity (GSB): this includes ideas related to planting more native and fruit trees, improving and promoting the university's vegetable gardens and encouraging use thereof, creating and maintaining gardens and green areas with local biodiversity, integrating fauna and flora in specific areas of the campus, and carrying out educational practices and activities in green spaces.
- Responsible use of resources (RUR): increasing air and water quality through regulating water use with push-button taps and toilets, improving irrigation systems, creating exclusive spaces for smokers...
- Sustainable diet (SD): eating local foods and reducing waste, donating leftover food to charity canteens, offering local and sustainable food options in cafeterias or implementing a system for selling leftover food at a discount.

- Accessibility and inclusion (AI): adapting the campus for people with reduced mobility through placing ramps and improving the paving, creating accessible bins, etc.
- Environmental awareness and education (EAE): raising awareness and participation in sustainability through workshops, seminars and educational activities; advertising and raising awareness about the importance of recycling and sustainable practices; encouraging the use of reusable utensils in the cafeteria through discounts and vouchers; promoting active participation in sustainability projects; and conducting awareness-raising campaigns about waste and energy conservation.

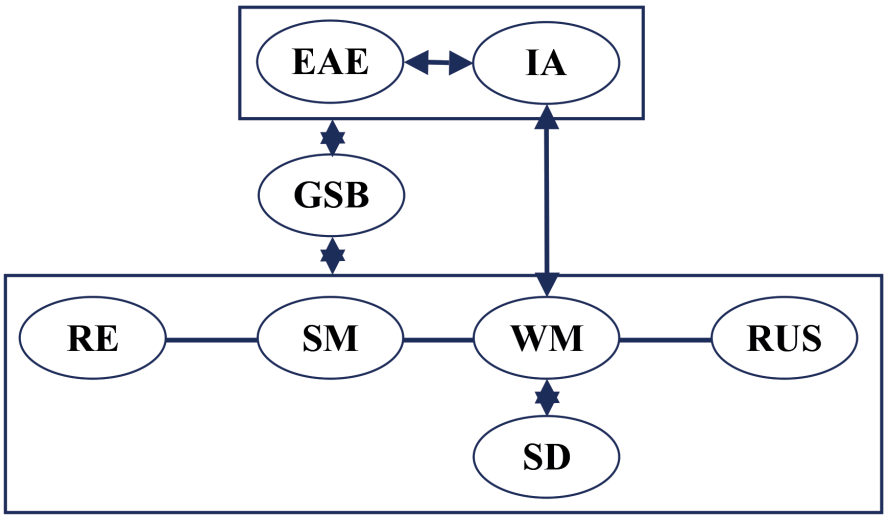
The arrangement of the groups' proposals into 8 categories shows the concerns of the students who took part in the participatory learning experience. Notably, this arrangement into 8 categories includes one category that is similar to the previous classification of the competencies developed and learning acquired, but from a different perspective. Table 5 outlines the categories and includes examples of literal statements that support their establishment.

TABLE 5. Categories constructed on the basis of the competencies acquired and learning outcomes after designing the paths for evaluating sustainability.

| Category (code) | Literal statements [coding] |
|---|---|
| Sustainable mobility (SM) | "Designing safe and attractive pedestrian and cycling spaces." [IJJ25:01]; "It would be very helpful to the environment if we used individual vehicles less and took advantage of public transport." [IJJ17:03] |
| Waste management (WM) | "Creating a compost bin for the cafeteria." [IJC03:04]; "Placing recycling bins in many areas of the campus to avoid mixing different types of waste." [IJC09:01] |
| Renewable energy (RE) | "Providing more solar panels for devices." [ILV10:02]; "Regulating water: taps and toilets should run for five seconds." [IJJ22:01] |
| Green spaces and biodiversity (GSB) | "Caring for 'green' spaces where there are vegetable gardens and fruit trees." [IJJ04:01]; "Establishing a flora and fauna environment in specific areas of the campus." [IJC14:03] |
| Responsible use of resources (RUR) | "Promoting responsible use of natural resources." [IJJ38:10]; "Controls should be operated by push buttons rather than turning. This will help us properly control water and water resources." [IJJ22:02] |
| Sustainable diet (SD) | "Offering local and sustainable food options in the university cafeterias and encouraging a reduction of food waste." [IJJ31:01]; "Donating leftover cafeteria food to charity canteens." [IJC02:02] |
| Accessibility and inclusion (AI) | "Accessibility to spaces and infrastructure." [IJJ06:01]; "Adapting bins to make them accessible." [IJJ20:01] |
| Environmental awareness and education (EAE) | "Increasing the use of open, natural spaces and teaching classes and/or activities near nature. The aim is to encourage a connection to and awareness of nature." [ILV00:01]; "Awareness-raising programmes about recycling and climate change." [ICL01:01] |

