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Promoting sustainability training in future teachers through research workshops in the University Ecological Garden

Summary

The current planetary crisis and the changes in the Spanish curriculum of Early Childhood Education require teacher training that enables future teachers to respond to these situations. This paper describes a constructivist teaching-learning sequence framed within the University Ecological Garden through an enquiry-based strategy. This educational intervention was carried out with third-year students of the degree in Early Childhood Education at the Universidad de Cádiz (Spain). Its outcome was a science dissemination event in which research workshops related to one or several sustainable development goals were organised. The validity of using real contexts like the garden space to achieve sustainability in the curriculum and of contributing to the scientific training of future teachers for them to be able to transfer educational interventions within the framework of sustainability was verified. Future proposals for improvement for a second implementation in the classroom were analysed.

Keywords: scientific knowledge, enquiry, garden, sustainability in the curriculum

Słowa kluczowe: wiedza naukowa, zapytanie, ogród, trwałość w programie nauczania

Introduction and objectives

Education, in its broadest sense, is constituted as an effective tool to bring about medium and long-term changes in citizenship. These changes are considered necessary because of the effects caused by human activities in our environment (UNESCO 2014, 2018). Human survival is at stake, as changes at the planetary level are observed that affect the environment, the economy and society in general. In this context, the Education for Sustainable Development (ESD) approach is considered an appropriate tool to achieve the Sustainable

Development Goals (SDGs), and to comply with the 2030 Agenda. It is therefore necessary to incorporate ESD into all areas of formal, non-formal and informal education. It is particularly important to include it in initial teacher training of all educational levels. In our case, the training of future Early Childhood Education teachers is considered.

Ensuring quality education is part of the responsibility of all educational institutions. It is even more necessary at universities, as they are responsible for ensuring their graduates have acquired the necessary knowledge and skills in sustainability (Ferguson Roofe 2019). As governments of different countries start to include the precepts proclaimed by the UN into their legislation, the curricula of future education professionals are being modified. This implies that being able to teach means demonstrating professionalism oriented towards sustainability. Target 4.7 of SDG 4 explicitly includes the following commitment:

By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development (United Nations 2015: 20).

It is therefore key to train those people that are going to be responsible for teaching ESD to children and adolescents. In other words, the teachers that are going to act as agents of change. The UN suggest this approach to education. It makes sense if it is an instrument to bring about the change we need. As Delors (1996) stated, education should permeate all spheres of life on the planet for it to generate a change in our conceptions about economy, society and the environment. Education should therefore be used in all its facets: formal, informal and non-formal; and from the approach of lifelong education (Delors 1996), but by using its main promoters, teachers, as the ones responsible for implementing this change. Initial and permanent teacher training is one of the key elements in this transformative goal.

The objective of this study is to describe a constructivist teaching-learning sequence (TLS) through the implementation of an enquiry-based strategy (EBS) in which the students, future Early Childhood Education teachers, design interactive research workshops (RWs) within the framework of one or several SDGs around scientific content for Early Childhood Education. The workshops take place during a science dissemination event held at the University Ecological Garden (UEG). A first assessment of the workshops is performed through two instruments: 1) a final report prepared by different teams of students throughout the subject, and 2) an assessment of the students who participated in the workshops through an on-line questionnaire after the event.

Theoretical framework

The 2030 Agenda and the SDGs: incorporating sustainability into the university curriculum

The starting point of this study are the UN resolutions, which serve as a global reference framework. The UN resolution of September 2015, A/RES/70/1, which includes the SDGs and their targets, is of particular relevance. In point 5 of the introduction, the following is stated:

This is an Agenda of unprecedented scope and significance. It is accepted by all countries and is applicable to all, taking into account different national realities, capacities and levels of development and respecting national policies and priorities. These are universal goals and targets which involve the entire world, developed and developing countries alike. They are integrated and indivisible and balance the three dimensions of sustainable development (United Nations 2015: 3, A/RES/70/1).

Shortly before, in 2014, UNESCO published a *Roadmap for implementing the global action programme on Education for Sustainable Development*. This document stresses the global need to focus efforts on training the population in the key concepts and actions for sustainable development. ESD is considered to be a key tool for the implementation of a new global action perspective. This implies considering two key aspects: first of all, the need for political authorities worldwide to assume the incorporation of ESD into educational systems. Ministries of Education should assume the responsibility of ensuring educational systems are prepared to face current challenges. Secondly, ESD should be key in teacher training, as future teachers should not only be trained in sustainability during their initial teacher training, but also throughout their permanent training. UNESCO (2014) establishes that priority actions should be aimed at training educators and teacher trainers, and at integrating ESD into the university curriculum. Incorporating sustainability in the curriculum is therefore not regarded as a requirement, but as a need.

