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Appreciation of primary preservice teachers about the potential educational use of citizen science in environmental education

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Abstract

Purpose – This study aims to determine prior knowledge regarding the term "citizen science" (CS) and evaluate preservice teachers' appreciation of the educational potential of CS.

Design/methodology/approach – Following the pedagogical framework of Experiential Learning Theory, a training program was designed for the subject of Environmental Education (EE) of the Primary

Ethics statement: This study was approved by the Bioethics Commission of University of Burgos, with ethics approval reference IO 8/2024. Informed consent was obtained from the teachers and students, all of them aged 18 and above, who took part in the study granted explicit consent for the statistical analysis of their data.

Data availability statement: Data associated with this study will be made available on request.

Declaration of competing interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Teacher Degree, incorporating CS activities. A quasi-experimental research was carried out with 36 primary preservice teachers who participated in this study, with a qualitative approach and without a control group. Two ad hoc surveys were defined for this study, the first one is related to prior knowledge about the term CS and a questionnaire was conducted to assess the educational potential of the CS after the implementation of the training program. The results showed a great initial lack of knowledge about CS but the appreciation of the preservice teachers after the educational intervention reveals the advantages and educational potential of CS.

Findings – Preservice teachers consider that CS can and should be incorporated, as part of the course syllabus, into the teaching system and this can be done in scientific-technological subjects or in all subjects with an interdisciplinary and transversal approach, with the majority of responses indicating that the development of generic skills would be the greatest perceived benefit for students.

Originality/value – There has been an increase in CS initiatives and projects in recent decades. However, despite the advantages for the participants and actors involved, its incorporation into higher education curricula is scarce.

Keywords Environmental education, Preservice teachers, Citizen science, Higher education, Elementary education

Paper type Research paper

Introduction

The implementation of quality Environmental Education (EE) is especially relevant in the case of preservice teacher training. In this context, it must be considered that it is necessary for future teachers to have knowledge, skills and attitudes that can be transfer to the classroom through quality teaching–learning sequences. Furthermore, they need to be able to reinvent EE through innovation and provide a global vision starting from the local level. The design of these teaching–learning sequences must be aimed at meeting the developmental needs of children and must allow them to acquire environmental knowledge and, at the same time, develop environmental skills and behaviors (Ahi *et al.*, 2017; Liu and Lin, 2015; Reid *et al.*, 2021). EE is presented, therefore, as something necessary for all citizens, taking into account that one cannot take care of what one does not know and understand, as well as being an irreplaceable instrument for sustainable development (Acosta-Castellanos and Queiruga-Dios, 2022; Novo-Villaverde, 2009). Precisely, one of the benefits of participation in citizen science (CS) projects is related to the EE acquired by people who participate (Bonney *et al*, 2009; Kenyon *et al.*, 2020; Peter *et al.*, 2021). CS enables the incorporation of research-based educational methodologies that results in an environmentally literate citizenry, with the ability to think critically, analyze environmental problems and work toward solutions (Short, 2010), in which each participant has the potential to become a principal researcher (Heigl *et al.*, 2019). Today, CS allows higher education institutions to expand their research areas and address problems that were initially beyond their reach, which is achieved by involving a large number of motivated people (Teo and Triantafyllou, 2020). CS can provide the necessary focus that EE requires (Green *et al.*, 2016) and the need for quality EE from an early age, directing this training toward action and problems (Hoffmann, 1978; Moseley *et al.*, 2010), for which, preservice teachers training plays a key role (Reid *et al.*, 2021). However, while there are educational experiences of integrating CS in the nonuniversity education curriculum (Calvera-Isabal *et al.*, 2023; Queiruga-Dios *et al.*, 2020), this is not the case in higher education, where informal learning is usually assumed and curricular integration is often absent (NASEM, 2018; Teo and Triantafyllou, 2020).

In this study, a teaching–learning program was designed for the EE subject for preservice teachers, following the Experiential Learning Theory (ELT) (Kolb, 1984; Kolb *et al.*, 2001), that integrates CS projects into the curriculum. This study aims to answer the following research questions:

RQ1. What is the prior knowledge of primary preservice teachers regarding the CS term?

