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Dealing with Urban Biodiversity Through Butterfly Gardens: A Project-Based Learning Proposal for Pre-Service Teachers Training

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Abstract: Research in environmental education points out the need for an improvement in pre-service teacher education training in this area. This proposal follows PBL methodology and focuses on the development of an environmental education project whose final product is the organization of a science fair for elementary school students. The 5-week project addresses the topic of urban biodiversity decline and uses the butterfly garden as an initiative to mitigate it. Four months after the program ended, a survey was administered to the 86 participating pre-service teachers. A mixed-methods approach was used, collecting quantitative data on perceptions of urban biodiversity decline, the One Health concept, and environmental education, along with qualitative keyword responses to open-ended questions about the butterfly garden's impact and the project's value for self-learning and professional development. Participants reported positive perceptions regarding butterfly gardens after participating in our environmental program, recognizing them as both a valuable educational resource and an effective initiative to mitigate urban biodiversity decline. Respondents showed a strong pro-environmental attitude, taking seriously their role in transmitting environmental values. Using a butterfly garden for teaching purposes offers insight into environmental literacy, connection with nature, and improvements in well-being and is a powerful platform for deep and meaningful pedagogical learning.

Keywords: urban biodiversity decline; environmental education; butterfly gardens; project-based learning; pre-service teachers

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1. Introduction

Over 76% of the overall EU population currently resides in or lives in close proximity to cities; in the case of Spain, this number is increased to 82%, showing a continuous growth curve since 1970 [1]. A frequent consequence of this ongoing urbanization process is the densification and expansion of urban areas, resulting in the loss of urban green spaces and biodiversity and subsequent decreases in human wellbeing and health, amongst other societal repercussions [2]. Animal species diversity in urban areas is often lower than in rural areas due to lack of suitable habitats, habitat fragmentation, and higher levels of pesticides and pollutants [3].

Although cities are not usually planned or built as refugia for plants and animals, they may contain important wildlife habitats, such as parks, squares, nature reserves,

cemeteries, and private yards [4,5]. Thus, cities offer many opportunities for the creation of additional, functional habitats, including for migratory and threatened species [6]. We have to take into account that pollinating insects have limited habitats and relatively short life cycles and require minimal space for feeding and nesting [7]. Thus, these relatively small habitat requirements make the creation of urban habitats not only manageable but also critical in the face of pollinator decline. Indeed, efforts to incorporate natural habitats into urban planning are increasingly common and are driven by conservation awareness, human health, and climate change mitigation [4]. It has been reported that botanical gardens, despite covering a very small percentage of the city area (0.002–0.22%), show disproportionately high butterfly species richness and diversity compared with the much larger surrounding city area [8]. Additionally, butterfly communities in the city area are more diverse in highly connected gardens, indicating that urban landscape planning must focus on improving connectivity inside the city in order to diversify the butterfly community composition [9]. Even roof gardens could be useful for increasing urban biodiversity, as long as they are built less than 50 m high and contain planted areas as well as shrubs for birds and nectar plant species for butterflies [10]. Living walls, vertical living roofs, and support vegetation that is either rooted on the walls or in a substrate attached to the wall itself provide a habitat for biodiversity in general [11]. The latter are examples of urban reconciliation ecology; this is the modification and diversification of anthropogenic spaces to support species-friendly habitats without compromising the human use of the land [12]. Living roofs and wall gardens hold significant potential for urban reconciliation ecology, offering a practical and engaging approach to enhancing biodiversity within human-dominated landscapes [13].

As previously mentioned, aside from attracting more butterflies and pollinators, such practices are likely to benefit other biodiversity and increase human connection with nature [14], generating well-being improvements [15] or even impacting human health by controlling transmission of zoonotic diseases [16]. Several studies have examined the contribution of green spaces to healthy environments and their physiological, psychological, and endocrinological human health benefits as well as potential socioeconomic advantages [17,18]. Considering that the linkages between biodiversity and health are intricate, multifaceted, and complex, efforts have been initiated under the One Health approach that includes the interconnectedness of people, wildlife, and ecosystems to improve global health outcomes [19]. Interestingly, it has been pointed out that the One Health approach should not be addressed solely within the healthcare perspective but also through education, encompassing the following three dimensions: human health, animal health, and environmental health [20]. A clear example that helps to elucidate this interrelation of the One Health approach can be found in the case of the transmission of diseases to humans by mosquitoes (e.g., malaria, West Nile virus, Zika) and the relationship with urban biodiversity. Taking into account vector-borne diseases, we must say that cities have been losing their natural defense against them: their biodiversity. Insectivorous animals (such as bats, swallows, sparrows, and spiders) are less and less frequent in our parks and buildings, which are the species that can control mosquito populations. So, when mosquito population increases, there are no predators to control it, with the consequent risk of disease outbreaks [21]. Therefore, increasing biodiversity allows for a better balance between the different niches of an ecosystem (environmental health). This environmental health contributes to the control of species that can introduce parasites or pathogens (animal health), thus protecting human health from zoonotic diseases [19–21].

The success of actions oriented both to urban reconciliation ecology and the One Health approach (such as implementation of living roofs, walls, or butterfly gardens) will depend on robust ecological engineering, addressing socioeconomic barriers, and fostering

active citizen participation through collaborative research and adaptive management strategies. This citizen-driven, research-based model can pave the way for a more integrated and resilient approach to urban conservation, where humans and nature can coexist and thrive [13]. Thus, the implication of the whole society is a crucial element for the success of large-scale, long-term urban reconciliation ecology initiatives and dissemination of the One Health approach. To achieve an involved society, we must take into account the socioeconomic barriers and devise a realistic strategy to overcome them. The socioeconomic barriers identified are as follows [13]:

Cultural perception: The structural characteristics and aesthetics of these initiatives do not correspond to society's pre-established notions of what a typical green space is. Since these initiatives might not conform to the conventional image of attractive green spaces, this could lead to negative public reactions, concerns about public acceptance, and lack of long-term commitment. For instance, we find that, in the case of rooftop gardens, they are often not as green and lush as people expect. The same happens with butterfly gardens, which are somewhat confusing and unattractive due to the presence of nourishing plants, which are not exactly ornamental.

Financial investment: The initial cost of installing this kind of green space can be a deterrent, even though it might be offset by long-term benefits. In addition to the installation cost, the cost of maintenance should be considered. The economic barrier is present in both private and public initiatives.

Public awareness and education: A lack of public understanding regarding the benefits and value of urban biodiversity can hinder the implementation of reconciliation ecology. Raising awareness about the ecological roles of often overlooked species or even those perceived as "unpleasant" is crucial for fostering support for these initiatives. Highlighting the connection between these spaces and the habitats of charismatic species, such as certain birds or butterflies, can be an effective strategy to garner public support.

