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## BEES AND CLIMATE CHANGE IN CHILDREN'S EDUCATION: DIDACTIC PROPOSAL BASED ON DESIGN THINKING

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*Sandra Laso Salvador*

Facultad de Educación y Trabajo Social,  
Universidad de Valladolid, Dpto. Didáctica  
de las Ciencias Experimentales, de las  
Ciencias Sociales y de la Matemática  
Valladolid- España

ORCID: 0000-0002-2691-0876

*Idoia Hernaiz Peláez*

Valladolid- España

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**Abstract:** This work addresses an experience carried out in the Second Cycle of Early Childhood Education in a public center in Castilla y León (Spain). The aim is to promote environmental awareness about a current topic, the disappearance of bees, through the Design Thinking methodology at this educational level. The activities designed for this learning experience are detailed, as well as the results observed, along with the conclusions drawn from their implementation.

**Keywords:** Early Childhood Education, Environmental Education, Design Thinking, Didactic Proposal, Bees.

## INTRODUCTION

Currently, we face an environmental crisis that has experienced a notable worsening in recent decades, closely linked to human activity. We are immersed in a world that is increasingly distant and unbalanced with respect to the environment, generating global repercussions and even threatening our survival as a species (Novo, 2017). This situation, which today seems unstoppable, is causing serious ecological problems.

The decline in the biological diversity of animals and plants on Earth is one such problem that has long been recognized. Historically, biodiversity loss has focused on vertebrate animals. However, in the last two decades, invertebrates are beginning to receive the attention they deserve, driven, among other factors, by the increasing decline in pollinating insects (Sánchez-Bayo and Wyckhuys 2019). As noted by Allsopp et al. (2008) these organisms play a crucial role in maintaining the balance of ecosystems and in global food production, which increases concern about their loss.

Thus, one of the species that is suffering the most from the influence of this environmental problem is the bee (Stefanescu et al., 2018), which has an impact on its pollination work.

The reasons behind the decline in their work are varied and, in general, act synergistically with each other. For example, some of the most obvious triggering factors are the loss of habitats, the use of pesticides, the existence of parasites, among others.

Faced with the aforementioned disturbing reality, caused mainly by the lack of awareness and information, it is imperative to address it from various perspectives. Consequently, the educational sphere emerges as a valuable and indispensable means to promote sustainability, disseminate the limits of the biosphere, raise awareness, instill values, rethink, as well as seek and offer solutions to the current situation (Novo, 2017).

Scientific education, and therefore environmental education, in the early educational stages is beneficial for several reasons. First of all, children enjoy observing and reflecting on nature. Furthermore, children's exposure to science contributes to the development of positive attitudes towards this discipline and facilitates a deeper understanding of the scientific concepts that will be learned later, including a greater appreciation and respect for the environment (Prokop and Tunnicliffe, 2008); Torres-Porras et al., 2017). Also, the use of scientific language influences the development of scientific concepts that children are capable of understanding and reasoning scientifically. Therefore, science is an effective means of promoting scientific thinking (Eshach and Fried, 2005). All of this is complemented by the fact that science is intrinsically related to the real world that children are naturally exposed to, promoting the development of reasoning skills. This way, it is evident to address Environmental Education in the field of Early Childhood Education, so that thinking oriented towards sustainability in future generations can be encouraged from the first years of life.

In this context, the proposal “Poly pollinator and climate change” arises, which is presented in this work. The experience aims to promote environmental awareness and scientific literacy about plants and insects, as well as address various skills in an experiential and practical way, facilitating meaningful, attractive learning and promoting interest in the environment in children (Prendes et al., 2021). The contents addressed, insects, plants, pollination and environmental problems, would be limited to the area of Discovery and exploration of the environment of the Early Childhood Education curriculum (Decree 37/2022, of September 29, which establishes the organization and curriculum of Early Childhood Education in the Community of Castilla y León-Spain).

