

Education for environmental citizenship and activism through the development of nature-based solutions with pre-service teachers

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Keywords: education for environmental citizenship, activism, nature-based solutions, climate change and loss of biodiversity, pre-service teacher education.

- The use of nature-based solutions in the promotion of the environmental citizenship.
- Nature-based solutions as a valuable resource towards empowerment for action.

Purpose: The study aims to assess the implementation of an intervention program that combines nature-based solutions with an environmental citizenship pedagogical approach for pre-service teachers. The research questions revolve around the educational potentials and challenges of this intervention. To our knowledge, no previous studies resorted to this combination to organize courses for initial teacher training.

Design/methodology/approach: For this qualitative and interpretative case study, data was obtained through focus groups. 30 pre-service teachers of the Basic Education Course (training kindergarten and primary school teachers) in Portugal participated in the intervention. The transcripts of the focus groups' content were subjected to categorical qualitative content analysis.

Findings: According to the participants, the implemented approach contributed to the development of a better understanding of the complexity of the environmental issues addressed, and of critical thinking skills. The pre-service teachers recognized the educational potential of nature-based solutions in the promotion of their environmental citizenship and activist competences and of the pedagogical knowledge necessary for its implementation.

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1 INTRODUCTION

1.1 Integrating environmental citizenship practices in teacher training

The European Network for Environmental Citizenship (ENEC, 2018) defines Environmental Citizenship (EC) as responsible pro-environmental behaviour of citizens who have the aim of solving current environmental problems and preventing the creation of new ones, as well as developing a healthy relationship with nature. The participation of individuals as agents of change is carried out in the private and public spheres through individual and collective actions (Hadjichambis et al., 2020). Given the scope and the ideas transmitted herein, this study subscribes to the definition proposed by the ENEC. This is a concept that encompasses a series of characteristics such as competences, knowledge, attitudes, values, and the necessary convictions to address environmental problems and to participate actively in society (Hadjichambis & Reis, 2020).

The need for EC arises from a series of complex environmental issues with which modern societies are confronted, such as climate change, energy crises and the destruction of natural areas. These problems require citizens to possess analytical skills that will enable them to take responsible decisions and actions (Georgiou et al., 2021; van Harskamp et al., 2021). The current lifestyle of a part of the population is not sustainable, and an urgent change is imperative, requiring multiple forms of action across sectors. Education represents one of these important sectors (UNESCO, 2021). The results of an international study published by UNESCO (2021) on the integration of environmental issues, with a special focus on climate change and biodiversity, and on educational policies and programmes in schools, from primary to secondary education, suggest the following measures: a) give more importance to environmental issues in education; and b) all teachers must have a good knowledge of environmental education, and be prepared to use that knowledge in transformational teaching approaches. In that study, “more than a third of survey respondents indicated that they did not include environment-related material in teacher training programmes” (UNESCO, 2021, p. 37), which demonstrates that there is a need to integrate these subjects in the early and continuing phases of teacher training. Moreover, based on a study with future teachers, Varela-Losada and collaborators (2018) identify a need to re-orient practices developed in Higher Education to train citizens to make responsible decisions and to act in a sustainable way. It was found that the pedagogical intervention (based on a holistic and participative methodology) that was used helped the future teachers to become more thoughtful and critical, to have a better understanding of the social-environmental issue under study (climate change) and be more aware of their capacity to contribute towards transformation in society (Varela-Losada et al., 2018). These results provide important guidelines for Higher Education, particularly in teacher training, with programmes that promote sustainability. Teachers are a key factor for society to make a stronger commitment to the planet, because

of the multiplier effect of their profession on the next generations (Varela-Losada et al., 2018). The integration of environmental citizenship in higher education, particularly in teacher training, is supported by the Sustainable Development Goals (SDG) established by the United Nations in the Agenda 2030. These goals are part of a plan to achieve a sustainable world (UN, 2019), as well as lifelong learning competences as defined by the European Union, including citizenship competences (European Commission, 2019). Citizenship competency has been defined as “the ability to act as responsible citizens and to fully participate in civic and social life, based on the understanding of social, economic, legal and political concepts and structures, as well as global developments and sustainability” (European Commission, 2019, p. 12).

For Dobson (2007), the best way to promote changes in the behaviour of individuals in order to achieve sustainable development is to include environmental citizenship in the curricula and to engage students direct action projects. In a revision of literature, Bader, Therriault and Morin (2017) determined although there were many environmental education initiatives that involved young people as citizens in social transformation, these often acted in an individual and limited way in relation to the environmental crisis. Thus, schools should encourage projects that will have real repercussions, where young people participate in actions that empower them to bring about change (Bader et al., 2017). The involvement of the young people in decision-making and the facilitation of their autonomy in school projects related to the environment is important to motivate them to take collective, critical and sustainable action. These experiences can reinforce young people’s confidence and capacity to change things, by intervening in collective actions to defend their values and protect or improve quality of life.

