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Changing Spanish preservice teachers' environmental attitudes with a citizen science program integrated in Environmental Education subject

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Abstract

This research analyzes the effect of the implementation of citizen science activities in the Environmental Education (EE) subject program of the Degree in Primary Education applying Experiential Learning Theory. Environmental Attitudes Inventory (EAI) was used to measure the change in environmental attitudes (EA) of 173 preservice teachers through a pre-test–post-test experimental design without a control group. Participation in the training program significantly improved EA in the 12 dimensions defined in the EAI. Of the dimensions included in the second order factor *Preservation*, *Enjoyment of nature* reached the largest effect size and *Environmental movement activism* is the one that obtains the smallest effect size. With regard to *Utilization*, all dimensions presented a large effect size. No significant differences were found in EA based on the gender variable. It can be concluded that the incorporation of citizen science activities in the EE program significantly improves EA.

KEYWORDS
citizen science, environmental education, Inventory of Environmental Attitudes, preservice teachers

1 | INTRODUCTION

Environmental education (EE) aims to provide the knowledge and skills necessary to protect and improve the environment for all living beings, provoking a cognitive, affective and behavioural change that allows human beings to maintain their lives and, at the same time, conserve nature (Hudson, 2001; Moseley et al., 2010). UNESCO, in the document *The Contribution of early childhood education to a sustainable society*, refers to the importance of starting this EE at an early age and continuing throughout life (Samuelsson & Kaga, 2008). In addition, starting EE at an early age allows children to develop fundamental knowledge about the environment at a scientific level (Moseley et al., 2010). To achieve this, it is necessary for preservice teachers to acquire this training so that they can transfer it to the classroom appropriately. Therefore, it is necessary for students to understand the environment as a whole made up of different systems and elements interconnected with each other (Liu & Lin, 2015). This can be achieved by working in educational contexts that allow improving environmental attitudes, since positive attitudes towards the environment play a key role that is linked to pro-environmental behaviour (Heimlich & Ardoin, 2008). It can also be argued that citizen science favours, on the one hand, the acquisition of environmental knowledge by promoting greater confidence in addressing environmental issues and, in addition, improves participants' environmental attitudes (Ahi et al., 2017; Liu & Lin, 2015; Merenlender et al., 2016).

In this research, an activity program was designed for the subject of EE following the Experiential Learning Theory (ELT; Kolb, 1984; Kolb et al., 2000) that involves the participation of preservice teachers in citizen science activities. Subsequently, the change in environmental attitudes of the participants is measured. That is, this study aims to answer the following research question:

Does the implementation of a training program in EE that incorporates citizen science activities produce a positive change in the environmental attitudes of preservice teachers?

2 | THEORETICAL FRAMEWORK

2.1 | Environmental education

During the *Intergovernmental Conference on Environmental Education*, held in Tbilisi in 1977, it was pointed out that “the ultimate aim of EE is to enable people to understand the complexities of the environment and the need for nations to adapt their activities and pursue their development in ways which are harmonious with the environment” (Hoffmann, 1978, p. 12), starting from an action- and problem-oriented approach, and adapting methodologies and materials to the needs of students. Thus, the objectives of EE were categorised into: awareness and sensitisation, knowledge, attitudes, skills to detect and solve problems, and citizen participation. A few years earlier, Stapp et al. (1969, p. 34), had already indicated as the objective of EE as “producing a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, aware of how to help solve these problems, and motivated to work toward their solution”. Thus, EE must help to understand that the human being is an inseparable part of a global system (human being, culture and biophysical environment) with the capacity to alter these relationships; and must provide an understanding of the biophysical environment, natural and artificial, as well as its role in today's society. EE also provides an understanding of existing problems and a motivation to solve the problems. From these first definitions, EE is not limited to the knowledge of the conceptualisation of the environment as the physical environment, but also includes the interactions between the different elements and existing systems. This orientation of the conceptualisation of the environment, as a set of systems and interactions that make life possible, is later reflected by UNESCO (Steele, 2010, p. 2) referring to the environment as “the product of both biophysical and social structures and processes, which we are a part of”. Thus, this EE must incorporate three dimensions (Türkoğlu, 2019): (1) EE as *about* environment; (2) EE as education *in* or *through* the environment; and (3) EE as education *for* the environment (Figure 1).