In the field of environmental education, we find perhaps the most powerful tool for addressing the socioeconomic barriers that prevent society from implementing and sustaining long-term urban ecological reconciliation initiatives. Environmental education could be a suitable platform for each individual to understand the environment and its interconnections with society and health and, more importantly, to find actionable mechanisms within their reach to mitigate environmental problems, such as the decline of biodiversity in urban areas [20]. Personal experiences with nature, in addition to knowledge about butterflies and ecosystems, are foundational to behavioral changes that can promote insect conservation and environmental stewardship [22,23]. Studies focused on environmental education for elementary students have shown a strong positive correlation between participation in nature-based environmental programs and increased ecological behavior, a more positive and empathetic view of nature, enhanced environmental knowledge, and connectedness to nature. These findings suggest that nature-based environmental education is a promising approach to fostering environmentally responsible individuals [24,25]. School is a key element in environmental education since the physical spaces of the school can be transformed into green spaces by implementing school garden programs. Numerous studies have demonstrated the importance and impact of school gardens (edible gardens, butterfly gardens, etc.) as effective teaching tools, both inside and outside the classroom. For example, edible gardens can change students' attitudes toward foods, particularly unpopular vegetables [26]. Butterfly gardening can be an effective tool for promoting insect conservation and environmental stewardship in schools. By integrating butterfly gardens into the curriculum and providing students with opportunities for hands-on learning and home-based projects, schools can foster a deeper understanding of the importance of butterflies and their ecosystems [27]. The use of gardens as teaching tools are proliferating across

all educational levels, serving as innovative spaces for teaching and learning, including in pre-service teaching programs at universities [28].

As an example of a university initiative that serves as the framework for the present work, we highlight the butterfly garden of the Universitat Rovira i Virgili (Tarragona, Spain). This garden, with a surface area of 180 m2 and located within a university campus, was implemented in 2018 to favor biodiversity within the campuses, creating a wildlife-friendly urban landscape and facilitating a new ecological corridor interconnected with the neighboring urban and peri-urban environment. This green space has plant species adapted to the Mediterranean climate, typical of the territory where the campus is located, and facilitates pollinators to complete their life cycle in the same garden [29]. From the very beginning, this garden has also served as an educational and outreach platform, both for the university community and for the general public. The study presented here is focused on the use of the butterfly garden as a center of pedagogical interest for an environmental education program designed for students of the Elementary Education degree of the Faculty of Education. The educational program designed follows the project-based learning (PBL) methodology, structured under the guidelines of the Buck Institute for Education, a reference institution in this methodology [29,30]. Problem-based learning has been identified as an action-oriented methodology suitable for environmental education [31–33]. PBL encompasses the three characteristics of teaching methods suitable for education for sustainable development: interactive and participatory (e.g., group discussion and peer assessment), inquiry-based (e.g., problem analysis and values clarification), and action-oriented (e.g., solving real community problems) [34]. The perceptions of pre-service teachers' students who have used PBL in environmental education are very positive. These students argue that this approach is beneficial, enhances creativity, encourages research and learning, and helps them to define environmental problems more clearly and to be actively involved in the solution process [35]. Among elementary school students, the application of PBL to environmental education topics has a positive impact on communication skills, information gathering, analysis and critical thinking, and some specific knowledge about environmental issues. Notably, PBL led primary school students to take action in their communities to address the environmental issues analyzed. Elementary students reported a sense of ownership of the project due to their close involvement in it [36].

This program has been implemented and refined over the past six years, resulting in a PBL educational proposal for elementary pre-service teachers that pursues two main objectives. On the one hand, this program aims to improve the disciplinary content knowledge of pre-service teachers in environmental issues. This program focuses on the problem of biodiversity decline in urban areas; its impact on environmental, animal, and human health dimensions; and analyzing possible initiatives to mitigate this problem, taking as an example the butterfly garden on campus. The development of this disciplinary content is framed within the One Health approach, a concept that is implicitly present throughout the educational proposal. On the other hand, this pre-service teachers' program focuses on the development of pedagogical skills in environmental education. To do so, students are challenged to design and implement, for a specific group of elementary school students, environmental education activities that are developed around the butterfly garden of the university campus.

The present research aimed to characterize the profile of our pre-service students a few months after the end of the program regarding their beliefs and opinions on urban re-naturalization initiatives such as butterfly gardens and their impact on biodiversity and human health. On the other hand, we also aimed to analyze their perceptions regarding the importance of environmental education and the usefulness of implementing school

activities on urban biodiversity. To this end, the three following research questions (RQ) are addressed:

1. What are pre-service teachers' perceptions about the role of urban renaturation initiatives, such as butterfly gardens, in enhancing biodiversity and fostering human–nature connections in urban areas?
2. What are pre-service teachers' perceptions about the environmental health, animal health, and human health and well-being benefits associated with urban renaturation spaces, such as butterfly gardens?
3. What are pre-service teachers' beliefs about the importance and effectiveness of environmental education and their own ability to integrate it into their teaching practices.

2. Materials and Methods

2.1. Participants and Context

This study was carried out with all 86 pre-service teachers who participated in the Butterfly Garden Science Fair project and who were enrolled in the second course of the Elementary Education Degree at the Universitat Rovira I Virgili (Spain) in the academic year 2023–2024. No additional criteria were used to select the sample. The Environmental Education program presented here was conducted as part of the course "Teaching and Learning of Experimental Sciences I" a 120-h course designed to offer both disciplinary content of experimental sciences (Biology, Geology, Physics, and Chemistry) and didactic strategies for its implementation in elementary school classrooms. The 120-h course is divided into six content blocks. The block related to the Environmental Education program consists of 18 teaching hours that took place between 22 April and 31 May 2024, divided into eight sessions. An important point is that these students, according to the syllabus followed in our university, had not yet had contact with elementary school children since the first internship period takes place in the first semester of the third year of the degree. Thus, the completion of this Environmental Education block had the additional challenge for them of facing real students for the first time in a real teaching context.