In Europe, Malešević and Mihaljević (2020) carried out a study focused on quantifying the efficiency of European universities in achieving the SDGs. To this aim, they used the data published by University Impact Rankings. The institutions attaining the highest ratings are the ones that, in addition to conducting research and publishing results, focus their efforts in areas such as gender equality, quality education for all, climate change, the achievement of peaceful societies, and economic growth. It is a matter of prestige and academic recognition to introduce sustainability-oriented policies at the European level. However, no consensus has been reached in Europe, nor in the rest of the world, with regard to how to measure sustainability or the scope of each SDG and its targets. Lepenies et al. (2023) consider this difference between countries is due to their different interpretations of the concept of sustainability. This aspect is relevant when it comes to standardising the meaning of terms related to sustainability to be able to compare national policies without interpretive bias.

At the national level, the university reform developed in Spain by Organic Law 4/2007 contributed to introducing sustainability into the curricula of some university degrees. However, it is not just about including sustainability in several degrees, but also about making efforts to include sustainability and the SDGs in the governance of universities. Blasco, Brusca, Labrador (2021) conducted a study that evaluated the influence of certain internal factors on the success of including the SDGs in Spanish universities. They concluded that the presence on the Internet, the internationalisation of the university, and the financial resources for research and infrastructure received from regional governments are key factors for Spanish public universities to promote the SDGs better.

In the context considered here, the Universidad de Cádiz (UCA, Spain), two key moments are worthy of note with regard to integrating sustainability into the academic management of the university. First, an Office of Sustainability was set up during the 2004/2005 academic year, and second, UCA explicitly included the SDGs and the 2030 Agenda in the third update (UCA 2021) of its strategic plan. However, it is necessary to introduce more in-depth changes in the different degrees and curricula considering the difficulties observed in the training of future teachers in terms of sustainability, the SDGs, and methodologies from the perspective of ESD. This has been confirmed by recent studies (García-González, Jiménez-Fontana, Azcárate 2020a, b; Aragón, Casanova 2022).

The University Ecological Garden as a learning context for scientific training and ESD

School gardening as a learning environment is a resource widely used internationally (Blair 2009). In the US, for instance, an educational strategy called “Garden-based learning” started to be implemented in the 1990s. An integrated approach was used through active, motivating, and connected experiences (Desmond, Grieshop, Subramaniam 2002). Several studies show its didactic potential to develop skills related to scientific knowledge (observing, asking questions, analysing, etc.), critical thinking, scientific discourse, and favourable attitudes towards science from an early age (Kim et al. 2020; Aragón, Sánchez, Enríquez 2021). It promotes the willingness of students to taste different vegetables and fruits (Robinson-O’Brien, Story, Heim 2009; Ohly et al. 2016; Holloway et al. 2023). The garden encourages reconnecting with nature through designing friendlier and greener playgrounds that promote the development of a positive environmental attitude and empathy towards nature (Wallace 2019). School gardening contributes to the social, physical, personal, and moral development related to motivation, self-esteem, and self-concept (Williams, Dixon 2013; Kearey-Moreland 2023).

In Spain, in the past decade, there has been a tendency to include gardens in initial teacher training, taking into account the role of future teachers when it comes to managing and using these spaces for learning. Gardens have mainly been used in the field of Didactics of Science (Eugenio Gozalbo, Ramos Truchero, Vallés Rapp 2019; Zuazagoitia et al. 2021; Aragón, Gómez-Chacón 2022; Eugenio-Gozalbo et al. 2022) and from the

perspective of different paradigms, such as environmental education (Eugenio, Aragón 2016), degrowth and environmental literacy (Rodríguez-Marín, Portillo Guerrero, Puig Gutiérrez 2021), and sustainability and the SDGs (Aragón 2017; Eugenio et al. 2018).

The enquiry-based strategy and research workshops to develop scientific competency in future teachers

The enquiry-based strategy has a long-standing tradition in education, and in the past decade it has been used increasingly, mainly to motivate students to learn science (Caamaño 2012). Together with modelling and argumentation, it shapes the scientific practices that encompass the current approaches of the purposes of science education (National Research Council 2012). Of the different meanings that exist of the term “enquiry”, this paper uses the one that refers to the various educational strategies used by students to develop enquiry skills, learn about scientific enquiry, and understand and learn scientific concepts (Barrow 2006). The EBS is contextualised in a constructivist framework of learning, and is the result of a transposition to the classroom of how scientists do science (Anderson 2002). According to Martin-Hansen (2002), when it is guided by teachers, significant improvements in science teaching and in the development of scientific skills in students are observed. This facilitates the acquisition of scientific competency, and promotes a positive attitude towards science (Alferi et al. 2011). Mule (2006) presents it as a strategy with great potential to prepare future teachers. However, it is hardly used in the classroom, as teachers do not assume its importance or need (Quílez et al. 2008).