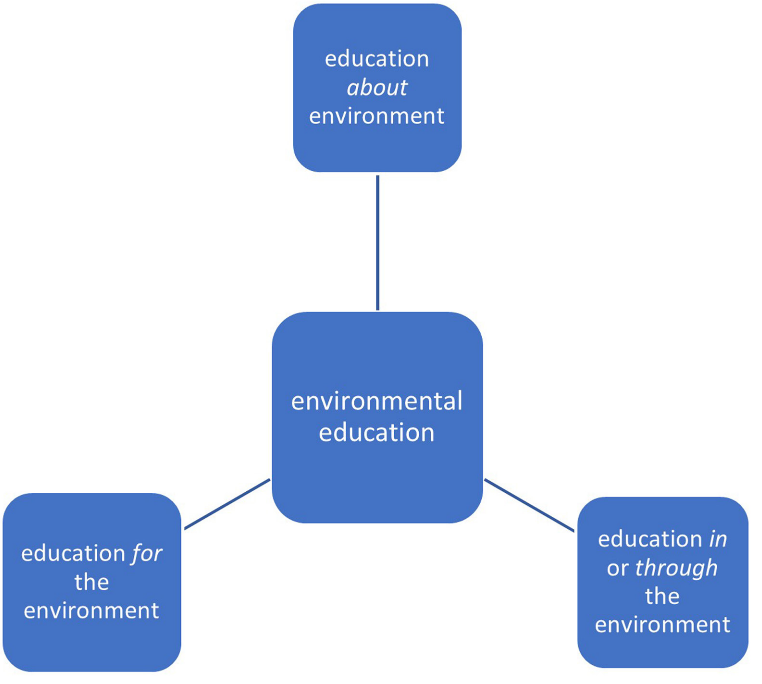

FIGURE 1 The three dimensions of environmental education (Türkoğlu, 2019).

In the case of preservice teachers and active teachers, it is of great importance that they have received adequate EE so that they can transfer this knowledge, skills and attitudes to the classroom and have the ability to create quality teaching-learning sequences. These teaching-learning sequences in EE must be designed to meet the developmental needs of children and enable them to acquire environmental knowledge, skills and behaviours (Ahi et al., 2017; Liu & Lin, 2015). In addition, they have the capacity to adapt and reinvent EE and to innovate from the local to the general issues (Reid et al., 2021).

Therefore, EE is presented as something necessary for all citizens, considering that what is not known cannot be taken care of. However, knowledge and even involvement in EE actions do not ensure a positive attitude towards the environment and pro-environmental behaviour either (West, 2015). A great obstacle for EE lies precisely in the interdisciplinary and multidimensional concept of the environment (Ahi et al., 2017; Barraza & Cuarón, 2004; Mason & Langenheim, 1957). However, there is agreement on the importance of positive environmental attitudes as precursors of pro-environmental behaviours (Bamberg & Möser, 2007; Liu et al., 2020).

2.2 | Environmental attitudes

Although attitude is a concept that admits various definitions depending on the psychological perspective with which it is approached (Crawley & Koballa, 1994; Zacharia, 2003), most researchers agree on the key aspect of the attitude construct as a tendency or internal state of the person. This tendency predisposes him/her towards favourable evaluative responses, if the attitude is positive, or unfavourable ones if it is negative; that is, "a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor" (Eagly & Chaiken, 1993, p. 1). According to the three-dimensional model (Breckler, 1984), these responses when evaluating the entity can be cognitive (thoughts, knowledge, conceptions, stereotypes, tendencies, memories, ideas, convictions and beliefs), affective (favourable or unfavourable predisposition associated with this set, feelings of pleasure or displeasure) or behavioural (decisions and actions of approach or distance around said object), as well as overt or covert. So that attitudes

TABLE 1 Multidimensional construction of environmental attitude (Milfont & Duckitt, 2010).