Hadjichambis and Paraskeva-Hadjichambi (2020, 2022) advocate the need for a pedagogical approach to Education for Environmental Citizenship (EEC) in times of environmental crisis, based on individual and collective actions carried out in the private and public spheres on a local, national and international scale. This approach is envisaged as an innovative and holistic tool that provides opportunities for students to develop knowledge, competences, values and attitudes necessary for environmental citizenship. The experience derived from these pedagogical practices promotes empowerment and motivation for the students to act and participate in society as agents of change, to solve contemporary environmental problems, achieving sustainability and restoring human relationship with nature. This approach integrates a series of pedagogical practices that can help promote the model, such as problem-based learning, learning competences for action, learning about community service, and learning based on socio-scientific research. Diversifying learning environments contributes to the development of competences.

However, as van Harskamp and collaborators (2021) pointed out, policies that endorse practices which promote environmental citizenship do not necessarily emerge from their implementation in an educational context. This integration is contingent on teachers’ recognition of the importance of EC, and on their grasp of this approach (van Harskamp

et al., 2021). They concluded that EC is sometimes not effectively incorporated in the classroom because of a simplistic perception of sustainability associated with recycling practices and individual behaviour in the home. In a higher education context, the empirical studies conducted by Linhares and Reis (2020, 2022) provide valuable insights into the effectiveness of pedagogical practices for environmental education among pre-service kindergarten and primary school teachers in Portugal. These studies showed the potential of Education for Environmental Citizenship in developing knowledge about environmental issues, as well as promoting students' pro-environmental capacities, values and attitudes. The implemented environmental activism initiatives had a positive impact on the pre-service teachers' competences for community action and social transformation. However, despite these positive outcomes, several challenges were identified, including difficulties in defining target audiences, adapting collective actions, and managing group work due to organizational and interpersonal skill gaps. After the interventions, several pre-service teachers still felt insecure about implementing a community activism initiative again, as they had little practice in this type of activity. In their opinion, they would need to go through more didactic experiences of this nature in order to carry out interventional pedagogical practices. These findings underscore the potential advantages of incorporating environmental citizenship education into teacher training programs while addressing practical challenges to ensure effective implementation.

Considering the crucial role of teachers in the instruction of environmental citizenship for students, Georgiou and collaborators (2021) analysed the perceptions of teachers about environmental citizenship by means of a systematic revision of empirical studies. Some of the conclusions about the teachers' perceptions were that: a) they showed a relatively low understanding of environmental citizenship; b) they were limited to a local, individual and private sphere; c) they affected teaching practices – compromising awareness of the complexity of environmental problems and the development of competences for intervention in the student community; and d) their perceptions can be improved with education and professional development initiatives. These findings indicate the importance of an effective and more efficient integration of pedagogical practices aimed at environmental citizenship education in teachers' training.

1.2 Nature-based solutions as a resource for active participation in climate change and biodiversity loss

Nature-based Solutions (NbS) are intended to help address, in a sustainable way, the different environmental, social and economic challenges faced by societies. "They are actions inspired by, supported by or copied from nature" (European Commission, 2015, p.24) that can use or improve existing solutions for those challenges, as well as explore more innovative solutions. Nature-based solutions resort to the characteristics and the complex processes of nature, such as the capacity to store carbon and regulate water flow, in order to reduce the risk of climate catastrophes and guarantee human well-being.

Ideally, these solutions should be resistant to changes, as well as efficient in terms of energy and of resources, and should be adapted to local conditions (European Commission, 2015). This way, NbS recognise the importance of nature and require a systemic approach to climate change, based on understanding the functioning and structure of ecosystems. Thus, NbS can help to protect from the undesirable impacts of climate change and to support biodiversity, preserving ecosystem services (Li *et al.*, 2021).

A report by the European Commission (EC, 2015) presented some examples of NbS, classified as to the type of solutions: regulation of air quality, regulation of climate, pollination, disease control. Some examples regarding pollination and interventions on agricultural land emphasise: a) restoring natural habitats that are rich in flowers, such as meadows (which includes roadsides and borders of fields); b) protecting bat roosts; c) providing nesting boxes or nesting locations for solitary bees that nest in cavities. Regarding air quality regulation and climate regulation, NbS can include the creation of green spaces in urban areas and the planting of trees. Other examples of NbS were used by the University of Cambridge with the aim of promoting advances in biodiversity, in a relatively easy, inexpensive way, and with visible and tangible impacts (Rowe *et al.*, 2018). The strategies adopted in different departments of the university were organized according to several categories: a) animals (nesting boxes, bird feeders, insect hotels, shelters for hedgehogs and bats, log piles); b) cultivation (community vegetable gardens, sites for pollinizers' nesting, sowing wildflowers); and c) designing landscapes to create ponds, green walls and rain gardens. An evaluation of these initiatives showed very positive results in terms of biodiversity gains and illustrated the importance of biodiversity in urban areas, and the positive impact of the natural environment on people's immune systems and mental health (Rowe *et al.*, 2018). Xie and Bulkeley (2020), also concluded that the implementation of NbS in cities can have a positive impact in biodiversity and sustainability.