RQ2. What is the appreciation of preservice teachers regarding the educational potential of CS after participation in CS projects?

Theoretical framework

Citizen science

In general terms, CS is usually referred to describe scientific research activities in which the general public actively participates. Although this term was coined by Irwin in 1995 to describe a type of collaboration between nonexperts and specialist scientists around research (Irwin, 1995), its potential as a means of promoting public understanding of science was quickly seen (Bonney, 1996). Since then, there has been a great development of projects and practices under the umbrella of CS, particularly in recent decades, due, in part, to the great development of communication technologies, which facilitates the participation of people, data exchange and dissemination of projects and their results (López-Iñesta *et al.*, 2022; Newman *et al.*, 2012). Thus, various international programs have promoted the development and participation in CS projects and activities, such as the Horizon 2020 program of the European Union (EU), which has increased the number of funded projects in Science with and for Society (SwafS) (Wagenknecht *et al.*, 2021; Wehn *et al.*, 2020). This great development has resulted in the term CS not having a univocal definition and being used with different meanings depending on the different approaches or methods used, or which agents drive it (Fan and Chen, 2019; Haklay *et al.*, 2021; Heigl *et al.*, 2019). However, within the spectrum of CS definition, organizations such as the *European Citizen Science Association* (ECSA) seek to characterize the CS through the *ECSA's 10 Principles of Citizen Science for good practice* (Haklay *et al.*, 2020; Robinson *et al.*, 2018), which can be summarized as CS projects that actively involve people in scientific research. Moreover, a scientific result is produced, there is a benefit for all people, citizen scientists can participate in multiple stages of the process and receive feedback, they contribute to the democratization of science, data and metadata are made available to the general public, with the participants acknowledged in results and publications, they are evaluated for their political value and the impact produced, and project leaders take into account legal issues of intellectual property and the environmental impact. Assuming these ten principles, the *White Paper on Citizen Science in Europe* (Serrano-Sanz *et al.*, 2014) associates the term CS with the participation of all types of people, regardless of their training and profession, in activities related to scientific research. Thus, all people can contribute to CS actions, which, for some authors, represents a democratizing 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 participation of the people involved can be of various types or at different stages or phases of the scientific process: bringing together teams, resources and partners, collecting and managing data through observation and measurement, performing calculations and analysis and even developing hypotheses or designing the methodology, to disseminating results and evaluating the program (Newman *et al.*, 2012).

CS therefore adds value to many scientific activities and links epistemic outcomes with societal values, producing benefits for participants related to personal growth, improvement in scientific literacy and enhancing positive attitudes toward science, as well as knowledge of environmental problems and fostering social innovation and policy impact (Bonney *et al.*, 2009; Vohland *et al.*, 2021). Furthermore, the CS is directly involved in the achievement of the Sustainable Development Goals (SDGs) of the 2030 Agenda (UN, 2015) because the data provided by the people involved serve to verify certain SDG achievement indicators (Queiruga-Dios *et al.*, 2020; Wehn *et al.*, 2020; Fritz *et al.*, 2019). Thus, CS is assuming an increasingly important role as a tool for science and engagement with the environment and environmental management (Curtis, 2018). The CS also presents great educational potential aligned with the new curricula of nonuniversity education (Calvera-Isabal *et al.*, 2023; Queiruga-Dios *et al.*, 2020), and likewise, it is considered that CS presents educational potential in the field of scientific education for EE and sustainability (Eugenio-Gozalbo *et al.*, 2022; Peter *et al.*, 2021).