There are different ways of interpreting an EBS when it comes to implementing it in the classroom. In this study, the guidelines established by several authors have been considered (Martínez-Chico, Jiménez Liso, Lucio-Villegas 2015; Couso, Jiménez-Liso 2020): 1) defining what should be known considering previous conceptions, and connecting them with the learning objectives; 2) formulating justified explanations (hypotheses that express a relationship between variables); 3) searching for evidence that allows contrasting the explanations through data obtained through experimental designs using different techniques and instruments; 4) analysing and interpreting the data collected, adapting the explanations initially formulated to the new information, thus improving its validity or usefulness, and 5) drawing conclusions from the results through tests, confirming or questioning ideas, and finally, communicating them.

As for the RWs, they seek to promote the conceptual, attitudinal and evaluative change on a specific topic, object, or activity in participants. They also combine theory and practice (Rodríguez Sánchez, Vargas Ulloa 2009). RWs are interactive strategies that promote research, and stimulate other learning linked to the intellectual, interpersonal, and social dimensions closely related to the development of scientific skills (Bonilla 2017). According to García-Guerrero et al. (2020), RWs are a means of disseminating science and technology in which experiences and knowledge are built by those who design the workshop together with those who participate in it. They are therefore an interactive science teaching

and learning model, which, according to Wenger (2011), enable creating communities of practice, that is, a group of people involved in a collective learning process around a specific domain of knowledge.

Methodology

The TLS was designed in the subject of Teaching the Natural Environment (TNE) taught in the first semester of the third year of the Degree in Early Childhood Education at the Universidad de Cádiz (Spain). It is the only compulsory subject of a scientific nature in the degree. The TLS is part of the Teaching Innovation Project called “Science in the vegetable garden: Interactive research workshops to contribute to the scientific training of future Early Childhood Education teachers” (sol-02200229409-tra) for the 2022–2023 academic year.

It was implemented in fifteen sessions of one and a half hours each with half the students of the class (while the other half was taking another subject), combining two spaces: the classroom and the garden (Appendix 1). The entire class consists of 67 students (97% female) aged between 19 and 23. The students were divided into twelve workteams (WTs) of four to six members each.

The UEG is located in an inner courtyard of the Faculty of Education Sciences, which occupies an area of 68 m². It combines different structures and elements. There are five garden plots (Fig. 1A), a learning area including desks and a blackboard, a storage area, a worm composting area (Fig. 1C) and a structure that holds a vertical garden and three insect hotels (Fig. 1B).

The TLS is structured into two phases. The objective of phase 1 is twofold: 1) bring students closer to the space of the UEG, and agree with them on the implications and future actions to be carried out based on the premises of being “ecological” and “didactic”, and 2) for the students to experience an EBS designed by the teacher first-hand to test the health of the soil in the garden. In Phase 2, the students initiate small enquiries in the garden with the help of the teacher. They are put into practice through RWs in a science dissemination event. At the beginning of Phase 2, two aspects are agreed on together with the students:

- the workshops are structured based on the steps of an EBS regarding a topic related to the garden;
- The topic chosen should be considered in the curriculum of the degree of Early Childhood Education and should address one or more SDGs.

Throughout the TLS, different instruments were used to assess the workshops. On the one hand, each WT was asked to deliver a final report of a length between 14 and 16 pages. This report was submitted upon completing the subject and consisted of a compilation of the activities that constitute the TLS itself, as well as a critical reflection on their performance after the science dissemination event. On the other hand, the students were asked to



Figure 1. Layout of the University Ecological Garden of the Faculty of Educational Sciences Universidad de Cádiz: A) garden plots; B) vertical garden, grow table and insect hotels; C) worm composting bins

Source: own elaboration.

complete an on-line questionnaire of 19 open- and close-ended questions (using a 5-point Likert-type scale) designed by the teacher to individually assess each of the workshops in which the students participated during the event.

Results

Description of the TLS

Phase 1: What is an eco-educational garden? And what is the soil in the garden like? Is it cultivable?

The purpose of session 1 is to bring students closer to the space of the UEG and gather their previous conceptions of this resource, its use in Didactics of Science and in Early Childhood Education. The idea is to know the garden model they have and awaken their

interest in this space as a place for learning and teaching science. For activity 1, they were asked the following question: **“What is an eco-educational garden?”** The students responded by developing a document together, first with their team, and then with the entire class. In this document, they presented their ideas regarding three aspects: a) what does ecological mean?; b) what does educational mean?, and c) starting from a hypothetical situation of beginning to work at a school and wanting to create a garden, what ecological and educational actions would be given priority?

In activity 2, the students visited the UEG in teams, and had to identify its different areas and elements. To do this, the teacher provided them with an exercise script to collect and share the information gathered. Back in the classroom, they held a discussion and reflected on the garden model they had in mind. In general, they expected to find a more traditional garden, and no one organised into garden plots with grow tables, or a vertical garden, which most of them had never heard of. Only some students identified elements such as insect hotels, worm composting bins, and very few knew the role of worms in recycling organic matter.