Second order factors	First order factors
Preservation	S1. Enjoyment of nature
	S2. Support for interventionist conservation policies
	S3. Environmental movement activism
	S6. Environmental fragility
	S8. Personal conservation behaviour
	S11. Ecocentric concern
	S12. Support for population growth policies
Utilisation	S4. Conservation motivated by anthropocentric concern
	S5. Confidence in science and technology
	S7. Altering nature
	S9. Human dominance over nature
	S10. Human utilisation of nature

influence people's responses towards some object, person or other aspects (Ajzen, 1989; Crawley & Koballa, 1994; Eagly, 1992). Although, currently, beyond the three-dimensional model, it is considered that affects, beliefs and behaviours are not a part of attitudes, but rather interact with them. Therefore, attitudes are considered as evaluative tendencies that can be inferred from and interact with affects, beliefs and behaviours (Albarracín et al., 2005); considering attitudes as evaluative reactions and interactions between these reactions (Dalege et al., 2016). In the field of environmental attitudes (EA), these could be defined, consequently, as a "psychological tendency expressed by evaluating the natural environment with some degree of favor or disfavor" (Milfont & Duckitt, 2010, p. 80). Following this contemporary approach to attitude structure, EA can be characterised through a multidimensional structure, with a horizontal structure or first-order factors and a vertical structure or second-order factors. Based on this conceptualisation, Milfont and Duckitt (2010) developed and validated the Environmental Attitudes Inventory (EAI), with a horizontal structure made up of 12 first-order factors or core dimensions, and a vertical structure made up of a single factor, *Generalized Environmental Attitudes*, or two correlated factors (*Preservation*, related to conservation and protection of the environment; and *Utilization*, related to the perception of mastery of the environment; Table 1).

In the EAI, these 12 scales or first-order factors contain a total of 120 items, 10 for each scale. Likewise, the authors developed other smaller versions, with 72 (EI-72) and 24 (EAI-24) items, the latter structurally validated by Ajdukovic et al. (2019). In this research, the EAI-24 has been used to analyse the change in environmental attitudes in preservice teachers. This questionnaire has been widely used in the scientific literature to analyse the change in EA with the incorporation of different methodological approaches in the EE programming of preservice teachers. Thus, for example, the use of problem-based learning (Kuvac & Koc, 2019), a transdisciplinary approach to EE in a literature subject (Martín-Ezpeleta et al., 2022), the participation in field work (Rachmatullah & Minsu, 2018) or carrying out literary activities of reading, analysis and creative writing of texts with an environmental theme (Martín-Ezpeleta & Echegoyen-Sanz, 2020). In this research, the participation and design of citizen science projects by preservice teachers were incorporated into the EE subject program.

2.3 | Citizen science

The term citizen science was coined by Irwin in 1995 to describe a type of collaboration between non-experts and specialist scientists around research. Thus, in the *White Paper on Citizen Science for Europe* (Serrano-Sanz et al., 2014) the term citizen science is associated with the participation of all types of people, regardless of their training and profession, in activities related to scientific research. The participation of the people can be of various types or in different stages of the scientific process: from collecting data through observation and measurement, performing calculations and analysis, and even developing hypotheses or designing the methodology, to participation in the dissemination of the results. Thus, everyone can contribute to citizen science actions, which, for some authors, represents a democratic approach to science and scientific policies. This achieves the commitment of the people involved and causes changes in how people interact with each other and with the environment. The effect of citizen science on the participants is related to the improvement in scientific literacy (Bonney et al., 2009) and the improvement of positive attitudes towards science, also improving knowledge of environmental problems. Furthermore, citizen science participates in the achievement of the Sustainable Development Goals (SDG) because the data provided by the participants is useful to verify certain indicators of achievement of the SDG (Queiruga-Dios et al., 2020).

In this way, citizen science is assuming an increasingly important role as a tool for science and commitment to the environment and environmental management (Curtis, 2018), increasing the number of citizen science projects with the development of technologies, which facilitates the participation of people, the exchange of data and the dissemination of the projects and their results (Newman et al., 2011). Furthermore, citizen science has great educational potential aligned with the new non-university education curricula (Calvera-Isabal et al., 2023; Queiruga-Dios et al., 2020). Thus, environmental knowledge significantly affects environmental attitudes, which, in turn, affect environmental behavioural intention. However, to provoke behavioural changes related to environmental awareness, people need to find eco-friendly activities or specify how daily actions impact the environment (Liu et al., 2020).