Citizen science in higher education

Higher education institutions and libraries are increasingly organizing CS activities. On the one hand, the aim is to improve the transfer of science and innovation, but these activities are also designed with an educational purpose, as well as to raise awareness of certain environmental issues or to promote technical and social skills in innovation work (Teo and Triantafyllou, 2020). At the same time, CS projects engage students in research activities while addressing global challenges (Calvera-Isabal *et al.*, 2023). Universities can thus broaden their research areas and address problems that were not previously within their reach by involving a large number of motivated people and, on the other hand, it allows them to strengthen ties with society and enhance the university's position in society (Wyler and Haklay, 2018). However, in most cases, no educational methodology is designed for the implementation of CS activities and projects, considering that informal learning will occur by the mere fact of participation in such projects. Learning outcomes are also not routinely assessed, with the result that, to date, insufficient progress has been made in creating a pedagogical framework for CS integration (NASEM, 2018; Teo and Triantafyllou, 2020). However, it is possible to integrate CS projects in higher education, even if this entails some difficulties related to the role of the students in the project, which can often be limited to mere data collection and reporting, and also to the role of the teacher, who needs to be trained for its curricular integration (Eugenio-Gozalbo *et al.*, 2022; Nistor *et al.*, 2019; Roche *et al.*, 2020). In higher education, CS seems to fit perfectly with sustainability education and EE, following initiatives to present science and real-world problems, such as the Goals of Sustainable Development (Calvera-Isabal *et al.*, 2023; Kenyon *et al.*, 2020).

Research goals. The goals proposed in this research are the following:

- Determine the prior knowledge of preservice teachers regarding the CS term.
- To analyze the preservice teachers' appreciation of CS after participating in CS projects.

Materials and methods

Context

This research was carried out in the subject of EE, which is taught in the fourth year of the Bachelor's Degree in Primary Education Teacher. It is a semester subject with an estimated workload of 125 h for students. The contents covered in this subject are: 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 students. On the other hand, some of the teaching–learning objectives pursued by this subject are to identify some problems that affect the local and global environment; to understand the interrelation between society-science-nature and its implications in achieving a sustainable environment; to understand the interrelation of environmental problems by analyzing their causes and consequences and acquiring critical capacity to provide and/or evaluate possible solutions; and to design viable sequences of activities in the classroom, working on the EE in a transdisciplinary way (Diez-Ojeda *et al.*, 2024). To achieve the learning objectives of the subject, the program incorporates participation in CS projects. But also, taking into account that the participants are preservice teachers who must transfer what they have learned to the classroom in the future, the implementation of CS projects is accompanied by the design of a pedagogy according to the ELT formulated by David Kolb (1984). This theory focuses on experiential learning from an integrative perspective that combines experience, perception, cognition and behavior (Kolb *et al.*, 2001) and was applied by focusing this pedagogy on scientific practices (Lehane, 2020). Thus, students participated in the CS project following the cycle of data collection and observation, data analysis, drawing conclusions in the context of scientific literature and, finally, sharing and feedback from peers and teacher, from which new questions arise for future research arise.

The development of the programming of the EE program followed, in summary, the following stages (Diez-Ojeda *et al.*, 2024):

- Presentation of the contents of the subject. The subject and the contents to be covered during the course were presented. The students carried out activities, individually and in small groups, to search for information and debate.
- Presentation of CS projects. With the participation of an external expert, who gave a dissertation on CS and some examples of projects. The students were introduced to the CS projects in which they were going to participate and which are described below.
- Participation in CS projects, carrying out field activities in different parts of the city to take samples to determine the indicators defined in each project. Students participated in teams of four people.
- Sharing, debate, reflection and conclusions. Analysis sessions and drawing conclusions from the results found.
- Other activities related to works and exhibitions carried out by students.

In this case study, the CS projects implemented in the EE subject were "Plastic Pirates" (www.plastic-pirates.eu) and "Vigilantes del suelo" [Soil Watchers] (https://vigilantesdelsuelo.es/). The CS *Plastic Pirates* project is developed in European rivers and aims to analyze the types of waste that can be found in different areas and riverbeds. The data collected regarding the type of waste and size is subsequently analyzed by expert scientists, making this information available to all interested people. On the other hand, the Soil Watchers project analyzes soil quality through physical, chemical and biological indicators, with the data obtained subsequently geolocated with the use of a smartphone app called Geonity (available at Google Play) so that these data is also available instantly for anyone who wants to consult them.

Sample

Convenience sampling was used to select the sample. In total, 36 students of the Bachelor's Degree in Primary Education Teacher at the University of Burgos participated in the research. This research is based on a quantitative/qualitative approach.