The 8 categories created from the student groups' sustainability proposals are arranged into an explanatory diagram that helps to understand the relationships between categories and possible macro-categories. Thus (see Figure 3), the categories of environmental awareness and education (EAE) and accessibility and inclusion (AI) were combined into a macro-category of *values*. The AI category is directly linked to waste management (WM), which is, in turn, related to sustainable diet (SD). These latter two categories (WM and SD), along with renewable energy (RE), sustainable mobility (SM) and responsible use of resources (RUR), form the other main macro-category: *proposals for efficient use of resources*. These two macro-categories are linked to a central category that provides the connection to green spaces and biodiversity (GSB). The category of environmental awareness and education (EAE), which is also present in the analysis of competencies developed and learning acquired, provides the link between these two explanatory diagrams (Figures 2 and 3), highlighting the relevance of this category in the development of environmental awareness and education for the promotion of sustainability on the university campus.

FIGURE 3. Relationships between categories: proposals for sustainability on the university campus.




## 4. Discussion and conclusions

This research analysed the paths designed by university students with the aim of evaluating university campus sustainability through a quantitative and qualitative approach.

In the first part, the quantitative results made it possible to define the profile and main characteristics of the paths designed by the student groups. As a result, the participating students proposed diverse types of dynamic, motivating activities at the different stops or milestones along the path.

Collaborative games, identifying species, themed workshops, creative activities, collaborative waste clean-up and planting for the renaturing of the campus, in particular, were proposed. The use of mobile applications for some of these activities is worth noting, especially for activities involving identification of plant species on the campus. This coincides with the study by Pedrosa et al. (2020) and highlight the educational benefits of using technology in the design and execution of educational pathways. Liceras (2013, 2018) also points out the advantages of creating paths in nearby, familiar places for the students, such as the university campus, because these familiar settings facilitate the use of prior knowledge, bolster a sense of identification with the surroundings and are easy to access.

Furthermore, the design of the paths provided some important key data that would be developed at each milestone and also an approach to thought-provoking topics for pedagogical reflection on the different sustainability sub-themes, which encourage active, shared learning. In this regard, Gallastegui and Rojas (2015) note that paths are effective in sparking curiosity and an interest in discovery. They also emphasise the importance of promoting exchanges of ideas and emotions, in addition to cooperation, because these are essential aspects in the process of constructing knowledge and solving problems. Boulahrouz (2021) also underscores that urban field outings can trigger new questions, which prompts critical thinking while at the same time applying the acquired knowledge and gaining experience in a familiar setting. The most common types of didactic methodologies were cooperative and collaborative learning, followed by gamification and workshop-based learning, which indicates a tendency toward dynamic, participatory methods (Baldwin, 2016; Martínez-Valdivia et al., 2023). It has been shown that integrating scientific knowledge, innovative pedagogical practices and community participation creates a democratic, participatory educational setting that strengthens values and competencies, thus achieving affective and emotional objectives that are aligned with the principles of environmental education (Andrade & Figueiredo, 2021).

In the second part of the study, the qualitative analysis provided crucial information about the competencies acquired by the students and their proposals for improving sustainability on the university campus (García-Hernández, 2020). In this regard, Gallastegui and Rojas (2015) emphasise that designing paths facilitates the development of competencies in ethical, socio-political and scientific areas and communication by providing a structured, contextualised setting in which students can apply and reinforce these skills through active practice and reflection. Specifically, authors like Martínez-Hernández et al. (2021), Medina et al. (2016) and Valverde-Fernández et al. (2018) agree that student-designed paths promote the development of key competencies such as linguistic communication, scientific and digital competencies and skills for learning to learn through experiential, collaborative activities. In addition, these authors found that this approach fosters social and civic competencies, as well as cultural awareness, by allowing students to explore and reflect on historical, environmental and social topics that are relevant within their urban environments.