To face these challenges and resolve the conflicts presented by environmental problems, design thinking is presented as a valuable tool. It is a methodology that plays a fundamental role in promoting creative thinking, essential to confront the complexity and speed of environmental problems. Furthermore, in line with Anderson (2012), it offers several benefits in the educational field, highlighting the ability to solve problems, encourage collaboration and promote innovation.

This way, the formulation of this proposal is not only oriented towards the acquisition of scientific knowledge, but also towards the development of didactic knowledge, using the Design Thinking approach (Dam and Siang, 2018) at the Early Childhood Education level.

## REVIEW OF WORK

Current educational regulations promote the implementation of elementary scientific education that enables children to experience rigorous and meaningful scientific learning. On the other hand, research in science teaching has not shown much interest in the Early Childhood Education stage. Little research has been carried out in this field, which highlights the prevailing need to carry out studies that use appropriate strategies to teach the contents mentioned in the first section (Prieto and Torralba-Burrial, 2021).

However, there are interesting educational proposals that can offer valuable ideas, although they present variables that complicate their application in the Early Childhood Education stage. Thus, it is relevant to highlight the works of Vega (2007), Hecker (2008), Laguía and Vidal (2008), Vizcaíno (2008), Sugrañes et al. (2012) or Amorín de Abreu et al. (2022).

In relation to bees, in a broad sense, there are varied proposals, mainly focused on the Primary Education stage (Fisher, et al., 2014; García et al., 2012). In Early Childhood Education we must mention the works of Montero et al. (2016), Rodríguez-Loinaz et al., (2018) and Valin et al. (2012), being proposals that seek observation, exploration and approach to the bee, without being complemented with environmental education that promotes pro-environmental behaviors and decision-making.

The topic addressed focuses on the fundamental aspects that must be addressed in Early Childhood Education. Essential knowledge for citizenship education, such as sustainability, is provided and a direct connection is established with the child's immediate environment. All of this is done through an experimental approach to activities, where the active participation of the child and collaboration with their peers is emphasized, under the framework of

design thinking, which favors innovation and creative thinking.

## **JOB DESIGN**

### **PARTICIPANTS**

The proposal has been implemented in a classroom of the second cycle of Early Childhood Education, specifically aimed at the first year of this cycle, covering ages from 3 to 4 years. The classroom is located in the city of Valladolid, belonging to the autonomous community of Castilla y León (Spain). It must be noted that the class has the maximum capacity of students, adding a total of 25 students, among which, fourteen are boys and eleven are girls. Everyone has participated, therefore, it is an incidental sampling in which no selection has occurred by the researcher.

The class is very participatory, with great concerns, desire to learn, with interest in nature and with great camaraderie. However, there is a wide diversity of students in relation to the evolutionary level. Furthermore, it is considered important to highlight that two of the students have special needs. One of them has a noticeable maturational delay and the other student, although he does not yet have a diagnosis, presents autistic profile behaviors. Therefore, greater support is provided to students who need it, facilitating their development at the same pace.

### **PROPOSAL DESCRIPTION**

Below are some of the aspects that have been considered important for the conception of the learning proposal. It is important for the reader to keep in mind that the planning is adjusted according to the children's contributions.

## **CONTEXTUALIZATION OF THE LEARNING PROPOSAL**

The learning proposal developed is called "Poly pollinator and climate change". It aims to train knowledge related to the biology of insects and plants, pollination and the problem of climate change, integrating scientific practices and critical thinking.

Working on these aspects with children is presented as a challenging task. Among the difficulties encountered, it is relevant to highlight the limited scientific training, as well as the aversion towards insects on the part of the majority of the participants. Furthermore, it is essential to take into account "plant blindness" (Wandersee and Schussler, 2001). This term refers to the common tendency to underestimate and overlook the variety of plant species. Therefore, the proposal includes the treatment of aspects such as the parts of the plant, its functions... and the interaction with pollinating insects. All this, explaining the loss of pollinators due to climate change through argumentation and modeling.