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. To collect data, an initial questionnaire was used to determine the students' prior knowledge about the term CS. This questionnaire only contained two questions:

(1) A1. Have you heard of the term "CS"?; and

(2) A2. Try to define the term "CS" in a few words.

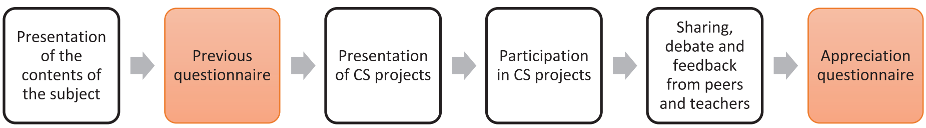
After completing the CS activities scheduled in the subject, the students answered another appraisal questionnaire on the potential of using CS in the classroom, designed *ad hoc*, which contained the following questions:

- B1. Do you think CS should be integrated into teaching curriculum?
- B2. Do you think CS can be integrated in the classroom activities?
- B3. In what subjects do you consider CS can be integrated in the classroom?
- B4. List the benefits that you think the curricular integration of CS can bring to students.
- B5. Would you integrate a CS project into the classroom?
- Justify, B6. Tell something that you have learned.

Questions B1 and B2 are similar, but they are intended to differentiate between the possibility of integrating CS into teaching and whether it should be integrated due to the educational benefits it produces in the participants. That is, the preservice teacher may find the implementation of an interesting activity but may consider that there are some types of difficulties in its implementation. Figure 1 shows the use of the data collection instruments in the flow of the subject program.

Data analysis

A quasi-experimental method was used in this study, with a qualitative approach and without a control group. In both questionnaires, designed *ad hoc* for this study, the percentage of affirmative and negative answers was analyzed for questions A1, B1, B2 and B5, whereas for the other questions (A2, B3, B4 and B6) a categorization was carried out after analyzing the responses. For this, a procedure based on grounded theory (Glaser and Strauss, 2017) was used to categorize the students' responses. In this sense, this section will show the methodological path followed in this research. Initially, the outcomes from the raw information were coded and categorized in two stages, open coding and axial coding (Strauss and Corbin, 2002). First, the texts of the responses were read in detail by the two main researchers to familiarize themselves with the content and to get a first understanding of the



Source: Authors' own work

Figure 1. Diagram on the different phases of data collection instruments according to the program flow

themes and details, performing the microanalysis (sentence by sentence) of this data. Figure 2 shows three fragments of the process followed in the open coding of the responses to question B4. Each concept obtained was associated with a color, corresponding to a specific category and subcategory.

The next step in this process was axial coding, which involves filtering the categories that have emerged in the previous stage. The information was reorganized creating new relationships between concepts. From among all the categories that emerged in the first phase of open coding, those that seemed most interesting were selected to further explanation. Selective coding allowed the identified categories to be grouped and integrated around a central category. In Figure 3, the conditional matrix was integrated into the central category of benefits of CS integration, and the dynamic integration between the core category, the categories and the subcategories can be seen.

Once the process was completed, the results of the categorization are shown in Table 1.

Results

Regarding the first research goal of determining the prior knowledge of preservice teachers regarding the CS term, in the answers to the question A1, 60% of the participants responded affirmatively. However, when asked to try to define the term (question A2), only 20% provided answers related to the participation of professional nonscientists in research projects; the rest of the answers related CS with activities of scientific dissemination or bringing science closer to society, or define it as that scientific knowledge that citizens should possess.

With respect to the second goal of analyzing the preservice teachers' appreciation of CS after participating in CS projects, after the implementation of the training program designed in the subject of EE, the results are shown below.

To the questions B1, B2 and B5, all participants responded affirmatively. The results of the categorization of the responses to questions B3, B4 and B6 are shown in Table 2.