3 | METHODOLOGY

3.1 | Context

The context of this research is in the subject of EE that is taught in the fourth year of the undergraduate Degree in Primary Education Teacher, according to the structure of the study plan at the University of Burgos. It is a semester subject, with an estimated student workload of 125 h. The contents of this subject are the following: knowledge of basic aspects of ecology and the environment (ecosystems, biodiversity, the Earth and its layers, the atmosphere and environmental problems), analysis of causes and consequences of environmental problems, research on environmental problems, and design of environmental projects for Primary Education students. Moreover, some of the teaching-learning objectives pursued by this subject are:

- Identify some problems that affect the environment, both locally and globally.
- Understand the interrelationship between society-science-nature and its implications in achieving a sustainable environment.
- Understand the interrelationship of environmental problems by analysing their causes and consequences and acquiring critical capacity to contribute and/or evaluate possible solutions.
- Design sequences of viable activities in the classroom working on EE in a transdisciplinary way.

The Theory of Experiential Learning was used to design the sequence of activities to be carried out as part of the EE program. The ELT focuses on learning through experience from an integrative perspective that combines experience, perception, cognition and behaviour (Kolb, 1984; Kolb et al., 2000). In this Experiential Learning, there are two key processes: experience and reflection on the experience (Dewey, 1938), so that students can develop solid theories that allow them to make decisions and solve problems. It is a dynamic vision of learning described as "a learning cycle driven by the resolution of the dual dialectics of action/reflection and experience/abstraction" (Kolb & Kolb, 2009, p. 43), being present the experiential learning at all times of the activity. Thus, this model moves in a cycle of grasping experience, which includes Concrete Experience (CE) and Abstract Conceptualisation (AC); and transforming experience, with Reflective Observation (RO) and Active Experimentation (AE) (Lehane, 2020). ELT has been used as a pedagogical framework for the design of activity sequences for scientific learning (Lehane, 2020) and in the field of EE (Moseley et al., 2020). Figure 2 represents the ELT model cycle designed in the process of this research, with a strong scientific focus.

In this way, in the implementation of the program and after the initial phase of presentation of the contents, the focus of the subject was oriented towards citizen science. Thus, students actively participated in citizen science projects taking data on pollution indicators (CE), analysed the data and submitted it to debate, comparing the results between the groups and with what was found in searches in the scientific literature (RO). Figure 3 shows the future teachers on a field trip while participating in the citizen science project *Plastic Pirates* (https://www.plastic-pirates.eu) that studies pollution, and the type of plastics and microplastics present in surrounding rivers.

Subsequently, through collective debate, conclusions were obtained (AC). Following the same dynamic, they also participated in the citizen science project *Vigilantes del suelo* [Soil Watchers] (https://vigilantesdelsuelo.es/). In this case, participants took data on indicators of the state of soil health and interpreted the results.

Lastly, as a final activity, the students, in teams of four individuals, had to design a citizen science project that they could later implement in their future classroom with Primary students (AC). As part of the design of this citizen science project, students had to think about what environmental aspects they wanted to address and what environmental parameters they needed to study (for example, in the case of the *Plastic Pirates* project, the main goal was about analysing the type of waste found, its location and the size and quantity of the particles) and how data on these parameters would be collected, or what would be the origin of the polluting agent and what would be the consequences produced in the environment. All this considering that it must be a realistic plan that can be implemented in the future with Primary Education students and that involves young students so that the educational benefits of participation in a citizen science project (López-Iñesta et al., 2022; Queiruga-Dios et al., 2020). In summary, the workflow in the EE subject can be seen in Figure 4.