In the subsequent sessions (session 3 to the first part of session 7, activity 17, Appendix 1), the different WTs carried out research with their respective teams to test the health of the soil in the garden through activities designed in a previous study (Zuazagoitia et al. 2021), following the steps of the EBS mentioned earlier. Conducting research (Fig. 2A and 2B) allowed the students to become familiar with the strategy and to analyse the socio-environmental problems and the SDGs linked to the soil in more detail. In short, this phase was meant as “training” to develop Phase 2 of the TLS (Appendix 1).

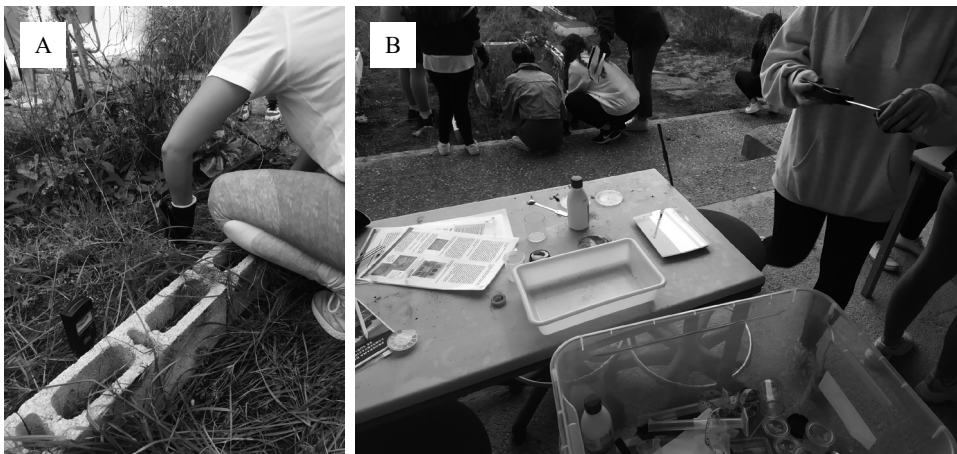


Figure 2. Conducting research on the health of the soil in the garden during Phase 1: A) collecting information on the pH of the soil; B) materials necessary to carry out the research

Source: own elaboration.

Phase 2: Design of Research Workshops (RWs) in the degree in Early Childhood Education following the EBS in the context of the UEG and regarding one or several SDGs

Phase 2 started in the second part of the session 7 (Appendix 1, activity 18) in which the WT selected a topic to design a research workshop following the steps of the EBS contextualised in the garden. The teacher used the conclusions of activity 1 of Phase 1 as a starting point. In activity 18, the teacher presented the structure of the final report that each team had to deliver of their workshop at the end of the subject. Likewise, she provided them with bibliographic material to begin the search for information related to their topics.

In session 8, each WT presented their conceptual map developed as a synthesis of the topic worked on in their research workshop, in which they highlighted the SDGs related to their workshop. It was a reflective session in which questions were asked and contributions were made between the different WT and the teacher. It helped define the central theme of each RW, and helped the students gain more knowledge about the SDGs. It was surprising to see that none of the teams considered SDG 4 (Quality Education).

Sessions 9, 10 and 11 were key to make progress in planning the RWs. The teacher specified guidelines and offered information on how to ask searchable questions, formulate hypotheses, and design experiments in accordance with several studies (García, García 1993; Ferrés Marbà, Sanmartí 2015). These scientific skills were the ones the future teachers had the most difficulties with when planning and carrying out their research (Aragón, Gómez-Chacón 2022).

- For the **problem question** guiding the RW, the following was stressed: it could not just be a simple question. Gathering data, measuring, organising information, manipulating and observing the different elements in the garden, etc. had to be included. It was considered preferable to use one central general question and a few secondary questions. The problem question had to be resolved by the participants of the workshop, and it had to be motivating, in the sense that it had to arouse curiosity and the desire to act. It also had to be related to daily life experiences.
- With regard to the **hypotheses**, they had to be formulated as assumptions and predictions, using the following expression: “If we believe that... then, if... we will observe that...”
- The **experimental designs** should enable obtaining results through experiences or techniques, which, after their analysis, would allow accepting or rejecting the hypotheses. The idea of mainly promoting scientific skills (observing, manipulating, collecting data, etc.) was stressed.
- The materials and resources available in the garden had to be known depending on the topics addressed in the workshops.
- The educational stage the research workshop was aimed at was specified, as well as the curriculum specifications: core competencies, specific competencies, and the basic knowledge the students wanted to address in their workshops. They were therefore asked to focus their workshop on children aged between 3 and 6 years and adapt it to the current Early Childhood Education curriculum (Real Decreto 95/2022).

In session 12, the different teams finished designing their RW based on the previous aspects, following the steps of the EBS. In the garden, the students started organising the resources for their proposals. In session 13 (Appendix 1, activity 28), each team explained their RW to the rest of the teams, and the teacher and the rest of the classmates provided feedback. This session allowed the workshops to be better adjusted, and organisational aspects for the science dissemination event were decided on together: spaces, duration of each workshop, materials required, number of students per workshop, etc. In session 14, the teams rehearsed what they were going to do in their workshops and recreated them in the UEG to adjust the duration of their RW to the time available, and to finish preparing the necessary materials.