2.2. Pre-Service Teacher Proposal Training Butterfly Garden Science Fair

The Environmental Education program presented here follows the project-based learning (PBL) methodology, and it was planned, structured, and designed under the guidelines of the Gold-Standard Project-Based Learning model of the Buck Institute for Education, a PBL reference institution [29]. Project-based learning is defined by researchers at Buch Institute for Education as a teaching method in which students learn by actively engaging in real-world and personally meaningful projects [37]. The beginnings of PBL, in the late 19th century, are associated with progressive education and John Dewey's idea that learning is a social process [29]. Dewey thought that schools and classrooms should be representative of real-life situations, allowing students to participate in learning activities interchangeably and flexibly in a variety of social settings [38]. Dewey focused attention on thinking, an iterative process by which students encounter a conceptual or practical obstacle, propose a solution, try it out, and reflect on the results [39]. Under this paradigm, the teacher becomes a partner in the learning process, guiding students to autonomously discover meaning within the subject area [38]. Through Project-Based Learning, students not only apply what they have learned but also develop three specific skills necessary for the 21st-century workplace, namely critical thinking/problem solving, collaboration, and self-management [30]. Students need structured opportunities to develop both these 21st-century competencies and, in our case, the skills needed to teach environmental education to elementary school students, and the Butterfly Garden Science Fair is one such opportunity for pre-service teachers training.

For the design of our PBL program, we started from the structure proposed in the Gold-Standard Project-Based Learning design framework [30]. According to this reference, a project is typically developed in four phases, following a process of inquiry and product development. Figure 1 shows the structure designed for our PBL program Butterfly Garden Science Fair.

Project Phases	Held Sessions	What Students Think About	How Teachers Support Inquiry	Teaching Resources
PHASE 1 Launch Project: Entry event and Driving Question	**Session 1**	Why PBL is important? What the difference is between PBL vs *doing a project*? What is the project asking me to do?	Kick-off event: Video recorded by elementary school children requesting a science fair with activities to solve their questions on environmental issues around the Butterfly Garden.	**Moodle Lesson 1:** *Initial thoughts on PBL* (prior to the project start). **Presentation** about PBL methodology and launching the Project. **Moodle Lesson 2:** *The importance of PBL.*
PHASE 2 Build Knowledge, Understanding and Skills to Answer Driving Questions	**Sessions 2, 3, 5, 7**	What do I need to know? What resources can and should I use? Can I trust the information I am finding? What is my role in the process? Who will I be sharing my work with? How can I manage the provided budget?	Provide information, guidance, resources and theoretical content according to the students' needs. Connect students with the environmental manager in charge of the Butterfly Garden on the university campus as well as the teachers of the schools involved.	**World Café Conversation technique** to define what a successful *Butterfly Garden Science Fair* should be like. ***Need to know* list** to track students' questions and learning in the project. **Co-creation of the rubric** to define the gold standard quality of environmental education activities for children. **Environmental education workshops** on the decline of urban biodiversity and the proposed Butterfly Garden.
PHASE 3 Develop and Critique Products and Answers to the Driving Question	**Sessions 4, 6**	Is my work on the rigth track? What new question do I have? How can I provide constructive feedback to my peers?	Help students apply the learnings to project tasks and in improving the final product (Science Fair activities for elementary children). Provide constructive feedback in a supportive and balanced way.	**Moodle Lesson 3:** *Austin's Butterfly* **Feedback sandwich technique** **Moodle Lesson 4***: Scaffold Student Learning*
PHASE 4 Final Product Delivery: Butterfly Garden Science Fair Day	**Session 8**	What should I explain about my work? What have I learned in this project?	Generate a strategy for assessment and reflection of the learning process.	**Assessment rubric for guest teachers** on the quality of the activities designed and the preservice teachers' implementation. Delivery of **activity summary sheets** and their subsequent evaluation. Check-list and rubric for **preservice teachers self-evaluation.**

Figure 1. Workflow of the PBL program Butterfly Garden Science Fair. Adapted from [30]. Detailed information on the PBL methodology and Need to know list [30], Word Café Conversation technique [40] and Feedback sandwich technique [41] can be found in the original references.

This project begins with a video in which some elementary school students ask university students to organize a science fair where they can answer all of their environmental questions. Previously, there was a work of alignment between the teachers of the university and the teachers of the school so that the interests of the school matched the teaching possibilities offered by the butterfly garden. Thus, the questions are either focused on how to design a butterfly garden and how to maintain it, or they are related to environmental issues (presence of pests, ecological balance in urban areas, diversity of pollinators, etc.). In the six years that we have been carrying out this program, the elementary school students have been from all educational levels, from first to sixth grade. In the specific case analyzed here, the elementary students were in the sixth grade.

The active involvement of pre-service teachers' students in the organization of the science fair entails the resolution of multiple questions and challenges, aligned with the learning objectives established for this environmental education program (Table 1). The objectives encompass two different dimensions: environmental education and teaching training.

Table 1. Learning Outcomes of the PBL program Butterfly Garden Science Fair.

Dimension	Description	RQ *
Environmental Education	Students identify the systemic relationships between human actions and the environment and initiate the adoption of sustainable living habits to contribute to biodiversity conservation from a local perspective.	1, 2
	Students are able to explain the selection of plants and architectural elements, justifying their usefulness, to create a butterfly garden.	1
Teaching Training	Students are able to teach about environmental education topics, through the design and implementation of high-quality educational activities, to promote environmental literacy among elementary school students.	3
	Students recognize their fundamental role, as educational agents, in the introduction of environmental values in society.	3
	Students understand the rationale behind the PBL methodology, through implicit and explicit reflection on the Butterfly Garden Science Fair, in order to reconcile this structure and implementation in their future as teachers.	No assessed here

* RQ refers to the Research Question of this manuscript that aligns with each Learning Outcome.

On the one hand, the environmental education dimension focuses on learning and reflection on the environmental issue of biodiversity decline in urban areas and the actions that can be taken to mitigate this situation. Specifically, students deepen their knowledge of butterfly garden initiatives, such as the one we have on our campus [29] (Figure 2), working actively with the environmental manager of our university, who participates throughout the project by providing information and feedback. All the knowledge acquired on this topic is applied in the second dimension of the objectives: teaching training. This second dimension focuses on the acquisition of the knowledge and skills necessary to design and implement quality environmental education activities for elementary school students. For this purpose, different actions are carried out throughout the project, and especially, the teachers of the schools participating in the science fair are taken as a reference. It should be noted that the rapport between the pre-service teachers and the participating schools is established from the moment the project is launched. From the very beginning, the pre-service teachers have direct communication with the elementary students and teachers for whom the Butterfly Garden Science Fair is organized so that activities are designed according to these students' specific needs.

(**a**) (**b**)

Figure 2. Butterfly garden of Universitat Rovira I Virgili during different editions of the Butterfly Garden Science Fair: (**a**) first edition of the Butterfly Garden Science Fair, 2018; (**b**) most recent edition of the Butterfly Garden Science Fair, 2024.