Despite the numerous potential benefits ascribed to NbS for facilitating the transition towards more sustainable cities and territories, there exists limited public awareness of NbS (McQuaid *et al.*, 2022). Furthermore, these initiatives are scarcely integrated into the curricula of higher education institutions (Mulvik *et al.*, 2023), and their educational potential remains largely unexplored and under-researched (Gras-Velázquez *et al.*, 2020; Mulvik *et al.*, 2023; Vasconcelos & Calheiros, 2022). The limited number of studies conducted thus far has unveiled the positive impacts of incorporating NbS into education. These include: a) fostering a closer connection between students and real-life problems; b) integrating climate change issues into the curriculum, not merely as theoretical concepts, but as tangible concerns with practical solutions; c) enhancing academic performance and well-being by deepening the connection with nature; d) promoting environmental awareness focused on biodiversity conservation and natural ecosystem preservation; e) instilling a sense of shared responsibility toward the environment; f) fostering the development of critical thinking and creativity in both teachers and students

(Antunes, 2022; Gras-Velázquez *et al.*, 2020; Mulvik *et al.*, 2023; Utkarsh, 2023; Vasconcelos & Calheiros, 2022). However, these same studies have identified challenges to the integration of NbS into education, including: a) a lack of teacher training to incorporate such activities into their teaching practices; b) the substantial time investment required for implementation; c) insufficient resources and programs; d) limited access to outdoor learning spaces; e) insufficient funding; f) a lack of awareness among students and the community regarding the benefits of adopting NbS.

This study seeks to address some of those challenges by putting forth and assessing an educational intervention for initial teacher training that integrates environmental citizenship education with the implementation of nature-based solutions. Its primary goal is to pinpoint the potential and challenges associated with this educational intervention. To our knowledge, no previous studies resorted to this combination to organize courses for initial teacher training.

2 METHOD

The present article shows part of the results obtained from a qualitative and interpretative case study aimed at assessing the implementation of an intervention program that combines nature-based solutions with an environmental citizenship pedagogical approach for pre-service teachers in Portugal during the academic year 2021-2022.

2.1 Participants

The participants in the case study consisted of 30 first-year students of the undergraduate course in Basic Education (a class of students training to be kindergarten and primary school teachers), who were completing the curricular unit of ecology during the second semester of the academic year 2021-2022 and participate in the intervention. All the participants were female and were between the ages of 18 and 24, with a mean age of 20 years.

2.2 Organisation of the intervention

The intervention took place over the course of 7 weeks, in accordance with the weekly organisation of the curricular unit of Ecology, which was in four-hour sessions. The intervention followed the main stages of the pedagogical approach to Education for Environmental Citizenship proposed by Hadjichambis and Paraskeva-Hadjichambi (2020). Table 1 presents a characterisation of the different learning activities implemented in each stage of the pedagogical approach to education for environmental citizenship combined with NbS. The intervention was carried out to provide future educators with innovative pedagogical practices and to respond to the objectives of the curricular unit: a) to understand the importance of biodiversity for the environment and for humanity; b) to understand the main threats to biodiversity; c) to identify the consequences of human activities and attitudes in different ecosystems; d) to learn about different strategies that

will protect biodiversity; and f) to implement NbS at the school campus (actions to preserve local biodiversity).

Students were grouped for the development of the activities, with each group in charge of addressing a specific environmental issue of their choice related with the topic of biodiversity loss. This broader topic was chosen by the teacher among the topics of the curricular unit of ecology.

Table 1. Description of the learning activities by stages of the pedagogical approach to education for environmental citizenship combined with Nature-based Solutions (NbS)

Stages	Description of the learning activities
I. Investigative activity (<i>Inquiry</i>)	<p>Compiling and analysing data regarding the environmental problem under study (searching different sources of information): structural causes (e.g., inefficient environmental laws and procedures to protect nature), unfair inter and intra-generational situations (e.g., accumulation of wealth by entrepreneurs, depriving future generations of certain ecosystem services), values upheld by each stakeholder and presentation of solutions to the problem (namely NbS). This data was important for each group to address the research problem, basing their arguments on scientific evidence. Each work group created a controversy map, with positive and negative arguments, the inter-relationships of the parties concerned and the values involved (stakeholders – e.g., environmentalists, students, mayors, heads of companies, etc.). Presentation and discussion of the maps in class.</p> <p>Learning activities: Search for information from different sources and interview with stakeholders to gather relevant information about the issue under study. Creation of controversy maps about the environmental problem under study, followed by a class presentation and discussion, and a campus tour aimed at identifying and raising awareness of its biodiversity potential. Additionally, the tour aims to pinpoint existing problems and encourage reflection on potential interventions based on NbS that can be implemented on-site.</p>

Table 1. (Continuation) Description of the learning activities by stages of the pedagogical approach to education for environmental citizenship combined with Nature-based Solutions (NbS)

II. Planning actions	<p>Planning individual and collective actions in the public and private spheres. This phase involved the planning of each NbS and also of other actions aimed at promoting their sustainability over time and the dissemination and public awareness about that topic.</p> <p>Learning activities: Each group completed a document in which they had to present the following aspects of the intervention: a) problem to be addressed; b) objective(s) of the intervention; c) description of the NbS that the group will implement; d) identification of difficulties that could affect the implementation and long-term effectiveness of the chosen NbS and respective overcoming strategies; e) identification of relevant resources and information about the problem; f) implementation of the NbS; g) way(s) of promoting dissemination and public awareness; and h) how to assess the relevance of the NbS and ensure its continuity.</p>
III. Civic participation	<p>Making decisions, bearing in mind alternative solutions and doing community actions – individual and collective. Promoting/implementing NbS in the community.</p> <p>Activities that were conducted: Intervention on campus with NbS. Each NbS was implemented on school campus. The class participated in all the actions proposed by the groups. The groups shared the solutions found to mitigate the problem (including NbS) in a discussion forum on the Moodle platform.</p>
IV. Networking	<p>Organisation of local/national networks: Disseminating NbS in social networks to influence and encourage the community members to change their behaviour and to collaborate in the initiative once they understand the importance of the problem.</p> <p>Activities that were conducted: Each group responsible for each NbS contextualized and presented its action, namely through the poster created and disseminated on their social networks such as Facebook or Instagram.</p>