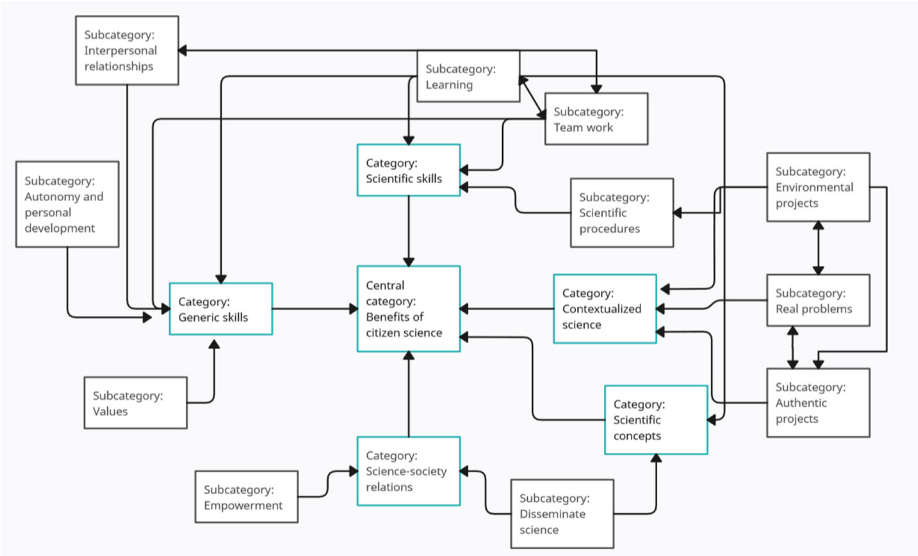
1. Some relevant aspects for students refer to group work, emotion management [development of generic skills-interpersonal relationships and group work], be part of a project learning about what scientific practices are like [scientific skills-procedural skills] and constructing learning [scientific concepts-construction], etc

2. Citizen science allows to improve the connection of science with society, improve the empowerment and collaboration of society [relations between science and society-explicit relationship]

3. Cooperative work is promoted [development of generic skills-interpersonal relationships and group work], students are involved in projects related to the real world [contextualized science-projects] fostering their commitment, camaraderie [development of generic skills-interpersonal relationships and group work]. In addition, real problems are approaching them, therefore, the student will become aware of these problems that are so present today, whether light pollution, noise pollution or that of rivers, seas, etc., and they will be part of this change, which results in an increase in your confidence [science and society relations - citizen participation] and desire to participate in more citizen science projects [development of generic skills-autonomy and personal development]

Source: Authors' own work

Figure 2. Open coding: fragments of the answers



Source: Authors’ own work

Figure 3. Flowchart of the integration between core category, dimensions and subdimensions

As can be seen from the results, with respect to the question B3, the responses collected refer to the incorporation of CS in the scientific-technological disciplines (30.56%) or in an interdisciplinary way but organized from scientific-technological subjects (30.56%). Regarding the question B4, most of the answers collected refer to the development of generic skills (80.56%), to the fact that participation in CS projects allows to show contextualized and applied science (50.00%), and that, at the same time, it shows the relationships between science and society (50.00%); and, with regard to the question B6, the highest percentage of responses indicate the significance and potential educational use of CS projects (50.00%), followed by having known a large number of CS projects (30.56%), as well as the appreciation that there is no need to set limits to education by incorporating different approaches and activities in the classroom (30.56%).

Finally, it is indicated that the question B5 was not incorporated in the categorization because all the answers were affirmative and the justification of the answers, in all cases, referred to what was answered in question B4.

Discussion

The idea of incorporating CS projects or activities into nonuniversity formal teaching to create teaching–learning activities is already reflected in scientific literature. This idea is motivated by the changes that these activities produce in the knowledge and behavior of the participants (Calvera-Isabal *et al.*, 2023; Queiruga-Dios *et al.*, 2020). Along these lines, this research shows the result of the implementation of a program for the EE subject of preservice teachers that incorporates CS activities. The goal of this program is to provide an EE *about* the environment, *through* the environment and *for* the environment (Türkoğlu, 2019). The design of the program has been carried out following ELT pedagogy, incorporating

Table 1. Categorization of the answers to the questions in the appreciation questionnaire