The teaching resources used throughout the project for scaffolding students' learning are detailed below (Table 2). In order to achieve the objectives aligned with the environmental education dimension, we counted on the collaboration of the university's environmental manager, who conducts an environmental education outdoor workshop focused on the

proposal of the butterfly garden as a strategy to mitigate the decline of biodiversity in urban areas. Specifically, this workshop presents the rationale behind a butterfly garden and shows different plants and elements that should be added to this kind of garden to achieve its goals and improve biodiversity. Our university's butterfly garden is analyzed and visited regularly during the project, as it is located next to the facilities of the Faculty of Education. This environmental expert is also present in different feedback sessions, and students can contact him directly throughout the weeks of the project. In addition, students are provided with different sources of information, both on environmental science and environmental education, in order to answer any question they may have about environmental issues and how to address them in classroom settings.

Table 2. Teaching resources implemented for PBL program *Butterfly Garden Science Fair*.

Dimension	Description	Information Source
Environmental Education	Environmental education workshops provided by environmental expert on urban biodiversity decline and butterfly garden initiatives.	[29] www.urv.cat/ca/vida-campus/serveis/medi-ambient/ (accessed on 23 January 2025)
	Provide information sources on environmental sciences.	https://mcng.cat/ (accessed on 23 January 2025) https://www.rspb.org.uk/ (accessed on 23 January 2025)
Teaching Training	Provide information sources on environmental education.	https://www.jardinsdepapallones.org/ https://taelh-uam.es/ (accessed on 23 January 2025)
	Rubric for both formative and summative assessment of the environmental activities designed.	Table 3
	Moodle lesson 1: Initial thoughts on PBL. Watch video and answer survey about main ideas of the video.	https://www.pblworks.org/video-tiny-house-project (accessed on 23 January 2025)
	Moodle lesson 2: The importance of PBL. Read text and answer survey about main ideas in the text.	https://www.pblworks.org/blog/importance-project-based-teaching (accessed on 23 January 2025)
	World café conversation technique with specific questions for our project.	[40]
	Moodle lesson 3: Austin's Butterfly. Watch video and answer survey about main ideas of the video.	https://eleducation.org/resources/austins-butterfly/ (accessed on 23 January 2025)
	Feedback sandwich technique used in classroom to assess the activities students were designing during the project.	[41]
	Moodle lesson 4: Scaffold student learning. Watch video and answer survey about main ideas of the video.	https://www.youtube.com/watch?v=rHbTF5uRF9o (accessed on 23 January 2025) https://www.youtube.com/watch?v=pTm6x5VBivk&t=10s (accessed on 23 January 2025)

Table 3. Rubric provided to the students in order to facilitate and guide the quality assessment of the designed activities.

Item	Very Poor	Poor	Good	Very Good
Activity focused on STEM and environmental content.	The science skills and environmental content to be addressed in the activity is not defined.	Only the contents that appear in the curriculum are listed, but there are no specific learning outcomes for the designed activity.	The curricular content and scientific bases on which it is based are defined. The learning outcomes also appear and are appropriate for the educational level.	The learning outcomes are realistic and consistent with the proposed activity. There is evidence that the content is being taught at a good level and that the teacher has mastered the associated scientific basis. The questions and vocabulary used are relevant and the teacher responds favorably to students' questions. Reliable and relevant sources of information are provided.
Activity aimed at developing competencies and skills.	No manipulative experience appears.	Students can perform a demonstration or experiment but without prior contextualization. No question or challenge to set the context.	Students are faced with a challenge that they have to solve experimentally. They use empirical information to reflect on a scientific and/or environmental event. The experience is engaging and awakens the interest of the students.	Students deepen their knowledge with a scientifically oriented question or with a discrepant event that generates cognitive conflict. Students are encouraged to formulate their own hypotheses and to test them experimentally. The experience is motivating and awakens students' interest, and there is evidence that this happens.
Assessment of the learning outcomes' achievement	There is no learning objective for the activity.	Learning outcomes are defined, but there is no evidence of the achievement level of these objectives by the students.	Evidences of the achievement level of the learning outcomes are collected at the end of the activity.	Evidence of the achievement level of the learning outcomes is obtained throughout the development of the activity. Appropriate adjustments are made if deficiencies and doubts are detected in the students.

For the teacher training dimension, a series of on-line tasks have been designed and are delivered through the Moodle platform, which constitute the training focused on the PBL methodology. In these Moodle lessons, students individually face four on-line tasks that comprise viewing a video or produced text followed by a quiz with questions related to each of the videos or text. These videos and the text serve to showcase Gold-Standard PBL projects (Moodle lesson 1), to understand the historical perspective of PBL (Moodle lesson 2), and to demonstrate good teaching practices in PBL for scaffolding and assessing students (Moodle lesson 4). Moodle lesson 3 ("Austin's Butterfly") is devoted to showing how constructive critique and revision could be delivered in an elementary school setting.

One of the PBL Gold-Standard elements is critique and revision since this is the process that enables students to create high-quality products. Critique and revision become a process that provides for formative assessment throughout the project [30]. Therefore, in order to be able to give this feedback properly, students have to know in detail the quality parameters of the final product, which in our case are environmental activities for primary school students.

A key resource for this purpose is the co-creation of the rubric that defines the gold-standard quality of environmental education activities for children. These activities are framed in the STEM field, and for this reason, they must be designed to promote scientific practices as well. Pre-service teachers' students are presented with a rubric that lists the key elements of a gold-standard environmental activity (Table 3). They must study the rubric in detail and propose modifications (usually related to clarifying vocabulary) and add some elements they consider important (usually associated with classroom management and adaptations for students with difficulties). This consensual rubric serves as a guide both in the critique and revision checkpoints (formative assessment) and in the final evaluation of the activities carried out in the Butterfly Garden Science Fair (summative assessment).

Finally, it is interesting to highlight that from the first year that this program was implemented, the hashtag #FiradeCienciesFCEP has been active on the X platform. There, the work carried out throughout the project is shown, making especially visible the final phase where the product is delivered: the Butterfly Garden Science Fair Day (Figure 2).

2.3. Data Source, Data Collection, and Analysis

This module is the only explicit training dedicated to environmental education that our pre-service teacher students receive at university. In this study, we were not interested in assessing the impact of the training program itself but in being able to describe the profile of students trained in our program with respect to their perceptions of environmental education. Therefore, we conducted a survey with a descriptive purpose some months after the end of the training. We did not propose a quantitative study based on the administration of a pre- and post-intervention survey since many studies with this structure have been reported without conclusive results. Results without statistical significance are frequently found, and qualitative data are utilized in order to draw conclusions supported by empirical evidence [25,26,42,43]. Instead, we considered it more interesting to carry out this prospective study that would give us an idea of what kind of perceptions students form from this experience about the topics of urban biodiversity decline, the concept of One Health, and the importance and usefulness of environmental education. These results will help us to identify aspects that can be improved in the pre-service teacher training that we provide at our university. However, by using mixed methodology, descriptors provided by the students in the qualitative part of the survey can only come from their reflection on this specific training activity, and this could give us data about the impact of this environmental module on pre-service teachers' perceptions.