Table 1. (Continuation) Description of the learning activities by stages of the pedagogical approach to education for environmental citizenship combined with Nature-based Solutions (NbS)

V. Sustained action	<p>Ensuring that, over the long term, stakeholders engaged in the action's implementation uphold and disseminate the NbS in order to sustain and enhance the activism initiative. This, in turn, benefits citizens with measures that contribute to the community's well-being and the sustainability of the planet.</p> <p>Activities that were conducted: Due to time restrictions, the dimension relating to “ensuring the continuity of the NbS”, that is, guaranteeing its sustainability, was only “thought of” by the groups, failing to implement the measures presented. The actions suggested by the groups were the following: a) ask the kitchen staff for help to take care of the garden, being able to plant/sow other spices and, thus, expand the garden; b) create initiatives/partnerships with one or more organizations; c) write a memorandum/letter of commitment to the school management to inform them of the existence of the NbS and obtain a commitment from the management bodies to maintain it over time; d) students from the next year’s course and beyond help maintain the shelter; and e) creation of a group of volunteers (students, teachers and non-teachers), to maintain the NbS.</p>
VI. Evaluation	<p>Both the teachers and students were constantly involved in a reflective process on how to improve the activities implemented in each stage of the intervention, allowing the integration of improvements in both processes and products.</p> <p>Activities that were conducted: Giving feedback about the different implemented activities.</p>

The activism initiative chosen by each group was organised around the development of NbS (Table 2). Each group adopted a different solution for biodiversity loss, a theme proposed by the teacher in charge of the curricular unit (the first author of this article). In the investigative stage, apart from the research carried out from different sources of information, the groups of students were also encouraged to interview stakeholders (Table 2) so they could better grasp the concepts and complexity of the problem under study.

The NbS implementation on the campus was made possible by interviews with experts and the search of information regarding each solution, prior authorisation from the directorate, the collection of the necessary materials and the prior construction of the shelters.

Table 2. NbS implemented in the school campus by the different work groups and stakeholders interviewed

Students' groups	Sub-topics addressed in the ambit of the problem – Loss of Biodiversity	Stakeholders interviewed	NbS implemented by the groups
Group 1	Intensive agriculture and monocultures	Technician from the National Federation of Beekeepers of Portugal	Hotel for insects
Group 2	Use of pesticides in agriculture	A member of the organization “Biological Gardens”	Shelter for hedgehogs
Group 3	Destruction of habitats	Specialist from the Portuguese Society for the Study of Birds	Feeder and waterer
Grupo 4	Use of pesticides in agriculture	Food engineer	Vertical herb garden
Group 5	Deforestation and pollution	Technician from Santarém local government (Environment and Sustainability division)	Seed bombs/ Sowing native (plant) species/ Cleaning an area
Group 6	Destruction of habitats	Biologist from the Alviela Science Centre – Carsoscope (Bats are one of the themes covered in this centre)	Shelter for bats

2.3 Research methodology

This broader study used qualitative methodologies (participant observation, focus group interviews, and students' work content analysis). This article focuses on qualitative data obtained from the focus group interviews realized at the end of the intervention with each group of students. This qualitative component, substantiated by means of a case study, was meant to make clear the process by which the participants construct meanings and describe what these meanings consist of (Bogdan & Biklen, 1994).

At the end of the intervention based on the model of Education for Environmental Citizenship and on NbS, focus groups were implemented with each group of students. This technique consisted in bringing together a small number of people in order to acquire a more in-depth understanding of the points under study, in a manner more efficient than with individual interviews. The group's interaction resulted in more in-depth data about the subject under study (Nagle & Williams, 2013). Furthermore, the data was obtained in a relatively quick and comprehensive manner (Silva *et al.*, 2014).

Each focus group discussion was structured around four aspects: 1) personal characterization of participants; 2) potentials and challenges of activities in Education for

Environmental Citizenship; 3) overall evaluation of the pedagogical intervention focused on the environmental citizenship education model; and 4) contributions resulting from the intervention, both in terms of personal and professional development of the participants. The use of a guide assisted researchers in gathering data that could be compared between groups, providing insight into how they could interpret the experience (Bogdan & Biklen, 1994). The six focus groups in this study (with 4-6 participants each) corresponded to the groups formed during the intervention. The groups were informed of the date and time for the interview through a previously disclosed schedule. Each group presented themselves at the scheduled time, and during the interview (with an average duration of 30 minutes), all group members could participate, supplementing each other's responses or providing alternative opinions.