In session 15, the science dissemination event was held for a total of three hours. However, as it was impossible for pre-school children to visit the UEG and carry out the workshop activities, the future teachers decided they would do them in turns. Two shifts of an hour and a half each were organised. Work teams 1 to 6 acted as teachers first, while teams 7 to 12 adopted the role of participants in each workshop. In the next shift, the roles were reversed, and teams 7 to 12 acted as teachers and teams 1 to 6 as students. Each workshop was held twice for a duration of 30 minutes each. The students were distributed randomly in each workshop to encourage interaction between the members of the different teams. At the end of the workshops, the students completed the on-line assessment questionnaire.

Some results of the research workshops designed

Final report on planning and assessing the RWs

Table 1 summarises the main sections of the final report prepared by the work teams. A wide variety of topics, all directly related to the garden, were addressed: water and irrigation systems (WT1), plant biodiversity (WT3, WT7, WT8), seeds (WT9) and insects (WT2), auxiliary plants (WT9), diseases and pests (WT5 and WT11), worm composting (WT6), and the vertical garden (WT4, WT12). The problem questions constituting the backbone of the RWs were considered relevant and suitable for adjusting to the criteria based on the guidelines provided in each session. The results show the importance of considering two aspects of the TLS: 1) the need to agree with the students on specific guidelines that help address the problem questions; and 2) organise several sessions in order to share the progress of the students' research and obtain feedback (from the teacher and classmates) on each of the steps in the EBS.

As for the SDGs, 75% of the teams link their research to two of them: SDG 15 (Life on Land) and SDG 12 (Responsible Production and Consumption). Although only 50% of the teams include SDG 4, it is still a significant result considering that at the beginning of the TLS, none of the teams had considered it.

Table 1. Brief description of the Research Workshops based on the final report drawn up by the workteams

Team	Topic	SDG	Problem question	Techniques and experiences planned
1	Water in the garden and irrigation systems	6, 7 and 17	Why is water important and necessary in our garden?	Use of different irrigation systems and reflecting on which the most efficient one is
2	Biodiversity of insects:	13 and 15	Which insects could be good for the garden? Why?	Manipulating materials to build the insect hotel Explanation of each element (pine cones, stones, dry leaves, etc.) coming from the garden or from nearby surroundings Identifying and observing insects Building the hotel
3	The plants in the garden	1, 3, 6, 7, 13, 12 and 15	What do plants need to grow and live?	Preparing the garden plots and planting seeds Identifying the plants and associations between plant families. Perform tasks of fertilising, planting different plant families, applying the mulching technique, and watering
4	Vertical garden	1, 2, 6, 12, 13 and 15	Where can we grow plants?	Observing and comparing the vertical garden and other kinds of gardens: shapes, sizes, types of plants, parts of plants Observing plants already planted in the vertical garden Showing the materials available to design and build the garden Building a vertical garden
5	Diseases and pests of the plants in the garden	1, 2, 3, 12 and 15	Can plants get sick?	Visit to the garden and labelling the different plants in each plot Explaining the different diseases plants can have Elaborating bio-preparations for some of the plants and applying them in the garden
6	Worm composting	3, 4, 12 and 15	How do the worms in our garden live?	Observing the characteristics of worms: eyes, nose, age (if they are young or adult; the clitellum can only be seen in adult worms). Preparing a drawer of the worm composting bin using organic waste. Experience the effect of light and humidity on worms
7	Cultivated biodiversity: lettuce	1, 3, 4, 12 and 15	Is lettuce a plant?	Observing seeds and samplings of different kinds of lettuce and preparing a garden plot to grow them

Table 1. cont.

Team	Topic	SDG	Problem question	Techniques and experiences planned
8	Cultivated biodiversity: cauliflower	2, 6, 12 and 15	What is a cauliflower? How does it grow and what does it need to grow?	Observing the cauliflower plant in the garden plot: leaves, stem, root. What other plants are they associated with? Observation of cauliflower seeds to be planted
9	Biodiversity of seeds	1, 2, 4, 6, 12 and 15	What are seeds used for? Where do they come from?	Manipulating different types of fruits and vegetables Observation and extraction of seeds Identification of several seeds of the plants in the garden
10	Auxiliary plants in the garden	3, 4, 12, 15 and 17	What are aromatic plants? What do you think they are used for?	Walking around the aromatic spiral, using our senses Explaining the effect of light/shade on how plants are arranged Relationship between type of plants and associated insects Preparing products: aromatic sachets and rosemary alcohol
11	Natural traps to avoid pests in the garden	4, 12 and 13	How can we protect the plants in our garden?	Searching and identifying plants in the garden Gathering data on the condition of the plants and the presence or absence of pests Preparing natural traps in accordance with identified diseases
12	Vertical garden	4, 7 and 11	What materials are necessary to build a vertical garden?	Presentation on different existing structures and shapes to create a garden Reflection on the use of recycled materials (milk cartons, plastic bottles) Exploring previous ideas about types of plants and elements necessary for their growth Building a vertical garden with the materials presented and some suitable plants for this type of garden

SDG – Sustainable Development Goals

Source: own elaboration.