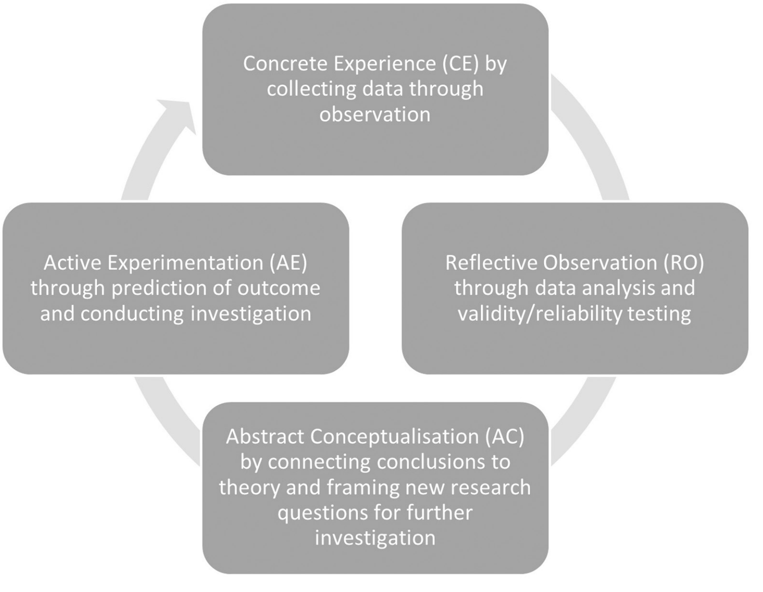

FIGURE 2 ELT model cycle focused on scientific practices adapted from Lehane (2020).

FIGURE 3 Preservice teachers participating in the citizen science project Plastic Pirates. (a) Waste pickup. (b) Separation and classification of waste. (c) Data generation. (d) Waste sample.

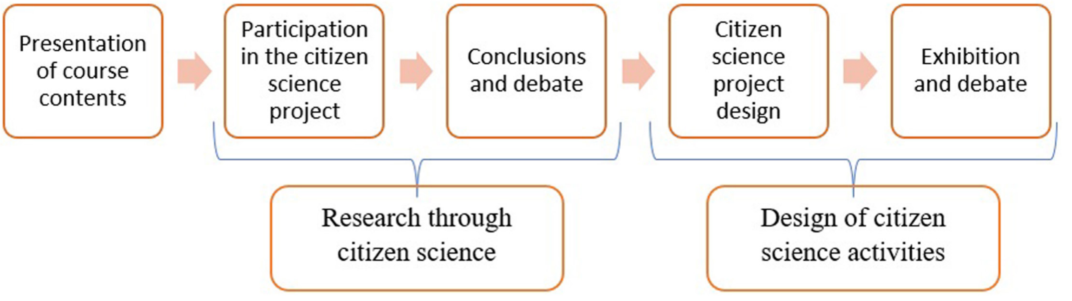

FIGURE 4 Workflow of the environmental education subject.

3.2 | Sample

Convenience sampling was used for the selection of the sample. The study sample was made up of 173 students, 138 girls and 35 boys from the Degree in Primary Education Teacher at the University. This research is based on the quantitative approach and has pre-test–post-test research design.

3.3 | Instruments

All the participants were informed of the objectives of the study, and they provided their full permission for the case study to be published. The EAI-24 was used to collect data (Milfont & Duckitt, 2010) for the measurement of environmental attitudes before and after the implementation of the learning program. The questionnaire uses a 7-point Likert-type scale, ranging from 1 (*strongly disagree*) to 7 (*strongly agree*).

3.4 | Data analysis

A before-and-after quasi-experimental design without a control group was applied. Data analysis was done by using the SPSS v.25 statistics package, which calculated the mean, the standard deviation, skewness, kurtosis, *t*-student and the Cohen's *d* coefficient. Skewness and kurtosis absolute values lower than 2 and 7, respectively, indicated no significant deviations from normality (West et al., 1995). Levene's test confirmed that in all cases the variances between the groups are equal ($p > .05$). Subsequently, the *t*-test for independent samples was carried out in order to know the influence of the gender variable. To know the effect of the designed intervention program, a *t*-student test for related samples was carried out (Hernández-Sampieri et al., 2015) and the effect size was calculated (Cohen's *d*), taking into account that *d* between 0.2 and 0.3 represents a small effect value; $d = 0.5$ means a medium effect value; and $d \geq 0.8$ represents a large effect value (Cohen, 1992).

TABLE 2 Descriptive statistics for the first- and second-order factors of the EAI pre-test–post-test, including the values corresponding to Preservation (P) and Utilisation (U).