2.4 Data analysis

The transcripts of the interviews were subjected to categorical qualitative content analysis, which allowed for a systematic organisation of the material obtained during the intervention and provided a better understanding of it (Bardin, 2009; Bogdan & Biklen, 1994). The codification process helped to identify regularities and patterns in the excerpts obtained which led to a definition of codification categories. These categories enabled the data to be classified. For this purpose, interview transcriptions underwent an analysis process that involved data reduction by identifying units of record (segments of content that served as the basic unit), taking into account the study's objective during the coding phase. The comparison of various units of record identified in the interviewees' responses, along with a re-reading, aimed to identify patterns and common characteristics to create categories that aided in interpreting the data during the categorization phase (Bardin, 2009). The qualitative dimension of the analysis was complemented by a quantitative approach, considering the frequency of occurrence of certain elements in the message. Thus, the use of quantitative indicators allows for establishing comparisons (Bardin, 2009).

2.5 Ethical aspects of the research

Each participant signed a free and informed declaration of consent at the beginning of the study. The study was approved by the ethics committee of the higher education institution to which the research centre of the authors of this study belonged.

To protect the identity of the subjects, all the data obtained in the study was kept anonymous. Codes were attributed to each group of students, which consisted of a number, from 1 to 6, preceded by a prefix associated with the instrument used to compile data (e.g., FG to designate the focus group interviews). For example, "FG 1" to "FG 6".

3 RESULTS

Below is the presentation of the results from the categorical qualitative content analysis of transcripts of the focus groups, centred on the educational potentials and challenges of

an intervention program that combines Nature-based Solutions with an environmental citizenship pedagogical approach for pre-service teachers.

3.1 Potentialities of an intervention program combining the model of education for environmental citizenship with NbS

According with the pre-service teachers, the major potentialities of the intervention program (combining the model of Education for Environmental Citizenship with Nature-based Solutions – NbS) are related with the development of: a) competences – scientific knowledge (mentioned by the 6 groups) and pro-environmental attitudes (4 groups); and b) knowledge about actions (e.g., the implementation of NbS) that can help to solve environmental problems (4 groups). Some features of the intervention program enabled them to understand the environmental problems under analysis, as well as how citizens can be empowered to intervene in the community to solve these problems.

All the groups referred to the knowledge developed with the work they did, including a better awareness and understanding of the environmental topics studied. For example, as a way of conserving and protecting biodiversity, four groups installed a shelter for animals on the institution's campus; the students learned that all animals are important, i.e., bats, which often evoke negative feelings in people, but are actually important for a healthy ecosystem, particularly in controlling insect populations.

“(…) the importance of all animals; they are all important (…). Because our work was about bats and they are important because of (undesirable) insects. We (tend to) think that they aren't good for anything, but they are.” (FG 6)

The future teachers revealed that they had also learned more about the role and the importance of bees, as well as ways to contribute to an increase in local biodiversity through the installation of structures called hotels for insects.

“I had never thought about the importance of bees, nor had I thought that hotels for insects could exist. I didn't have any idea that there were so many different species of bees, nor that they lived so long.” (FG 1)

This knowledge helped the pre-service teachers establish cause and effect relationships, and to understand the complexity of the problems under study. Furthermore, they showed that they had the capacity to think critically about the topics that were covered:

“Yes, we even interviewed organic vegetable gardeners. We associated agriculture with the use of pesticides.” (FG 2)

“We tried to help birds by making a bird feeder. I had never thought about the negative aspect, that by feeding them, birds stop foraging for food. I had never thought that it (the bird feeder) could harm them.” (FG 3)

The scientific knowledge constructed during the intervention program is the basis for students to reflect on these topics and to understand their complexity, so that they feel

capable of spreading the word and teach these topics in their future profession, as future teachers' primary school and kindergarten teachers:

“I had never thought, in fact I didn't know that hedgehogs are beneficial to agriculture.” (FG 2)

“I think that now we are more prepared to raise awareness and to teach.” (FG 3)

During the focus group discussions, some participants made reference to the development of pro-environmental attitudes. Four groups endorsed actions that could be implemented individually to preserve and protect biodiversity. They demonstrated a positive and protective feeling in relation to the environment, acknowledging the added value of certain measures that could be implemented in daily life. They had an attitude of interest and desire to get involved in environmental issues by adopting strategies to solve environmental problems in general and to protect biodiversity in particular; they even considered integrating those measures in their future professional activity.

“I think that not everyone realises that we can reduce pollution by creating a vegetable garden, as we did, without using pesticides.” (FG 4)

“(...) it would be very beneficial if each individual, in their homes, planted flowers so that bees could pollinize. And also build little houses for bees, that is, hotels.” (FG 1)

“It made me want to carry out another action. For example, the document I read had a lot of initiatives, and if it was up to me, I would have undertaken many of them. Perhaps in a few years, when I am working, in my classroom, I will remember, when I am thinking of doing something with my group of children.” (FG 6)

Other learning experiences that the groups mentioned had to do with the construction of knowledge about actions that can have a positive impact in the environment. The interviewees believe that by learning about new strategies to preserve and protect biodiversity they have an opportunity to “save the environment”:

“Through the other groups I learned about other ways, apart from the one we devised. For example, I didn't know about those seed bombs. With these works, I learned that there were new ways of saving the environment.” (FG 1)

A series of actions carried out on campus involved building shelters, and were feasible because the groups learned what type of materials were needed to build shelters for the different types of animals:

“The materials that we could use to build a house, or shelter.” (FG 3)

“We were going to use palettes, in a certain way, but when we talked with [a specialist] we realised that it couldn't be done like that at all.” (FG 6)

According to the pre-service teachers, the intervention program has several potentialities related with the following specific characteristics: a) the inclusion of an inquiry stage (mentioned by all groups – 6); b) the promotion of activism initiatives in the

community (5 groups); c) the organization in stages (4 groups); d) the focus on a real local problem identified and chosen by the students (2 groups); e) the controversy mapping (2 groups); f) the implementation of NbS (2 groups).