It works on the three areas of the Early Childhood Education curriculum (Decree 37/2022, of September 29, which establishes the organization and curriculum of early childhood education in the Community of Castilla y León). However, it is the area of Discovery and Exploration of the Environment in which the proposal is mainly framed. The objective is for children to discover, observe and explore the elements that make up their environment, facilitating the acquisition of new knowledge and promoting attitudes of care and respect.

The proposed activities aim to achieve comprehensive and meaningful learning through motivation and experimentation. To achieve this, they rely on both cooperative work, which requires the participation and collaboration of group members, and an individualized approach that encourages

children's autonomy. In order to maintain children's interest and motivation, each session is intentionally structured, alternating activities that require greater concentration with recreational activities that involve movement.

The proposal includes introduction and motivation activities, the acquisition of new knowledge, consolidation and review. It also offers a variety of activities that address aspects such as fine motor skills, plastic expression, creativity and active listening. To facilitate understanding and reinforcement of knowledge, at the beginning of each activity what was covered in the previous session will be reviewed through brief questions, and at the end of the day, at the moment of farewell, we will reflect on the activities carried out throughout the day. All of this integrated into the five phases involved in the Design Thinking methodology (Dang and Siang, 2018; IDEO, 2013).

Likewise, to encourage the curiosity and initiative of schoolchildren, problems and challenges are proposed, resources from their natural environment and recycled resources are used, and ICT resources are also used in a conscious and educational way. In addition, a song and an animated story created specifically for this proposal are incorporated, since both are fundamental tools in the teaching-learning process. These are attractive and effective for communicating both knowledge and emotions, especially in the Early Childhood Education stage.

The nine sessions of the proposal are interrelated and take place consecutively. They have been ordered considering criteria of complexity and cognitive demand of the content worked on. Likewise, it is believed to be essential to begin with an initial session that motivates children and allows them to express their ideas, interests and emotions regarding insects, and in particular about bees. This way,

we seek to identify the emotions that insects can generate, evaluate to what extent they cause rejection or not, and how their interest affects learning.

## CONTENTS OF THE LEARNING PROPOSAL

Table 1 shows the declarative knowledge that we seek to transmit to children in this proposal.

However, in a proposal like this, other knowledge of a procedural or attitudinal nature plays a crucial role. Some of these are detailed in Table 2.

## DEVELOPMENT OF THE SESSIONS

Table 3 presents a summary of the 9 proposed sessions, detailing the design thinking phase that works, the objectives pursued and the associated activities.

## INFORMATION COLLECTION INSTRUMENTS

Information was obtained through interventions and discussions during the assemblies, since, given the possible communication difficulties in children of this age, this option was considered the most appropriate. In addition, the productions produced by the students were used as another collection instrument. The information obtained was contrasted with the records in the diary of the two teachers involved in the implementation.

Characteristics of bees	<ul style="list-style-type: none"> <li>• Morphology: parts of the bee's body (head, thorax, abdomen, wings, antennae, legs).</li> <li>• Life cycle: egg, larva, pupa, adult bee.</li> <li>• Common bee species.</li> <li>• Habitat</li> </ul>
Functions of bees	<ul style="list-style-type: none"> <li>• Pollination: explanation of how bees help in the pollination of plants.</li> <li>• Honey production: how bees collect nectar and turn it into honey.</li> </ul> <p>Social organization: life in a hive and the role of worker bees, drones and the queen bee.</p>
Importance of bees	<ul style="list-style-type: none"> <li>• Role in the food chain and food production.</li> </ul> <p>Consequences of declining bee populations.</p>
The plants	<ul style="list-style-type: none"> <li>• Planting flowers and plants that attract bees. Observation of bees in natural environments or simulation of hives.</li> </ul>
Relationship with the environment	<ul style="list-style-type: none"> <li>• Awareness about biodiversity and interdependence in the ecosystem.</li> <li>• Human impact on bee populations: climate change.</li> </ul>
Care and conservation	<ul style="list-style-type: none"> <li>• Measures for the conservation of bees: reuse</li> <li>• Actions to take to protect bees in their environment.</li> <li>• Actions against climate change.</li> </ul>