	Pre-test				Post-test			
Dimensions	Mean	SD	Skewness	Kurtosis	Mean	SD	Skewness	Kurtosis
P	5.17	0.64	−0.16	0.54	5.46	0.45	0.32	0.37
S1	5.35	0.86	−0.18	0.74	6.05	0.62	−0.18	0.19
S2	5.43	0.82	−0.24	0.65	5.73	0.68	−0.04	−0.23
S3	5.24	0.80	−0.47	0.85	5.36	0.69	0.04	0.44
S6	5.28	0.78	0.36	−0.12	5.53	0.72	0.33	−0.29
S8	5.50	0.87	−0.73	2.55	5.73	0.77	−0.34	0.70
S11	5.57	0.87	−0.87	2.89	5.81	0.77	−0.42	0.82
S12	3.67	0.86	0.20	0.19	4.01	0.94	0.45	0.02
U	3.20	0.43	0.25	0.49	2.17	0.27	−0.06	0.54
S4	2.88	0.90	0.48	0.78	2.09	0.58	−0.01	−0.08
S5	3.73	0.67	0.26	−0.63	2.52	0.61	−0.71	−0.25
S7	3.50	0.71	0.19	−0.23	2.23	0.63	−0.22	−0.60
S9	2.55	0.74	0.35	−0.39	1.95	0.47	−0.16	1.60
S10	3.31	0.78	0.35	−0.16	2.07	0.62	0.11	0.09

4 | RESULTS

The results of the descriptive analysis (mean, standard deviation, skewness and kurtosis) for each first-order and second-order factor, both for the pre-test and the post-test, can be seen in Table 2.

The values of skewness and kurtosis are less than 2 and 7, respectively, in absolute value, so the distribution does not deviate significantly from normality (West et al., 1995). Likewise, the average scores for the scales included in *Preservation* increase after the intervention and those of *Utilization* decrease. Thus, assuming the normality of the sample, the *t*-student test for independent samples was used to compare the mean scores based on gender (Table 3).

In order to analyse the change in environmental attitudes in the students, the *t*-test for related samples was carried out between the results of the pre-test and the post-test. In addition, the *d*-Cohen was obtained. The results are shown in Table 4.

The result of the intervention shows a significant difference between the results of the pre-test and the post-test in all the dimensions of the EAI. Concerning the first order factors, there is a significant change in S1($t(172)=13.46$; $p<.00001$), with an effect size of $d=0.93$. In the scales corresponding to *Utilization*, in which the effect size is large: S4 returns $t(172)=-10.85$, $p<.00001$ and $d=1.05$; for S5. $t(172)=-19.35$, $p<.00001$ and $d=1.90$; for S7, $t(172)=-25.17$; $p<.00001$ and $d=1.90$; for S9, $t(172)=-13.52$, $p<.00001$ and $d=0.96$; and for S10, $t(172)=-20.84$; $p<.00001$ and $d=1.77$. Regarding to the second-order factors, while for *Preservation* a medium effect size was obtained ($d=0.56$), for *Utilization* the effect size was larger ($d=2.87$).

5 | DISCUSSION

This research shows the programming of an EE subject for preservice teachers that incorporates the three dimensions that this type of training should seek: education about the environment, through the environment and for the environment (Türkoğlu, 2019). In the design of the program, a learning sequence has been defined following

TABLE 3 *t*-test for independent samples for gender for first- and second-order factors.

	Pre-test			Post-test		
Dimensions	*t*	df	*p*	*t*	df	*p*
P	−0.38	171	.705	−0.11	171	.909
S1	−0.41		.683	−0.12		.907
S2	−1.39		.166	−0.42		.677
S3	0.83		.409	0.42		.673
S6	−0.07		.944	0.11		.915
S8	−0.35		.730	−0.62		.540
S11	−0.43		.670	0.08		.469
S12	−0.16		.872	0.04		.968
U	0.92		.989	0.16		.874
S4	1.91		.357	0.08		.939
S5	−0.09		.932	0.07		.948
S7	1.22		.223	0.27		.790
S9	−0.71		.480	−0.25		.803
S10	−0.27		.791	0.13		.896

Note: The results show that there are no significant differences based on the gender variable ($p < .05$) neither in the pre-test nor in the post-test.

$p < .05$.

TABLE 4 *t*-test results for paired samples on pre-test and post-test, and effect size.

Dimensions	*T*	df	*p*	*d*
P	12.88	172	<.00001	0.56
S1	13.46		<.00001	0.93
S2	5.93		<.00001	0.40
S3	3.94		.00012	0.16
S6	5.71		<.00001	0.33
S8	6.41		<.00001	0.28
S11	5.50		<.00001	0.29
S12	6.54		<.00001	0.38
U	−33.19		<.00001	2.87
S4	−10.85		<.00001	1.05
S5	−19.35		<.00001	1.90
S7	−25.17		<.00001	1.90
S9	−13.52		<.00001	0.96
S10	−20.84		<.00001	1.77

Abbreviations: *d*, Cohen's *d*; df, degrees of freedom; *p*, *p*-value; *t*, *t*-test statistics.