All groups highlighted the inquiry stage because they considered that it helped them understand the problem. Research was an important element in accessing information about the addressed problems and how to develop NbS:

“What helped me to understand the problem was the research part. With the research I realised, for example, that it is not only the bee hotel that saves bees. Bees need a queen bee to live in a place (...).” (FG 1)

“(...) researching information to learn more about hedgehogs and their environment.” (FG 2)

“The research work made us think more about what bats might need.” (FG 6)

The interviews to stakeholders enabled the participants to obtain information that was not available on the internet, and to acquire a better understanding of contents and NbS:

“In my opinion (...) the interview provided us with updated information about things that we couldn't find on the internet. The lady, who was well-informed about the subject, was able to explain things much better and answer our questions. We said that we were available to help with whatever was needed.” (FG 1)

Several groups valued the opportunity of implementing community actions. The participants considered that any possible (form of) dissemination of the problem and of its solutions was important. People who have access to this information can help improve a certain situation, and raising awareness can be the road that leads to environmentally friendly practices; they become agents of change.

“We can create shelters close to home for hedgehogs. Since hedgehogs are beneficial in agriculture, farmers can reduce the number of pesticides. I think that dissemination is important so that we can act in the best way.” (FG 2)

“Helping others is also a part of our future profession. The video we made helped in the end. Whoever watched it may have been affected.” (FG 6)

Given the complexity and dimension of environmental problems, the participants of two groups felt that action in the community is only possible if it is done in a group, in a collective way. They did not consider individual action to be an option – due to its limited impact –, so there was a stronger valorisation of collective action than individual action:

“I think that individually I wouldn't do it because there are situations that require a lot of work, and I would have to be really interested. (...). But in a group, always.” (FG 2)

“If an entire class gets together to change something, the impact will be greater.” (FG 5)

According to several participants, the organisation in stages enabled them to learn at all times, and retrieve important information related to different aspects of the work:

“In my opinion, all the stages were good, because in each one we managed to learn something important. For example, in my opinion, with the research I was able to discover the disadvantages of pesticides; with the map of controversies, I determined which organisations and groups of individuals agree with the use of pesticides and which don't ...” (FG 4)

“One of the positive factors was that we went through all the stages, which helped us, even for future projects, to realise that it's not only making something (for example, a feeder), and that there is more work involved.” (FG 3)

Another important aspect of the intervention program valued by the pre-service teachers was the study of a local problem chosen by each group, focusing on the problem of biodiversity loss. They verified that dealing with a local problem which was close to them, resulted in participants' higher motivation and involvement in the work, since they felt that the action that they were promoting was useful, and could be used in the long term. The action they had to implement on the school campus to solve and/or minimize a problem identified by the group made special sense to the students.

“We were asked to look at our surroundings and to identify an environmental problem that we could solve, which raised our awareness about how things around us are changing, and what we can do to solve this situation.” (FG 5)

“It is about finding solutions for real problems that affect our school and our community. It is very motivating to do actions that have an impact on the place where we live and where we study.” (FG 5)

Choosing the topic was considered as a positive aspect because of the freedom to pick a topic that they were interested in, which resulted in greater involvement of the group in the long run.

“Having the freedom to choose a topic. (...) I think gave us the freedom to pick something that we were interested in. That freedom was very important because it gave us enthusiasm to work.” (FG 5)

Another task that was valued was *controversy mapping*, which helped structure the ideas and interests of the different parties associated with the problem, and better understand their roles, and the inter-relations of *stakeholders*.

“I also highlight (...) the map of controversies. I thought that it was very important because this map gives us a much clearer impression of the ideas, interests, values and actions supported by different groups of individuals in regard to certain controversial environmental issues. We see the different perspectives and become aware of the complex network of interests that are at the origin of the problem.” (FG 3)

The stage of NbS implementation was referred to positively by two groups. They believed that its added value derived from the practical character of the interventions on

the school campus. In their opinion, implementing the NbS was an important activity that can be done with children to develop a sense of responsibility.

“I liked the fact that we actually implemented the solution instead of it being only theoretical, that we went there, made the house. (...) Yes, it’s different.” (FG 2)

“In general, this course needs more practical things, that is, more activities that we can do with children. I think that this is one idea. It’s easy to make a feeder to put outside. It prepares them to be responsible. For example, every week we have a group of three children that go there. They check everything and see if more food is needed. (...) Therefore, I think that it was very important in that aspect.” (FG 3)

3.2 Difficulties of the intervention program based on the model of education for environmental citizenship and NbS

The difficulties mentioned by the participants of the study were related to: a) the development of the NbS (mentioned by all groups – 6); b) some difficulties in finding specialists/stakeholders (2 groups); c) the different stages of the intervention program (1 group); d) the controversy mapping (1 group); and e) the functioning of the group work (1 group).