The main conclusion is that designing environmental education paths has been found to play a key role in helping groups of university students to learn about sustainability, to evaluate it and to come up with proposals for tackling the climate emergency on university campuses. The analyses reveal that the participants developed a profound understanding of environmental education and awareness and of the importance of adopting sustainable practices and responsible life habits. The qualitative results suggest that the socio-educational path was an effective tool for achieving competencies and learning related to diverse key aspects of urban sustainability, such as saving water and energy, promoting the use of public transport for sustainable mobility, responsible and local (km 0) consumption and appreciation of green areas and natural spaces in the city, along with accessibility (Álvarez-Herrero, 2023; Fernández & Ramos, 2015). Furthermore, the students linked these actions to ending poverty and developing inclusive, safe cities that are resilient to the climate emergency, in line with previous studies by Alcántara and Medina (2019), which highlight the educational potential of paths to promote comprehensive environmental education and the acquisition of competencies for evaluating urban sustainability. These emerging categories show how the learning experiences contribute to the students' personal and professional development, highlighting their perception of the active role in sustainability and the integration of innovative methodologies in the educational process. The analysis reveals that the active approach and the participatory environmental diagnosis methodology used in the educational path not only fosters the acquisition of technical knowledge but also promotes a meaningful change in attitude toward sustainability and environmental management (Basulto et al., 2017).

Likewise, the proposals for improvement prepared by the students reflect a strong commitment to sustainability and suggest specific areas for implementation of more effective environmental practices on campus. The proposals for improving university campus sustainability focus on several key areas. When it comes to sustainable mobility,

the recommendations include fostering the use of bicycles and electric vehicles, promoting public transport and car-pooling and installing stationary bicycles to generate power for lighting. In waste management, they suggested increasing the number of recycling and composting bins, implementing accessible options with labels in Braille and adding waste bins with ashtrays for cigarette butts. Regarding renewable energy, they advocated increasing the use of solar panels and installing solar-powered lampposts and solar-powered USB charging stations. To improve green spaces and biodiversity, planting more native trees, improving the urban garden, maintaining gardens with local biodiversity and integrating flora and fauna on the campus was proposed. In terms of accessibility and inclusion, adapting ramps, placing bins at accessible heights and creating distinct paths in nature areas was recommended. To bolster environmental education and awareness, organising workshops and activities about sustainability, promoting the use of reusable utensils and carrying out awareness-raising campaigns was suggested. In terms of the responsible use of resources, improving water management by installing taps and toilets operated by push buttons, optimising irrigation systems and creating exclusive spaces for smokers was proposed. Finally, in relation to sustainable diet, the suggestions included donating leftover food, offering local, sustainable options and implementing a system for selling leftover food at a discount. Similar results were found in the study by Boulahrouz (2021), in which the students analysed the conditions of an urban area in Girona and came up with proposals for improving it in light of social and/or environmental sustainability criteria. Diverse aspects of sustainable development were addressed in the improvements, most notably, topics like urban planning, sustainable agriculture, biodiversity, energy and civic participation. Likewise, ties to a number of sustainable development topics were established, working around some of the SDGs. This author notes that, as the youths begin to identify the sustainable development problems that affect their communities, they can turn them into daily actions aimed at living sustainably.

Thus, the findings suggest that this kind of educational intervention can serve as a model for future initiatives in environmental education and urban sustainability. However, the study has also identified areas that require future research and enhancement. It is essential to more closely analyse the objectives and activity sequence, the resources used and the students' degree of engagement in implementing the proposals for improvement. In addition, through long-term monitoring it will be possible to evaluate the impact of these paths in terms of sustainable practices and university culture in general.

To conclude, the results highlight the value of active, participatory methodologies and designing educational pathways as effective tools for promoting sustainability and competency-based learning. Furthermore, these methodologies foster collaboration among students, the development of critical and analytical skills and social responsibility (Carbonell et al., 2023). The paths not only educate about environmental issues, but also inspire university students to become agents of change in their communities, promote civic commitment and bolster the ability to work as a team to resolve complex problems (López & Segura, 2013). This study offers an analysis of a promising, innovative resource for sustainability education in university settings, opening up new channels for enriching and expanding educational practice in this field.

## Authors' contributions

**Leticia-Concepción VELASCO-MARTÍNEZ:** Conceptualisation; Formal analysis; Methodology; Validation; Writing (original draft); Writing (review and editing).

**Juan-Jesús MARTÍN-JAIME:** Conceptualisation; Resources; Supervision; Visualisation; Writing (original draft); Writing (review and editing).

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## Artificial Intelligence (AI) Policy

The authors do not claim to have made use of Artificial Intelligence (AI) in the preparation of their articles.

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