The survey designed for this study has two parts: one where quantitative and the other where qualitative data are sought. The first part consisted of a 4-point Likert-scale questionnaire composed of 13 statements, in which students rated their opinions from 1 (strongly disagree) to 4 (strongly agree) regarding their perceptions to previously mentioned aspects (urban biodiversity decline, One Heath, and environmental education). Most of the statements were designed by the authors, except three that were obtained from a published instrument [44]. Those three items are related to the importance of incorporating environmental education into the educational system and are identified in Table 4. In the qualitative part of the survey, pre-service teachers' perceptions were analyzed based on the keywords in their responses to these two open-ended questions.

- Write three words that reflect your opinion about the impact that a butterfly garden like the one at the university can have on the urban biodiversity where you live;
- Write three words reflecting your opinion about your participation in the project (usefulness for your professional future, lessons learned, opinions about the impact of the "Butterfly Garden Science Fair" on primary school students, etc.).

Table 4. Quantitative responses of 84 pre-service students.

Research Question	Statement	Completely Disagree	Disagree	Agree	Completely Agree
RQ1	In addition to attracting butterflies, a renaturation space such as the butterfly garden contributes to the increase of biodiversity of multiple species in the urban environment.	0.00%	0.00%	30.49%	69.51%
	Urban renaturation initiatives, such as the butterfly garden, increase people's connection with nature.	1.22%	1.22%	50.00%	47.56%
	* In large cities, there is not much room for action to increase pollinator biodiversity.	19.51%	42.68%	37.80%	0.00%
RQ2	* A renaturation space like the butterfly garden does not generate substantial improvements in people's physical and mental well-being	8.5%	3.7%	57.3%	30.5%
	The conservation of urban biodiversity has a positive impact on human and animal health.	0.0%	0.0%	36.6%	63.4%
	An increase in biodiversity helps prevent the transmission of diseases from animals to humans.	2.4%	25.6%	56.1%	15.9%
RQ3	It is important to include environmental topics in the educational system [37].	0.0%	0.0%	15.9%	84.1%
	Each student in a teacher training institution should be required to study an environmental course during his/her studies [37].	0.0%	13.4%	46.3%	40.2%
	It is every teacher's responsibility to include environmental subjects and values in his/her teaching [37].	0.0%	2.4%	37.8%	59.8%
	Participating in the Butterfly Garden Science Fair project, focused on the butterfly garden, has allowed me to see that I am capable of bringing environmental education topics to elementary school classrooms.	0.0%	3.7%	52.4%	43.9%
	Developing a project like the butterfly garden can inspire students to take individual actions to protect the environment.	0.0%	1.2%	43.9%	54.9%
	The loss of biodiversity and its possible solutions is a topic that interests elementary education students.	1.2%	23.2%	52.4%	23.2%
	When designing the activities for the Butterfly Garden Science Fair project, I realized it is possible to address different environmental education topics with primary students (sustainability, ecology, biology, health, etc.).	0.0%	2.4%	39.0%	58.5%

* Responses to items presented as negative sentences were reversed. RQ: research question; RQ1: What are pre-service teachers' perceptions of the role of urban renaturation initiatives, such as butterfly gardens, in enhancing biodiversity and fostering human–nature connections in urban areas?; RQ2: What are pre-service teachers' perceptions of the human health and well-being benefits associated with urban renaturation spaces, such as butterfly gardens?; RQ3: What are pre-service teachers' beliefs about the importance and effectiveness of environmental education and their own ability to integrate it into their teaching practices?

Once we completed the initial draft, we asked a committee of six experts in environmental education, pedagogy, and research methods in education to validate the items. Experts were asked to analyze each item and mark it (from 0 to 10) according to its relevance to the issue, assessing if each item was valid, appropriate, and unequivocal. We recorded their comments and observations. As a result of this validation process, some items were rewritten.

Pre-service teachers' students were asked to participate voluntarily and anonymously in the on-line survey. They were contacted by e-mail and provided with a link to the questionnaire created on the Microsoft Forms platform. Before accessing the survey, students were presented with a detailed information sheet about the project and were required to accept informed consent before proceeding to answer the survey. The questionnaire does not collect any sensitive data from the participants, only information regarding their gender. The data are stored in the One Drive system of the Universitat Rovira i Virgili.

To correctly analyze the quantitative results, the answers to negatively formulated items were reversed. In Table 4, items with reversed answers are identified with an asterisk. The data obtained in this quantitative survey were analyzed using SPSS Statistics 29 software. The descriptors obtained from the qualitative questions were grouped according to their semantic root and frequency. Through this content analysis of the main thematic areas, we obtained different categories that allowed us to describe the perception of pre-service teachers regarding the butterfly gardens as initiatives that mitigate the decline of urban biodiversity and their relevance as a center of didactic interest.

To ensure a comprehensive and systematic analysis, this study employed a triangulation strategy to integrate qualitative and quantitative data. Triangulation enhances the validity of findings by cross-verifying different data sources and methodological approaches. In this study, methodological triangulation was used, where qualitative data from open-ended responses were analyzed alongside quantitative survey results to provide a deeper interpretation of participants' experiences.

3. Results

3.1. Pre-Service Teachers' Description from Quantitative Data

The environmental education program detailed here was carried out during the 2023–2024 academic year, and the survey was conducted four months after the pre-service teachers' participation in the project (October 2024). The sample consists of a total of 84 fully completed surveys, corresponding to 31.6% male and 68.4% female students. The reliability (Cronbach's alpha) of the survey was $\alpha = 0.734$, meaning that the whole survey consisted of one scale of high consistency, and it was deemed adequate to measure pre-service teachers' perceptions of environmental actions dealing with urban biodiversity decline.

Participants were asked about their level of agreement with a series of 13 statements that correspond to the study's research questions, as shown in Table 4.

3.1.1. Pre-Service Teachers' Perception About the Role of Urban Renaturation Initiatives

The first relevant result is that all students (100%) recognized the positive impact of an initiative such as the butterfly garden in increasing urban biodiversity. Remarkably, 69.5% of the students completely agreed with this idea. Likewise, the vast majority, 97.56%, agreed or strongly agreed with the idea that an initiative such as the butterfly garden contributes to increasing people's connectivity with nature. Despite this optimistic view, we identified that 62.18% of our students did not consider that the urban renaturation actions devoted to city biodiversity enhancement can be developed on a large scale.