The difficulty experienced by all groups was connected with the development of the NbS, probably due to the novelty of this approach and the lack of information on how to implement it. Identifying the most appropriate location to install the NbS presented some challenges:

“It was difficult to find information about the most suitable place to install the shelter that we built.” (FG 6)

Additional research and interaction with the teacher were needed to determine the most suitable location, keeping in mind the available conditions and means, which resulted in some adjustments being made before arriving at the final NbS.

“It was difficult to find the solution. We searched until we found the seed bombs.” (FG 5)

Construction of the NbS, which in most of the groups consisted of a shelter, was a challenge for some groups. According to them, the problem was finding the right materials to build the shelter and putting the structure together, which required some adaptations. Nonetheless, the students in both groups said that in the end they felt fulfilled because they had accomplished their objective, and they considered that this stage had been an “adventure”, a “worthwhile” experience, and they were “happy” with the result.

“The challenge was to build the structure. We thought that it would be easy, but then we had to change things. It was difficult, but at the same time it was an adventure because we were building the whole thing.” (FG 4)

“The problem occurred in the store, where they didn’t cut what we needed. The measurements were too small. But in the end, we were happy.” (FG 6)

Another difficulty mentioned by two groups was the challenge to get the stakeholders to participate in the interview. The first contacts got no response from the specialists. However, this situation was overcome when other specialists were contacted and agreed to be interviewed.

“For me, it was the fact of trying to contact several people and they wouldn’t respond. (...) We tried to schedule the interviews, but were unsuccessful. Our first contacts were with institutions which had offered to help us, but in the end they didn’t.” (FG 2)

For one of the groups, *controversy mapping* was a difficult task and required the students to research documents so that they could identify and better understand certain inter-relations among *stakeholders* (interested parties/involved in the problem), and to contemplate the complexity of the problem under study: explaining how different social groups can have an effect on a problem (helping to find a solution, or aggravating the problem).

“Also, that part that we had to do ... what we called the beneficiaries and those adversely affected. In our minds we knew who the injured parties were and who the beneficiaries were. It was a question of searching for documents that proved it. It was very challenging.” (FG 5)

One of the groups said that since initially they were not familiar with the model of education for environmental citizenship, it was challenging to work with because it involved different stages.

“I think that in the beginning it was a bit complicated. We didn’t have much knowledge (...) and we had little time to carry out so many tasks.” (FG 3)

The collaborative work was considered by one of the groups to be difficult, and they claimed that the process didn’t go as smoothly as it could have: “I think that the biggest challenge was working in a team.” (FG 5)

4 DISCUSSION AND CONCLUSIONS

As in the studies of Hadjichambis *et al.* (2022) and Linhares and Reis (2022), the empirical data of the present qualitative study indicate that the participants developed EEC competences through the pedagogical approach of Education for Environmental Citizenship. The results of this study also suggest that if an intervention is structured in accordance with the stages of the pedagogical approach to EEC it can have a positive impact on the students’ EC. Therefore, the ability to develop EEC competences are one of the strengths of this intervention.

Among the competences acquired by the future teachers with the work that was carried out, was a better grasp of the environmental topics that were addressed, and the capacity

to think critically. Similar results were also obtained in the study by Linhares and Reis (2022) with future teachers, in which the developed scientific knowledge and the ability to make informed decisions based on critical thinking were highlighted.

The pre-service teachers expanded their professional knowledge and learned how to implement this type of approach in the classroom. The knowledge acquired can serve as an incentive to integrate practices guided by this model. Despite future teachers demonstrating capabilities to engage with the community (Linhares & Reis, 2020), not all groups indicated feeling confident to undertake community activism initiatives. Given the complexity of environmental issues, some participants only envision the possibility of acting collectively rather than individually in the community. This undervaluation of individual roles may reflect a lack of confidence in each individual's power to act responsibly in the community. It could also indicate an understanding that collective action will have a more significant impact on the community. Only a robust integration of Environmental Citizenship Education (ECA) practices through the incorporation of Nature-based Solutions (NbS) into teacher training curricula can effectively prepare future teachers to integrate these practices into their future professional endeavours (Gras-Velázquez *et al.*, 2020; Utkarsh, 2023). Simultaneously, it helps them understand their role as citizens with the power to drive social and environmental transformation. As Varela-Losada *et al.* (2018) argue, teachers play an important role in mobilizing society to prioritize environmental commitment, given their substantial impact on young people views and behaviours. The work that was developed also promoted values and attitudes, concern for the environment, and helped prevent situations and behaviours that jeopardise ecosystems.

The students felt that they learned about the interventional aspect, particularly with their actions on campus using NbS which mostly involved the installation of animal shelters. This practical action-oriented component was intended to mitigate environmental problems that cause biodiversity loss and promote actions to protect biodiversity. We consider, like Pineda-Martos *et al.* (2022), that integrating this practical component based on NbS promoted the development of more critical systemic thinking and the environmental citizenship in these future teachers.