$p < .05$.

the ELT guidelines, combining experience, perception, cognition and behaviour (Kolb, 1984; Kolb et al., 2000). So that, based on experimentation in field activities, analysis and data collection, the student groups could draw conclusions. In each part of the process, there was feedback between groups and with the teaching staff to obtain conclusions and reflections on environmental problems. Thus, participation in citizen science activities was taken as a real context to carry out the field trips, among whose benefits for the participants are changes in interactions with the environment and improvement in knowledge of environmental problems (Bonney et al., 2009; Queiruga-Dios et al., 2020). Based on the field trips, the students designed their citizen science project for future application with young Primary students, promoting quality EE at an early age since this design addresses the dimensions of education *about*, *in* and *for* the environment, with an action- and problem-oriented approach (Hoffmann, 1978; Moseley et al., 2010; Türkoğlu, 2019). To do this, university students had to conduct their own research, which was also subsequently exposed and defended, receiving feedback from classmates and teachers, thus closing the ELT learning cycle (Lehane, 2020). This approach is aligned with the vision of UNESCO (2021) indicating that EE must be a key component of educational curricula in 2025, and preservice teachers play a key role in this transfer (Reid et al., 2021).

Moreover, ELT and the development of outdoor field trips can be considered the basis for lifelong learning. It changes students' beliefs about the environment, as they improve their knowledge by interacting with the social, cultural, and physical environments around them. This study finds that ELT is an effective model for designing outdoor EE programs. Using ELT encourages collaborative practices, enhancing EE's effectiveness. By improving interactions between formal and informal educators within the ELT framework, outdoor field trips can become more comprehensive experiential learning experiences, thereby enhancing student learning (Moseley et al., 2020).

The research results show a significant improvement in environmental attitudes, with a medium effect size ($d=0.56$) for the second-order factor *Preservation*, but a large effect size ($d=2.87$) for *Utilization*. Thus, it could be indicated that, as a result of the application of the EE program, students have improved scores related to the need to preserve nature in its natural state and protect it against the use and alteration of human beings. However, the biggest change has occurred in *Utilization*, that is, the students, after the intervention, consider that it is less correct to take advantage of nature and modify it for human purposes. Related to this dimension, large effect sizes have been obtained in *Conservation motivated by anthropocentric concern* ($d=1.05$). Therefore, after the educational intervention, students perceive that environmental policies must prioritise the well-being of nature. Large values were obtained for several factors, such as *Confidence in science and technology* ($d=1.90$), that is, science and technology can repair and avoid environmental problems; *Altering nature* ($d=1.90$), that is, the environment must be preserved in its original state; *Human dominance over nature* ($d=0.96$), that is, the human being is not above nature; and *Human utilization of nature* ($d=1.77$), that is, environmental protection is a priority over economic development. However, in some studies preservice teachers were reluctant to prioritise nature conservation over economic development (Kuvac & Koc, 2019). Regarding the *Preservation* scales, one of the factors presented a large effect size, *Enjoyment of nature* ($d=0.93$), indicating a better attitude of students towards spending time in nature after the educational intervention.

Moreover, there is a dimension that has had the smallest effect size: *Environmental movement activism* ($d=0.16$). Despite having produced a significant change, which indicates that the effect produced by the educational intervention has not excessively enhanced the attitude towards environmental activism, in terms of getting involved in organised environmental actions. Nevertheless, this is in line with the fact that pro-environmental attitudes are not necessarily associated with a high degree of involvement in environmental activities (Carmona et al., 2021).

With respect to the gender variable, no significant differences have been found in environmental attitudes in any of its dimensions either before or after the educational intervention. However, in the scientific literature, several studies have been found in which the results show differences depending on the gender variable (Bergman, 2016; Domingues & Gonçalves, 2020; Fremerey & Bogner, 2015; Martín-Ezpeleta et al., 2022; Sutton & Gyuris, 2015; Tikka et al., 2010), but no significant differences were found in other studies according to gender (Carmona et al., 2021). This discrepancy in the results could be due to cultural and social differences between the samples participating in each investigation. On the one hand, EE is currently the objective of educational programs and as a consequence EA could tend to become homogenised (Carmona et al., 2021). However, many of the research consulted are very recent studies, so more research should be carried out aimed at shedding light in this sense and determining if there really are differences in EA based on the gender variable or if there is any additional variable associated with it.