Question	Categories	Explanation
A2. Try to define the term "CS" in a few words	A2.1. Wrong definition	A totally different definition is indicated to the meaning of CS
	A2.2. Approximate definition	An approximate definition of CS is indicated
B3. In what subjects do you consider that CS can be integrated in the classroom?	B3.1. All subjects	CS can be integrated into all discipline syllabus
	B3.2. Natural sciences and mathematics	CS can be integrated into disciplines of natural sciences and mathematics
	B3.3. Scientific-technological subjects	CS can be integrated into disciplines of natural sciences, mathematics and technology
	B3.4. Interdisciplinary approach	CS can be integrated interdisciplinary but starting from scientific subjects
B4. List the benefits that you think the curricular integration of CS can bring to students	B4.1. Contextualized science	Students will perceive science applied to solve environmental problems
	B4.2. Generic skills	Students will develop generic skills
	B4.3. Scientific skills	Students will develop scientific skills
	B4.4. Scientific concepts	Students will learn and reinforce scientific concepts
	B4.5. Sience-society relations	Students will understand connections between science and society
B6. Tell something that you have learned	B6.1. Large number of CS projects	Students have known about the existence of many CS projects
	B6.2. Put no limits on education	Do not set limits on the work that can be developed in the classroom and approaches that can be implemented
	B6.3. Meaning and use of CS	They have known the meaning of the term CS and how to apply it in the classroom
	B6.4. Empowerment	They have appreciated that participation in CS projects can produce empowerment

Source: Authors' own work

Table 2. Results of the open questions B3, B4 y B6 according to the categorization made

Question	Categories	%
B3	B3.1. All subjects	19.44
	B3.2. Natural Sciences and Mathematics	19.44
	B3.3. Scientific-technological subjects	30.56
	B3.4. Interdisciplinary approach	30.56
B4	B4.1. Contextualized science	50.00
	B4.2. Generic skills	80.56
	B4.3. Scientific skills	30.56
	B4.4. Scientific concepts	11.11
	B4.5. Science-society relations	50.00
B6	B6.1. Large number of CS projects	30.56
	B6.2. Put no limits on education	30.56
	B6.3. Meaning and use of CS	50.00
	B6.4. Empowerment	19.44

Source: Authors' own work

experience, perception, cognition and behavior, adapted to scientific practices (Kolb, 1984; Kolb *et al.*, 2001; Lehane, 2020).

The questionnaire prior to participation in CS activities reveals a great lack of knowledge of these projects on the part of the preservice teachers training (80% of the participants did not know how to define the object and meaning of CS). This result is obtained despite the great expansion that CS is having, gaining in the incorporation of actors and fields of action (Wagenknecht *et al.*, 2021), and the great potential that CS has for EE (Peter *et al.*, 2021). On the other hand, these results are consistent with the fact that CS activities are not reaching all sectors of society, with people with a higher level of education being the most involved in this type of projects (Haklay, 2018). The EE, as an instrument for sustainable development, needs the support of the socioeconomic, scientific-technological system, administrations and citizen networks (Novo-Villaverde, 2009). Thus, the creation of links between the EE and the CS could benefit both simultaneously. On the one hand, the CS would serve as a platform for environmental literacy, favoring the EE of society, and on the other hand, EE can use CS projects to transfer to society all the additional benefits of these projects to society.