3.1.2. Pre-Service Teachers' Perception About Urban Renaturation from the One Health Approach

Taking into account the pre-service teachers' answers to questions devoted to the One Health approach (RQ2), we observed that 100% of pre-service teachers agreed or strongly agreed with the idea that urban biodiversity favors animal and human health. However, when asked about more specific aspects related to the One Health framework, their opinions became more divided. More precisely, 12.2% of respondents did not consider that a space like the butterfly garden generates improvements in people's physical and mental wellbeing. And, much more relevantly, 62.19% did not agree that an increase in biodiversity helps prevent the transmission of diseases from animals to humans.

This section is devoted to the quantitative data concerning pre-service teachers' attitudes towards environmental education and their future role as environmental educators (RQ3). We found that our students had a positive attitude towards the importance of incorporating environmental education into the educational system. Remarkably, 86.5% of students agreed or strongly agreed with the idea that pre-service teachers must study an environmental course during their teacher training period at university. Additionally, they took seriously their role as a key agent in transmitting environmental values into society. In this way, 97.6% of respondents agreed or strongly agreed with the idea that it is the teachers' responsibility to include environmental issues and values in their teaching.

The last set of items, in the quantitative survey, focused on the pre-service teachers' experience around the butterfly garden as an environmental education resource. They agreed or strongly agreed (98.8%) that using initiatives such as butterfly gardens as learning centers may have a positive impact on students' environmental commitment and behavior. We have found that, although the vast majority of respondents had a positive perception, almost a quarter of the respondents (24.2%) believed that biodiversity loss is not a topic that is of interest to primary school students.

Finally, taking into account students' opinions about the professional impact of their participation in the teaching environmental program, they reported an increase in their self-efficacy in teaching environmental education (96.3% of agreement) and the realization that lots of different environmental topics could be addressed with elementary education students (97.5% agreement).

3.2. Pre-Service Teachers' Description from Qualitative Data

The descriptors obtained from the last two questions of the survey were grouped according to their meaning and frequency, allowing a deductive categorization into main thematic areas. Through these categories, we identified recurrent themes and salient perceptions of pre-service teachers regarding butterfly gardens as initiatives that mitigate the decline of urban biodiversity and their opinion from a didactic point of view. Thus, these pre-service teachers' perceptions are directly related to the impact of our PBL environmental education program. The questions focused on the reflection of the only experience they had with this environmental issue during their university training: the Butterfly Garden Science Fair.

3.2.1. Pre-Service Teachers' Descriptors About the Impact of a Butterfly Garden on Urban Biodiversity

The content analysis suggests that students perceive the butterfly garden as a multifunctional initiative with positive impacts in several dimensions: (1) strengthening urban biodiversity, (2) promoting sustainability, (3) generating environmental awareness and education, and (4) improving emotional well-being (Table 5). These findings underscore the potential of butterfly gardens as environmental educational and conservation tools, highlighting their importance in the formation of future environmentally responsible citizens.

Table 5. Main categories of the content analysis and representative words obtained from participants' responses to the following question: "Write three words that reflect your opinion about the impact that a butterfly garden like the one at the university can have on the urban biodiversity where you live."

Categories	Representative Keywords
Connection with nature and biodiversity	Biodiversity/Diversity (28) [1], Nature (23), Conservation (8), and Ecological/Ecological Awareness (4)
Positive impact and sustainability	Positive (15), Sustainability/Sustainable (12), Improvement (4), and Progress/Advancement (2)
Environmental awareness and education	Awareness (14), Education/Educational (7), and Responsibility (5)
Well-being and emotional benefits	Health (7), Wellness (5), Inspiration (5), Tranquility (4), Relaxation (4), and Happiness (2)

[1] These numbers are the occurrence frequency of each word in the sample as a whole.

The high frequency of descriptors such as Nature (23 mentions), Biodiversity (22 mentions), Environment (9), or Conservation (8) indicates that the participants perceived the garden as an effective means to reinforce the interaction between humans and natural ecosystems. This theme highlights the importance attributed by pre-service teachers to the regeneration and conservation of biodiversity in urban spaces. The second identified category is a positive appreciation of the butterfly garden's environmental impact, reflected in terms such as Positive (15 mentions), Sustainability (12 mentions), and Improvement (4 mentions). This points out that students associated the existence of the garden with a beneficial change in the urban environment, promoting sustainability and environmental resilience. A significant group of descriptors, such as Awareness (14 mentions), Education (7 mentions), and Responsibility (5 mentions), show the educational and awareness-raising dimension that students attributed to the butterfly garden. Participants perceived it as a tool to foster environmental responsibility and promote sustainable practices in society. Finally, the analysis also reveals a focus on the physical, emotional, and psychological well-being associated with the garden, represented by words such as Health (7), Well-being (5 mentions), Tranquility (4 mentions), and Relaxation (4 mentions). These responses suggest that the garden was considered to not only impact the environment but also provide intangible benefits related to mental health and connection to nature.

3.2.2. Pre-Service Teachers' Descriptors About the Impact of a Butterfly Garden on Their Teacher Training

The content analysis suggests that students perceived their participation in the Butterfly Garden Science Fair project as a multidimensional experience that positively impacted their professional training, their environmental awareness, and their motivation and commitment. The categories identified regarding this perception are described below (Table 6).

The most prominent category is focused on appreciation of learning (the learning and professional development category), with descriptors such as Learning (27 mentions), Education (7), and Knowledge (6). These descriptors reflect that student considered the experience as a key opportunity for their professional development, as it allowed them to acquire new skills and knowledge relevant to their future as elementary education teachers. The second most recurrent category is the perception of usefulness, described through words as a Useful/Utility (16), Practical (6), or Effective (2). This finding suggests that participants considered the project as a valuable experience that can be directly applied in their professional practice and daily life. One group of descriptors, namely Educa-

tional/Education (13), and Environmental education (4), highlights the importance of the pedagogical dimension of the project. Students perceived it as a significant resource for environmental education and science teaching at elementary school. Another interesting thematic area that emerges from the content analysis is the environmental awareness and sustainability category. Participants used descriptors such as Awareness (10 times), Sustainability (6), Nature (4), or Environment (4), highlighting the impact of the project in raising awareness among all participants about the importance of caring for the environment and building a more environmentally responsible future. Last but not least, we found that entertainment is another theme highlighted in our results with descriptors as Fun/Entertaining (12), Inspirational/Inspiration (7), or Motivational/Motivating (6). The project was therefore valued not only as an educational experience but also as entertaining and stimulating. Likewise, the idea of motivation reinforces the perception that the project was inspiring and promoted excitement among the participants.