The authors want to highlight the benefits of incorporating citizen science in the EE training of preservice teachers. In addition to the improvement in the EA of the participants, citizen science projects are often designed by research institutions that support the development of the activities, so that the participants are collaborating in a global project in which data is obtained from different locations (López-Iñesta et al., 2022; Queiruga-Dios et al., 2020). At the same time, through the activities designed in the training program, preservice teachers acquire the ability to transfer this active EE to their future students through innovation and reinvention, thus responding to the call of the 3R: reimagine, recreate and restore EE (Reid et al., 2021).

In addition to the benefits that have been identified for both teachers and students, the training of EE leadership is another consequence of training preservice teachers, because they will be trainers in the future. Governments need to incorporate EE leadership into different statements, and this can start by schools. Implementing EE requires additional work from school' directors and adequate support from policy makers (Gan, 2021).

6 | CONCLUSIONS

This research addresses the gap in the scientific literature on how the participation of preservice teachers in citizen science projects improves the environmental attitudes of participants. But, at the same time, it incorporates the methodological keys for its integration into the curriculum of the EE subject, which could be the origin of a EE framework.

It has been proven how the incorporation of citizen science activities into EE programs significantly improves the EA of preservice teachers. Thus, citizen science can result in a key factor that allows the reinvention and updating of EE based on the analysis of specific environmental issues that affect the local community, and local communities in other locations, and that allow participants to acquire the knowledge of environmental problems as a global issue. In this sense, the recommendations for educational authorities are aimed at studying the creation of structures that favour the implementation of citizen science programs for the EE. This should be provided for all people and, in particular, for preservice teachers, as well as the creation of frameworks that favour research about the results of their implementation. This will also favour the transfer of programs related to the environment and citizen science to university education, given the educational potential that they are revealing in non-university and non-formal education.

EE must be part of the policy; otherwise, the environment will not be fully integrated into school agendas. The concept of EE leadership needs practical implications, such as promoting the implementation of EE in schools and the development of a sustainable vision that embraces the principles of sustainability and EE. It is important to identify the role of EE as a tool to achieve educational goals, a tool to address the environmental crisis, and a means to achieve both goals.

Particular attention should be given to the critical role that today's preservice teachers will play, as they will be responsible for the education of a significant proportion of young people in the future. Teachers play a key role in effective EE in the classroom and can influence children and youth's worldviews and attitudes, their interactions with the environment, their participation in decision-making, and their ability to make informed and responsible decisions. If teachers (or preservice teachers) lack knowledge, skills, or commitment, they are unlikely to succeed as leaders of environmental change in schools and produce environmentally literate students.

If teachers, as role models, are aware of the need to care for the environment, their students will be too. According to this research, it is crucial that future teachers reflect in their behaviour what they learn in EE classes.

Therefore, they should be trained as EE leaders and promote the idea that nature does not need people, people need nature. For a deeper understanding, the projects to be developed can include various activities that help future teachers find solutions to reduce environmental pollution.

As future avenues of research lines and with the purpose of reinforcing the results of this research, it would be advisable to carry out longitudinal studies to analyse the quality of the EE of the teachers participating in this program, when working with children at schools, and, also analyse the results of this education on the youngest students. The students participating in this research were preservice teachers and the research has been developed in the subject of EE. However, authors believe, and this is also a future line of research, that due to the large number of topics and themes covered by citizen science projects, as well as its practical and applied nature, citizen science can be incorporated into many other university studies. A citizen science project could even be developed between different subjects and/or different degrees or different universities so that citizen science would be integrated into the curricula. Incorporating citizen science into university curricula could also provide a framework for addressing the SDG.

AUTHOR CONTRIBUTIONS

MAQD and MDO designed the research. MAQD and MDO designed and implemented the educational program and citizen science activities. MDO and MQD conducted the data analysis. MDO wrote the first draft of the manuscript. All authors contributed to manuscript writing, read and approved the final manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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