Table 1. Contents of the proposal

Procedural contents	Attitudinal contents
Bee watching	Scientific attitude
Flower planting	Rigor and precision in the description of observations
Beekeeping material exploration	Valuation of the work of bees and biodiversity
Promotion of artistic expression	Curiosity about everyday events
Information search	Participatory attitude and respect for colleagues
Bees dramatization	Respect for the environment

Table 2. Procedural and attitudinal contents of the proposal

SESSION 1. WHAT DO WE KNOW?	SESSION 2. WHERE ARE THE BEES?	SESSION 3. THE POLY BEE
Empathy	Empathy	Empathy
<b>Goals:</b> - Promote positive environmental actions through music. - Communicate prior knowledge.	<b>Goals:</b> - Obtain basic knowledge about bees. - Know words related to bees and plants. - Discover the importance of pollination.	<b>Goals:</b> - Empathize with the bees. - Understand pollination. - Understand the incidence of human actions related to climate change. - Identify climate change and its impact on the Planet.
Listen to the song "Let's take care of the Earth" ( <a href="https://www.youtube.com/watch?v=UorQi7gj8sk">https://www.youtube.com/watch?v=UorQi7gj8sk</a> ). Open questions about prior knowledge and interest and emotions caused by insects.	Search for bees in the school yard. Questions about bees and the observation made in the yard. Explanation of aspects related to plants	Story reading (own creation) explaining pollination ( <a href="https://drive.google.com/file/d/1u8Jnm0S2Lc9XYgN4chbFJul6K3tX076n/view">https://drive.google.com/file/d/1u8Jnm0S2Lc9XYgN4chbFJul6K3tX076n/view</a> ) and consequences of human actions on the planet. Develop empathy map on Poli bee.
SESIÓN 4. NUESTRAS ACCIONES	SESSION 5. I HAVE AN IDEA	SESSION 6. OUR POTS
Definition	Ideation	Prototyping



<b>Goals:</b> -Recognize the protagonists of the story. -Promote systemic thinking related to humans and the environment. -Understand the pollination process by working on gross motor skills. -Detect positive and negative human actions on the Planet.	<b>Goals:</b> - Generate attitudes of care and respect towards animals and the environment. - Understand the importance of caring for the Planet. - Provide ideas that mitigate the environmental problems affecting bees.	<b>Goals:</b> -Apply knowledge about plants and floral morphology. -Make pots with recycled packaging. -Transmit the importance of reusing materials. -Generate attitudes of care and respect towards animals and the environment. - Decorate the pots creatively, working on fine motor skills.
Establish relationships between pollinators and plants, through the application of the “actor map” and “star/stop/continue” techniques (IDEO,2013)	Reading the story and brainstorming to decide how to help Poli improve his situation.	Make pots that will be used to plant flowers.
<b>SESSION 7. PLANTS FOR POLI</b>	<b>SESSION 8. LOOK WHAT WE HAVE DONE!</b>	<b>SESSION 9. GOODBYE COP!</b>
Prototyping	Testing	Testing
<b>Goals:</b> - Fight climate change through positive actions. -Apply knowledge about plants and floral morphology. - Participate in the creation of a green area that minimizes the effects of climate change on bees and pollination. -Generate responsibility towards the care of plants.	<b>Goals:</b> - Detect the knowledge acquired. -Disseminate the project to promote its continuity. -Encourage the creation of a larger green area.	<b>Goals:</b> - Detect the knowledge acquired. - Make a drawing for the Poli bee. -Express verbally what the drawn drawing is about. -Evaluate the proposal made
Explanation of aspects related to plants and planting seeds in the pots created.	Argue about the problems addressed and decision making.	Prepare a drawing for Poli and group evaluation of the creations made.