Table 6. Main categories of the content analysis and representative words obtained from participants' responses to the following question: "Write three words reflecting your opinion about your participation in the project (usefulness for your professional future, lessons learned, opinions about the impact of the "Butterfly Garden Science Fair" on primary school students, etc.)."

Categories	Representative Keywords
Learning and professional development	Learning (27), Education (7), and Knowledge (6)
Utility and practical applicability	Useful/Utility (16), Practical (6), Effective (2), and Application (2)
Environmental Education and teaching	Educational/Education (13) and Environmental Education (4)
Environmental awareness and sustainability	Awareness/Consciousness (10), Sustainability/Sustainability (6), Nature (4), and Environment (4)
Fun and motivation	Fun/Entertaining (12), Inspirational/Inspiration (7), and Motivational/Motivating (6)

4. Discussion

Pre-service teachers' perceptions of the role of urban renaturation initiatives were highly positive, as reflected in the results. The fact that the urban renaturation issue is addressed in our pre-service teacher training only in the project described here indicates the positive contribution of this teaching proposal to our students' environmental knowledge and awareness of urban decline biodiversity and nature connection. It has been shown that, to promote a positive connection with nature, it is important to combine experiential elements with well-designed and well-implemented activities [43,45]. Some aspects of nature activities that predict nature connection are activities that help us to engage with nature through our senses; activities that evoke feelings such relaxation, excitement, or amazement; and activities that foster a sense of meaning and provide opportunities for learning new things [45]. According to our results, we can infer that some of these key features are found in our environmental training proposal.

Despite their overall positive perception, respondents held a pessimistic view regarding the viability of large-scale urban renaturation to enhance biodiversity. Here, we therefore find a first opportunity for improvement in our environmental teacher training program. Environmental educational approaches should focus on developing students' ability to think critically from multiple perspectives and to advocate for positive changes in their communities [20,46,47]. Therefore, we need to devote efforts to redefine the present

proposal, placing more emphasis on critical thinking and systemic thinking [20]. Any teaching program should encourage the development of a systemic understanding of environmental problems, recognizing the interconnection of multiple factors and analyzing possible solutions.

The quantitative results from items assessing the perception of the One Health approach suggest that pre-service teachers did not receive adequate training on this topic. Although during the Butterfly Garden Science Fair project, this concept was embedded in the different sessions, these results show that the One Health approach needs to be addressed more explicitly.

In the literature, we found very interesting examples of teaching proposals for environmental education under the One Health approach, although this term is not always mentioned. Different ways have been published to effectively tackle One Health education and the interconnectedness of human, animal, and environmental health. We found some activities that utilize a scenario linking pesticide use in agriculture to reproductive problems in both humans and harlequin flies [48]. Others were planned as a team effort, with students working in small groups and discussing information on the environment, animal, and human health [49]. Other activities focused on socio-scientific issues close to the students, such as the accumulation of environmental toxins in fish from the Baltic Sea [43] or local environmental issues (forest fires, gold mining, and waste management), within a Local Environmental Problem-Based Learning framework [44]. In all these cases, students were confronted with an environmental issue that was mostly close to their reality. Then, they were asked to analyze information related to the three dimensions of the One Health approach (environmental, animal, and human health) and make decisions or propose actions in order to solve the initial problem. In this way, the more holistic and interconnected vision of One Health was addressed implicitly but was always present in the training activities [48–51]. Therefore, another area for improvement in this pre-service teachers' environmental education proposal is the inclusion of an activity such as the ones described above. Another possible approach we should analyze is whether we can include a socio-scientific controversy that encompasses the three dimensions of One Health and that involves the design of a butterfly garden as a final product. In any case, we should improve our training proposal by including more explicitly the interconnection of human, animal, and environmental health.

Our findings show that students have a positive attitude toward incorporating environmental education into their teaching learning and future practices. Whether the students' training in this module shaped their overtly pro-environmental attitude is impossible to know from our results. In any case, it is important to point out that previous studies have found the same pro-environmental attitudes of pre-service teachers' students, and these attitudes were improved during academic studies but not in a statistically significant way [44]. This fact points out the need to devote more efforts to environmental education research and improving its teaching during pre-service teachers' training.

It has been shown that aspects of specific activities, such as emotional engagement and learning opportunities, are crucial for promoting positive nature-related outcomes, such as biodiversity loss [45]. Maybe, in order to improve pre-service teachers' perception that biodiversity loss is not an interesting topic, we can include some activities oriented to intensifying an emotional connection to this topic. We can choose and focus more attention on charismatic species or even those perceived as unpleasant as a claim [13].

It is interesting to note that our qualitative results support and complement our quantitative results. Statements in the quantitative survey that address the impact of respondents' participation in the project were those related to RQ3 (Table 4). As mentioned in the quantitative results section, participants showed a mainly positive or strongly positive belief in

the importance of environmental education and the role of teachers in this endeavor. In the same way, the qualitative analysis showed also a positive vision that can be extracted from the emergence of categories such as "learning and professional development", derived from words such as Learning (27 mentions), Education (7), or Knowledge (6), or "utility and practical applicability", derived from words such as Useful/Utility (16), Practical (6), or Effective (2). In the same way, the main categories that emerged when participants were asked about the impact of the butterfly garden on urban biodiversity show a clear correlation with statements related to RQ1 and RQ2 (Table 4). The category "connection with nature and biodiversity" strongly correlates with the respondent's opinion about the statement "Urban renaturation initiatives, such as the butterfly garden, increase people's connection with nature", with which 97.56% of respondents agreed. Similarly, the emergence of categories such as "positive impact and sustainability", "environmental awareness and education", and "well-being and emotional benefits" also supports the mainly positive perception and beliefs expressed in the quantitative survey about the garden, its impact on improving biodiversity, and human well-being.

It has been reported that it is quite difficult to prove the effects of educational proposals on environmental attitudes [44]. The use of mixed methods, both quantitative and qualitative, has proven to be one of the best ways [25,28,42,43]. Considering our study and based on the qualitative results, we presume that some of these positive attitudes were obtained as a result of their participation in the PBL environmental program. It should be noted that the very specific topic of the decline of urban biodiversity and the proposal of the butterfly garden was only addressed in the present environmental program. The descriptors provided by the students in the qualitative questions can only come from their reflection on this specific training activity. The results show that pre-service teachers reported positive perceptions of butterfly gardens after participating in our environmental program, recognizing them as both a valuable resource for environmental education and an effective initiative to mitigate urban biodiversity decline. Overall, this program not only met the learning outcomes related to environmental education but also contributed to the personal and professional development of the students, preparing them to be agents of change in society through their role in elementary education, which are objectives of the teacher training dimension of this study.