In 2015, the UN established the 17 SDGs organised into five critical areas of importance: **people** (SDGs 1, 2, 3, 4 and 5); **planet** (SDG 6, 12, 13, 14 and 15); **prosperity** (SDG 7, 8, 9, 10 and 11), peace (SDG 16) and partnership (SDG 17). The RWs addressed different topics (Table 1) mostly related to the **planet** are as of the SDGs, but also to **prosperity**. Only WT1 and WT3 included SDG7 (affordable and clean energy). None of the teams considered SDG 5 (gender equality) or SDG 16 (Peace).

All the SDGs are integrated and interconnected, and interventions in one area have an impact on the results of others. Their development should therefore balance environmental, economic and social sustainability. According to Gómez-Gil (2017), the SDGs allow proposing systemic responses to a global and interrelated view of sustainable development to address extreme poverty or unsustainable consumption patterns, which were not addressed by the Millennium Development Goals (MDGs). However, future teachers seem to relate their research more easily to the SDGs linked to the **people** and **planet** are a sin detriment of the ones related to **prosperity**, **peace**, and **partnerships**. To a certain extent, this is to be expected, since their studies focus on phenomena and natural elements in the garden. Therefore, perhaps, certain SDGs are not being considered in the subject. This may be a weakness that should be taken into consideration in future implementations. The development of a systemic and interrelated view between the SDGs of the different areas should be encouraged.

With respect to the techniques and experiences used in the RWs, they were focused on developing scientific skills and abilities (a total of 34 kinds). Of all the skills and abilities, 38.2% referred to the observation aimed at identifying or recognising different elements in the garden (plants, insects, pests, etc.). 32.3% were manipulative skills, such as preparing a garden plot, or manufacturing things such as natural traps and bio preparations, as well as building structures for the vertical garden and the insect hotel. To a lesser extent, linguistic skills enabling the construction of scientific knowledge were considered (Santmartí 2007), such as associating or explaining (14.7%). 5.8% alluded to more complex cognitive processes like reflection, and only 2.9% referred to data collection. The results show that the UEG is a learning space that has great didactic potential to develop scientific competency, especially in its more procedural dimension, as other studies have pointed out (McArthur et al. 2010; Aragón, Gómez-Chacón 2022; Eugenio-Gozalbo et al. 2022).

One of the benefits mentioned in the final reports upon completing the RWs was that all the work teams stressed the interest and involvement of the workshop participants. For example, WT9 commented their engagement had a positive impact on their own performance: “Our classmates’ involvement contributed to the smooth running of the workshop, and it also motivated us in our actions as teachers”. It is considered a relevant aspect, since it is clear that workshops held in real contexts encourage students to become actively involved in a collective learning process, in this case natural processes related to the garden. This was already pointed out by Wenger (2011). Three WTs (2, 7 and 9) referred to the personal satisfaction of being able to run the workshop as previously planned. It is thus observed that the experience generated positive emotions that are likely to have an impact on the students’ learning, and when considering the garden as a didactic resource in future teaching practices.

Regarding the main weaknesses and improvements to be made in their workshops, the work teams mentioned changes to adapt them to research workshops. For instance, WT4 commented: “The vertical garden should be placed at a more suitable height for pre-school children”. WT6 mentioned that “some classmates were repulsed by worms.

Perhaps the workshop should start with interesting facts about worms to awaken the participants' curiosity about worms, hence minimising their prejudices".

Participants' assessment of each research workshop

The answers the students provided to assess the RWs organised during the science dissemination event are shown in Table 2. Of a total of 57 students who completed the questionnaire, a large number of participants assessed the workshop positively in the different aspects indicated.

Table 2. List of items of the on-line assessment questionnaire and the percentages of the results obtained

On-line questionnaire items	Results*
The organic garden in the subject is a valuable space for the scientific training of future early childhood education teachers	96% strongly agree or agree
The organic garden has contributed to my training with regard to the SDGs	96% of the students strongly agree or agree
While designing my workshop, I received useful feedback from the teacher	91% of the students strongly agree or agree
While designing my workshop, I received materials and resources from the teacher that were satisfactory for its implementation	92% of the students strongly agree or agree
While designing my workshop, I received appropriate feedback from my classmates to organise it	86% of the students strongly agree or agree
The workshop clearly followed an enquiry-based sequence worked on throughout the subject	98% of the students strongly agree or agree. Only 2% disagree
The workshop enables providing an answer to the question posed at the beginning of the workshop	98% of the students strongly agree or agree. Only 2% disagree
The workshop allows working on one or several SDGs	96% of the students strongly agree or agree. The remaining 4% disagree
The workshop enables developing certain scientific abilities or skills such as formulating hypotheses, observing, manipulating, analysing data, communicating ideas, etc.	98% of the students strongly agree or agree
The workshop manages to awaken interest in science and the desire to know more about the topic	98% of the students strongly agree or agree
Finally, indicate if you would use it as a future teacher or during your internship period	39% of the students would use it without any modification. 59% would use it, but adding certain improvements. The remaining 2% would not use it

* A 5-point Likert-type scale was used for the responses (5 – strongly agree to 1 – strongly disagree).