With respect to the preservice teachers' appreciation of the educational potential of CS in education, analyzing the responses to the questions B1 and B2, and taking into account that all participants answered affirmatively, they clearly perceive this great educational potential. This educational potential of CS is qualified through the analysis of the rest of questions. Thus, for example, in the answers to the question B3, the analysis shows that the primary preservice teachers' appreciation is that CS projects can cover all school disciplines, although starting from scientific-technological disciplines. In terms of the benefits that they believe it can bring to their future students (question B4), they pointed out many of those that are evidenced in the scientific literature, such as the achievement of both generic and specific competences, the learning of scientific concepts (Eugenio-Gozalbo *et al.*, 2022; Phillips *et al.*, 2018; Queiruga-Dios *et al.*, 2020; Roche *et al.*, 2020) and the understanding of the existence of relationships between science and society (Calvera-Isabal *et al.*, 2023; Haklay, 2018; López-Iñesta *et al.*, 2022; Wyler and Haklay, 2018), and, at the same time, work on contextualized science and applied to real-world problems (Haklay *et al.*, 2021). Finally, regarding the open-ended question on "tell something that you have learned," in addition to knowing the meaning of the term CS and its potential educational use, participants indicate that they have learned about the existence of many CS projects. Also, some responses pointed to the importance of not putting limits on education, in the sense of highlighting the importance of offering a diversity of educational options to students. From this response it could be inferred that participation in CS allows preservice teachers to appreciate the advantages of using active methodologies or proactive teaching–learning approaches. Furthermore, it indicates the empowerment provided by CS, which is also an advantage widely reported in the scientific literature (Haklay, 2018; Kenyon *et al.*, 2020; Wehn *et al.*, 2020). The results obtained are in line with those found in other studies conducted on active teachers, although in this case on secondary school students who participated in CS activities (Bracey, 2018). In the aforementioned study, the teachers involved reported a positive change in the student's perspective on how they see science and scientific practices, as well as their vision of the environment, and their feeling of having the ability to create science to improve the world.

In summary, it can be indicated that the learning of preservice teachers is relevant because, starting from a position of widespread ignorance of the term CS, they have detected the educational potential of integrating CS in their future classroom interventions, with the benefits that it entails.

Conclusion

This research has determined the prior knowledge of the term CS and has evaluated the preservice teachers' appreciation of the educational potential of CS after participating in a CS program in higher education. This program has been developed in the training of preservice teachers in the EE subject using the ELT pedagogical framework. This is especially relevant in teacher training because they have to acquire the pedagogical knowledge necessary for the application of EE in the classroom. In this context, future teachers, after participating in the designed activities, understand the meaning of CS and the implications for their future students of participating in CS projects.

The main findings of this research refer to the positive perceptions found in preservice teachers regarding the educational potential of CS. The integration of CS in university context achieves a double objective: on the one hand, it achieves a quality EE for students; on the other hand, as future teachers, it provides them with a tool with which to transfer to the classroom an applied and contextualized teaching related to the environment.

This study has implications for educational policies. In this sense, the authors would like to recommend to the educational authorities the creation of the necessary institutional frameworks for the incorporation of CS into the educational projects of university studies beyond EE. In this way, the educational advantages that CS brings to students, researchers and the institution itself can be transferred to university structures while at the same time strengthening ties with society. So, universities can use their potential and act as meeting points between educational, scientific, political and business institutions and favor the development of global networks. The study also presents implications for teacher training institutions and preservice teachers at nonuniversity levels, which can favor the design of resources and projects with which to generate quality EE adapted to students of all ages with the incorporation of CS. This training of preservice teachers and active teachers will favor the curricular integration of CS.

One of the limitations of the study is the small sample of students, so it would be advisable to carry out further studies with larger samples and in other contexts. Nevertheless, the study is a starting point from which to conduct qualitative studies related to the appreciation of preservice teachers regarding the benefits of incorporating CS in the classroom. Another limitation of the study is that it has been conducted in a specific context of the University of Burgos, so it does not necessarily describe trends present in other universities and in other countries. However, the results obtained may be of interest to other researchers and professors, who can use them as a starting point for further research and experiences.

Future lines of research will explore the advantages of incorporating CS projects into the curriculum in higher education on a permanent way. To this end, complementary activities will be designed around the CS project to enhance the desired learning objectives based on the subject syllabus and, in addition, to complement it with other educational approaches such as science, technology, engineering and mathematics (STEM), science, technology, engineering, arts and mathematics (STEAM) or Learning-Service, among others that allow incorporating other interdisciplinary learning objectives. Subsequently, it would also be interesting to analyze the change in the preservice teachers' appreciation of the educational potential of CS with the use of different educational approaches and methodologies. In this way the student's role will go beyond mere data collection and presentation, and thus presumably improve students' appreciation of the educational potential of CS. Another line of research will be aimed at the creation of a pedagogical framework that will allow the incorporation of CS in the university context, in the diversity of contexts and disciplines. Finally, longitudinal studies will be carried out to monitor how teachers trained with this approach transfer CS to the classroom and the results they obtain.

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