In summary, we found that the pre-service teacher students, after participating in our PBL environmental program, showed awareness from an environmental perspective of the problem of declining urban biodiversity and the specific renaturation initiatives of butterfly gardens. They showed a deepened knowledge and recognition of the butterfly garden initiative's potential for increasing urban biodiversity, promoting sustainability and environmental resilience and also improving citizens' connectivity with nature. Interestingly, they highlighted the role of this kind of garden on enhancing human well-being from emotional and psychological perspectives. They also considered that a butterfly garden could be a tool to foster environmental responsibility and promote sustainable practices in society. When analyzing pre-service teachers' perceptions towards the formative impact of the PBL environmental program presented here, they widely used words such as Learning, Useful, Utility, Educational, Awareness, Fun, and Inspirational. They expressed that this program had a positive impact on students' environmental commitment and behavior. It was perceived as a key opportunity for their professional development, an inspiring and valuable experience that can be directly applied to their professional practice. All these perceptions seem to be fairly permanent since the survey was conducted four months after the end of the training program.

Additionally, quantitative analysis allowed us to identify some aspects of our proposal that need to be improved. The design of pre-service teachers' training programs should

take into account the characteristics of the student population, which are influenced by their social, cultural, and physical environments, and include all the necessary components for adequately preparing future educators to effectively address the environmental education of their future elementary students [20,28,43,44,46,47,51]. Among these components, we should include in our teaching task the treatment of environmental problems close to our students from a perspective of systemic thinking guided toward action, which takes into account the multidisciplinary and multifactorial structure of the environmental problems that, as a society, we have to deal with. This interconnection is well addressed under the One Health approach [44,47–49,51]. As we found in our results, the inclusion of this holistic view needs to be well planned, and activities should explicitly include the interconnection of human, animal, and environmental health. We found that without explicit and intentional thinking and reflection on the three dimensions of One Health, students did not overcome their negative and often wrong perceptions (i.e., role of biodiversity in preventing zoonosis or the idea that there is plenty of room to improve biodiversity in urban areas).

Our results support the idea that it is pivotal to design and implement environmental activities through direct contact with nature (e.g., through a butterfly garden) to encourage all these reflections that positively affect the environmental perceptions of future teachers [24–28]. We emphasize the importance of implementing educational programs in pre-service teacher training on environmental education issues that simultaneously tackle conceptual (greater environmental literacy), affective (greater connection with nature, impact on well-being, and One Health approach), and methodological (increase in their self-efficacy as teachers in environmental education) dimensions. From this need to improve the environmental education of future teachers and to provide reference activities to inspire them, we can also add that a main contribution of this work is the creation of a web space within the Environment Department of the URV, where the activities designed by the university's students for the Butterfly Garden Science Fair are published. The link to this space is https://www.urv.cat/ca/vida-campus/serveis/medi-ambient/biodiversitat/firadelaciencia/ (accessed on 23 January 2025).

5. Conclusions

The present environmental education proposal is focused on the issue of urban biodiversity decline and the initiative to implement butterfly gardens in these areas to mitigate it. For this purpose, we used the butterfly garden on campus at the Universitat Rovira i Virgili where the Faculty of Education is located. As the framework for our work, the butterfly garden can symbolize a commitment to sustainability while providing inspiration for how similar initiatives can be developed in other academic or community contexts.

We use a mixed methodology, namely a survey with both a quantitative and qualitative section, to characterize the perceptions of the pre-service teachers' students about different aspects four months after the end of the PBL environmental program. Quantitative data elucidated the pre-service teachers' perceptions about the topics of urban biodiversity decline (aligned with RQ1); the impact of renaturation in environmental, animal, and human health under the One Health paradigm (RQ2); and the importance and usefulness of environmental education (RQ3). The qualitative data provide information on students' perceptions about the impact of a butterfly garden on urban biodiversity (RQ1) and the impact of their participation in this Butterfly Garden Science Fair project (RQ3).

The results suggest that pre-service teachers' students showed awareness of the urban biodiversity decline issue. Specially, they showed a deepened knowledge and recognition of the butterfly garden initiative's potential for increasing urban biodiversity and promoting sustainability, environmental responsibility, and environmental resilience. From the human health perspective, they perceived that butterfly gardens facilitate citizens'

connectivity with nature and contribute to enhance human well-being, also from emotional and psychological points of view. However, these students were not able to perceive the role of biodiversity from a wider perspective (for example, recognizing the interconnection between biodiversity, animal health, and zoonosis). This result points out that in pre-service teachers training programs, the One Health approach needs to be addressed explicitly. Our results show that without explicit and intentional thinking and reflection on the three dimensions of One Health (environmental health, animal health, and human health), students do not overcome their negative and often wrong perceptions, and they do not deal with biodiversity decline from a wide and holistic perspective. Therefore, more programs devoted to biodiversity decline in urban settings should be designed that include the One Health approach as a learning outcome.

When analyzing students' views on environmental education, they showed a strong pro-environmental attitude. They recognized the importance of environmental education, and they took responsibility in their key role in transmitting environmental values into society. Taking into account the impact of the PBL environmental program under a pedagogical lens, we found a very positive impact on pre-service teachers' students. This experience positively impacted their professional training, their environmental awareness, and their motivation and commitment. Notably, it was perceived as a key opportunity for their professional development, an inspiring and valuable experience that can be directly applied to their professional practice. Remarkably, they reported an increase in their self-efficacy in teaching environmental education after participation in this PBL environmental program.

In summary, we present here an environmental training proposal for pre-service teachers' students on the issue of urban biodiversity decline. The use of a butterfly garden for teaching purposes offers a wide range of outcomes: insights into environmental literacy, connection with nature, and improved wellbeing. Thus, it is a powerful platform for deep and meaningful pedagogical learning.

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Institutional Review Board Statement: Ethical review and approval were waived for this study due that it does not collect any sensitive data from the participants, who agreed to the questionnaire on a completely voluntary basis and, above all, this study does not collect any data that could identify the participants, so their anonymity is guaranteed. Data collection was carried out on-line and the authors only contacted via e-mail to request their participation, without any in-person interaction with them that could lead to coercion. The study is not student-centered, but rather their opinion helps us to assess our educational proposal. Therefore, the data collected are considered as a monolithic whole, without focusing on identity aspects, socio demographics or other factors concerning the profiles of the participants. Nevertheless, to collect the data we followed the procedure required by the ethical committee of our university, which is described in Section 2.3 Data source, data collection and analysis.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

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