In terms of how the pedagogical approach of Education for Environmental Citizenship was organised, what the participants valued most, globally, was the different stages that enabled them to acquire knowledge of the environmental problems under study, and to gradually determine a connection among the various dimensions of the problem. More specifically, the interviews that each group planned and conducted with stakeholders associated with the problem, and the controversy mapping, were considered an added value for understanding how to implement NbS on the school campus. In the implementation of NbS, the groups were responsible for an action that contributed to biodiversity protection, and by planning and experiencing the action, some of the groups realised the potential of this type of activity to promote children's sense of responsibility.

Similarly, as others have argued (Rowe et al. 2018; Xie & Bulkeley, 2020), we consider that the campus served as a window of opportunity to address urban biodiversity, and the NbS that were developed could contribute to biodiversity protection.

The interventions based on NbS also have drawbacks. In the ambit of this study, some of the difficulties that arose were: finding information about how to implement NbS, choosing a NbS that was achievable and accessible, finding a location on campus to implement it, and finally, its construction. However, collaborative work among the people of the group, and between the group and the teacher, with relevant guidance and clarification helped overcome the difficulties encountered. Furthermore, carrying out the different stages of the model resulted in an understanding of the problem, and of how each NbS was best adapted to the problem under study (the benefits, challenges and effectiveness). Linhares and Reis (2022) also identified difficulties related to activity management. The future teachers were not familiar with the type of work that an approach of this nature requires, placing them at the centre of their learning process. The supervising teacher plays a crucial role in guiding the work groups in this context.

Given the potential of this pedagogical approach of EEC combined with NbS in the development of competences (scientific and professional knowledge, capacitation for action, values and attitudes), and determining which methods and strategies work best with certain students, these teaching methodologies should be part of the curriculum of teacher training. As van Harskamp and collaborators (2021) argue, an approach with these characteristics allows for opinion formation, for working the ethical dimension and other aspects related to sustainability, particularly environmental citizenship competences. This is a path to follow so that teachers have a better chance of promoting EC in their classes and to help them educate environmental citizens. In fact, EEC can only work when teachers are aware of what environmental citizenship implies and when they are qualified to use these pedagogical approaches. For an effective integration into the curriculum of an approach based on Nature-based Solutions (NbS), it is crucial to include it in both initial and in-service teacher training. This is a perception that prevails among the majority of teachers who participated in the study by Gras-Velazquez *et al.* (2020), considering it important to have training in this area and the time to prepare lessons to incorporate this approach. Similar to Mulvik *et al.* (2023), we also advocate for the importance of conducting more in-depth research to understand how to extract the full educational potential of these types of activities.

As in the work of Georgiou *et al.* (2021), the actions developed by the future teachers (in this study) involved local environmental problems, and it would be beneficial to extend this type of action to more comprehensive NbS, for example, to the community (outside the school). However, contrary to the observations of Georgiou *et al.* (2021), these future professionals promoted collective action, and even felt that action in the community was only feasible if done in a group, given the complexity of environmental problems.

Nature-based solutions showed potential for use in intervention programs for environmental citizenship education, thus encouraging awareness of the target groups about global environmental, social and economic issues. Just as Varela-Losada *et al.* (2018) concluded in a study with future teachers, we consider that it is essential to encourage schools and communities to become informed about the socio-environmental problems of our planet, empowering people to participate in sustainable actions, individually and collectively, to mitigate problems such as climate change and biodiversity loss. As mentioned above, NbS are actions that, if properly inserted in an EEC pedagogical approach, are important for addressing local and global environmental problems, involving communities and promoting knowledge, competences and values so that future teachers conduct informed action. EEC involves holistic methodologies that provide information about the environment, but also promotes an examination of values, and stimulates reflection. This is a transformational approach to teaching science, which addresses the planet's urgent needs, and consequently those of modern societies.

This research makes a useful contribution to the field of teacher training and impacts future generations to be more environmentally conscious. To our knowledge, no previous studies resorted to the combination of environmental citizenship education with the implementation of nature-based solutions to organize courses for initial teacher training.

The study's limitations arise from the fact that this campus intervention only involved the specific class itself; it would likely have had a more significant impact if other groups of citizens and/or community students had participated. Additionally, the pedagogical approach's Stage V (related to the sustainability of the action) was not adequately explored. The future teachers only identified and planned ways to maintain NbS over time in this stage, without implementing them. This limitation restricts the potential impact of the actions taken and their sustainability over time.

Future research should build on the limitations of this study. First, it is considered relevant to investigate more comprehensive interventions based on NbS, which could involve community partners and implement them in the broader community (beyond the campuses). It is essential to understand how to implement measures that ensure the maintenance and sustainability of NbS. Enlarging the student cohort and incorporating a pre-post application of the Sustainability Consciousness Questionnaire, which has demonstrated potential in assessing the impact of educational interventions aligned with the EEC pedagogical approach (Linhares & Reis, 2022), could facilitate the identification of the course's influence on particular cognitive, affective, and behavioural variables integral to environmental citizenship. Secondly, in order to better evaluate the impact of the intervention on the teachers' environmental citizenship competences and classroom practices, it would be important to implement a longitudinal research study concentrate on tracing the trajectories of teachers, examining the evolution of their perceptions and practices on environmental citizenship education from pre-service training into their teaching practices within school classrooms.

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