SDG – Sustainable Development Goals

Source: own elaboration.

The results show a positive impression on behalf of the students of the use of the garden to improve their scientific training, integrate active methodologies such as EBS, and their knowledge about the SDGs. In line with similar studies, future teachers generally value the educational experiences in the context of the garden positively, especially to develop professional teaching skills (Hurtado-Soler et al. 2020). They consider the garden as a valuable environment to learn science, and to address sustainability and climate change globally (Corrochano et al. 2022). These results show it is important to continue using this resource in initial teacher training.

The benefits identified by the participants, out of a total of 55 responses, were classified into three categories. The first one includes the statements related to the methodology used in the classroom. The students used terms such as dynamism, interactive, or playful approach, activities with a hands-on approach, etc. This category obtained 76.3% of the responses. The second category refers to the importance of peer learning. The dynamics developed in the workshop enabled putting forward and sharing ideas with other students. This factor was the most important benefit identified by 10.9% of the students. Finally, the contents taught and learnt were the most relevant part of the workshop for 12.7% of the participants.

Regarding the weaknesses of the workshops or aspects to be improved, a total of 56 responses, which were grouped into 4 categories, were gathered. 42.8% considered that the workshops did not have any weaknesses, or did not need to improve any aspect. The other three categories were divided into aspects related to the content, the strategy developed, and the organisational aspects of the workshop. 12.5% of the participants pointed out that the content was excessive and inappropriate, 30.3% stressed methodological issues such as including a more playful aspect, excessive explanations, or few activities. Finally, 14.2% considered organisational aspects such as planning the workshop itself, the work space, or the little time spent as weaknesses.

The students were also asked to identify the SDGs they considered had been addressed in each workshop (Table 3) they had participated in, as well as the score they would give the workshop they participated in (score out of 10).

A very similar trend was observed in the assessments made by each WT when they indicated the SDGs most linked to their workshops. The participants did not include SDGs 5, 8, 9, 10, or 16. The rating given to each of the workshops is quite high. Seven of the twelve workshops were given a score of 9 or higher, the lowest one being 8.1.

Table 3. List of the workshops held, the Sustainable Development Goals (SDG) worked on in each one, the number of participants per workshop and the average score out of 10 given by the students

SDG	Workshops											
	1	2	3	4	5	6	7	8	9	10	11	12
1	–	–	–	–	–	–	8	–	10	–	–	2
2	–	–	–	–	–	–	–	1	9	–	–	2
3	1	4	7	–	4	1	8	–	3	7	10	2
4	2	3	1	2	4	5	–	8	9	4	9	6
5	–	–	–	–	–	–	–	–	–	–	–	–
6	5	–	–	1	–	–	–	1	10	–	–	–
7	1	1	–	–	–	–	–	3	–	–	–	6
8	–	–	–	–	–	–	–	–	–	–	–	–
9	–	–	–	–	–	–	–	–	–	–	–	–
10	–	–	–	–	–	–	–	–	–	–	–	–
11	–	–	–	–	–	–	–	–	–	–	–	6
12	–	–	–	5	2	1	8	7	–	1	5	8
13	1	4	–	1	5	3	–	1	–	6	6	2
14	1	–	–	–	–	1	–	3	–	–	–	2
15	–	3	–	1	1	1	7	–	–	5	–	3
16	–	–	–	–	–	–	–	–	–	–	–	–
17	5	–	–	–	–	3	–	–	–	–	–	–
Nº Participants	10	8	8	6	10	8	9	9	11	8	12	12
Average mark	9.3	9.3	9.7	8.9	9.5	10	8.1	8.9	9.0	9.4	8.7	8.7

Source: own elaboration.

Conclusions and proposals for improvement

The validity of using real contexts like the garden space to achieve sustainability in the curriculum and of contributing to the scientific training of future teachers for them to be able to transfer educational interventions within the framework of sustainability was verified. The first results analysed allow us to conclude that the students, guided by the teacher, were capable of designing small investigations around topics of interest within the framework of several SDGs. However, it was necessary during the TLS to develop a more holistic view in the students. They had to become aware of the interrelation that exists between the different SDGs and critical areas in order to address sustainability from its three (environmental, economic and social) dimensions. It needs to be taken into account

that future teachers, according to recent studies, tend to have more difficulties when dealing with the social and economic spheres (García-González, Jiménez-Fontana, Azcárate 2020a; b; Aragón, Casanova 2022).

The TLS designed around the garden uses the RW as the final product of the EBS, which allows combining theoretical knowledge with real and applied practice. In the TLS, RWs play an important role, since they are very useful as a means of disseminating science. Experiences and knowledge were built together by those who designed the workshops and those who participated in them (García-Guerrero et al. 2020). The students, when assessing their own actions in the garden, highlighted the interest shown by the participants in their workshops. This seems to have had a positive impact, and made them feel satisfied with their work and with their own learning.

Gardens are conceived as a platform for ESD in the context of schools and universities. They enable connecting local actions with global thinking (Rothe 2023). Involving students in the management of these spaces and in the design of didactic proposals promotes empowerment, collaboration, transformation, and local appropriation (Wals, Benavot 2017, cited in: Rothe 2023), values universities should promote and transfer to schools. However, it is necessary to continue improving the design of educational interventions in initial teacher training in order to face current challenges in a global and interrelated manner. Likewise, these interventions should integrate educational strategies and resources of Didactics of Sciences implemented in the garden to train students to design transformative proposals and act as true agents of change (Corrochano et al. 2022).

Appendix 1

Sequence of activities of the teaching-learning sequence (TLS) designed and implemented in the context of the garden in the subject of Teaching the Natural Environment for academic year 2022–2023

Phases	Sessions/ space	Sequence of activities (TLS)
Phase 1	1/classroom and garden	Activity 1. What is an eco-educational garden? Sharing and collection of previous ideas Activity 2. Getting to know the garden. Approaching the space of the UEG
	2/classroom	Activity 3. Exploring previous ideas about soil Activity 4. What is soil to you? What functions does soil have? What environmental problems are associated with the soil? Activity 5. Recapitulation – what do we know about soils? Activity 6. What do you imagine the soil to be like inside? Make a drawing indicating the name of each of the elements

Phases	Sessions/ space	Sequence of activities (TLS)
Phase 1 cont.	3/classroom	Activity 7. Presentation of the steps/phases of an EBS Activity 8. Is the soil in our garden good for planting? Activity 9. Sharing previous ideas Activity 10. Formulating hypotheses. If we wanted to know what the characteristics of the soil in our garden are in order to plant in it... What do we need to know? And how could we find out?
	4/classroom	Activity 11. Designing experiences to know the health of the soil through the Health Cards of Agro-ecosystem Health Cards (AHC). Presentation of the template to know the health condition of the soil. Measuring instruments to be used and the data collection form
	5/garden	Activity 12. Going to the garden. Data collection, use of materials and measuring instruments, and data collection form
	6/classroom	Activity 13. Reorganising the information regarding the parameters to measure the soil and answer the initial problem question Activity 14. Preparing a group report
	7/classroom	Activity 15. Comparison and review of previous ideas on the definition of soil, what we find in the soil, soil functions and related socio-environmental problems. Presentation of the relationships between socio-environmental problems of the soil with the SDGs Activity 16. Explanation of knowledge developed in the EBS
Phase 2	7/classroom	Activity 17. Choice of topic to design a research workshop based on the EBs and in the context of the UEG. Connection with the results obtained from activity 1 in Phase 1 Activity 18. Presentation of the structure of the final report of the workshops made up of tasks associated with each stage of the EBS Activity 19. Preparation of the first part of the report: a) search for information related to the topic of the workshop; b) SDGs linked to the topic and reasoning, and c) preparation of a conceptual map as a synthesis
	8/classroom	Activity 20. Feedback session and presentation of concept maps to redirect and concentrate related topics and SDGs
	9/classroom	Activity 21. Define the problem to be solved by the groups. Brainstorm proposals of possible questions. Choice of a central question and several secondary questions Activity 22. Work groups' presentation of the topic and problem question. Sharing ideas with the entire class and feedback session

Phases	Sessions/ space	Sequence of activities (TLS)
Phase 2 cont.	10/classroom and garden	Activity 23. Formulation of possible hypotheses based on the problem question and presentation of a structure as assumptions Activity 24. Feedback from the teacher regarding formulating hypotheses Activity 25. What resources and materials are available in the garden for our workshop? Preparation of a list of resources
	11/classroom	Activity 26. Curriculum specification: what skills and knowledge are expected to be developed through the workshops?
	12/classroom and garden	Activity 27. Design of the workshop based on the problem question, hypothesis and curricular specification.
	13/classroom and garden	Activity 28. Feedback on the first design. Discussing the workshops and organisation of spaces and resources in the garden
	14/garden	Activity 29. Feedback on the second design. Rehearsal and preparation of the workshop in the garden
	15/garden	Activity 30. Organisation of a Scientific Dissemination Day in the garden through workshops and assessment by experts in the field of didactics of science Activity 31. Assessment session of the students participating in each workshop by means of an on-line questionnaire

UEG – University Ecological Garden; EBS – enquiry-based strategy; SDG – Sustainable Development Goals

Source: own elaboration.

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