Table 3. Sequence of the proposal

## ANALYSIS OF RESULTS

The results derived from the implementation of the proposal are presented below. The first session is designed to investigate and make children aware of the emotions and interest aroused by the topic under study. It is believed that emotions play a crucial role in any teaching-learning process. In the answers to the initial questions during the first session, the children showed that they had certain knowledge about caring for the planet or bees. However, none of them had knowledge about what pollination entailed, as they associated this concept with the word “police.”

In the second session, they greatly enjoyed searching for bees in the yard, showing excitement as they called out to them with phrases like “bee?, bee?” After approximately five minutes, they began to express comments such as “There is none”, “It is not there”, “I can’t find any bees”, among others. The presentation

about bees caught their interest, and the images were especially striking. A notable detail is that, when showing the slide of the bee’s wings, a student covered her eyes and exclaimed with fear: “I’m not going to look, I’m not going to look!”

In the third session, they provided numerous answers about what might be happening to the bee Poli, but none of the children linked the bee’s sadness to Climate Change or pollination. Later, they paid attention to the story, which helped them understand what pollination is and why Poli the bee was feeling sad. During the screening, every time a child performed an incorrect action, a student exclaimed “Very bad, child, very bad!”, and at the end, some students expressed concern about everyday actions, such as: “Hey, but to start the car we need smoke to come out.” Throughout the entire proposal, they asked the teachers to tell them

the story again. The empathy map (Figure 1) allowed us to collect their impressions after reading, understanding the problem.

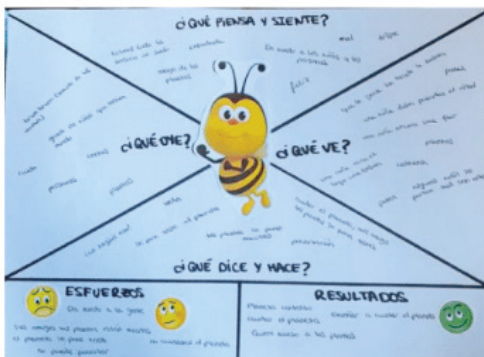


Figure 1. Empathy map generated

In the fourth session, the most outstanding activity was the experience of “Pollination”, since experiencing this process made it easier for them to understand and internalize it more effectively. In the assembly, the “Actor Map” technique is carried out. To do this, remembering the story of “Poli the Bee”, the teacher asks the students who appeared in the story. The students must mention Poli the Bee, the Planet, the plants and the children. Once they have mentioned all the protagonists, the teacher will show their images and place them in an area of the classroom forming a circle (Figure 2), while explaining their interconnection and that the negative actions carried out by one of the parties, has an impact on all the others, in the same way it happens with positive actions (“systemic thinking”).



Figure 2. Map of actors placed in the corner of the classroom

Regarding the “Star/Stop/Continue” activity, they faced technical difficulties with the digital screen, which complicated its execution and resulted in the projection of few of the prepared images. For this reason, it is considered important to point out that all activities that involve information and communication technologies (ICT), if they are not available, could be carried out by printing the materials.

In the fifth session, the continuation of the story captured a lot of interest from the children, who understood its purpose and discerned what actions they must take to preserve the planet and collaborate with bees and pollination. During the brainstorming session, they participated actively, and some of their answers surprised the teacher by evidencing the acquisition and consolidation of the previously discussed knowledge. Thus, some of the answers provided mentioned throwing things in the trash, turning off the tap, loving the planet, taking care of plants, planting trees...

Likewise, they experienced great enthusiasm during the sixth and seventh sessions, linked to the ornamentation of the recycled pots, the planting of daisies and the subsequent establishment of the green area in the school yard (Figure 3). Since then, they showed constant interest in its maintenance and expressed eagerness to witness its germination. The day they noticed that some of the plants had sprouted, they experienced great excitement.





Figure 5. Student Drawing 8: A flower, the Poli bee with a basket and pollination

In conclusion, it has been observed that the majority of children have met the evaluation criteria, as reflected in their responses and in some specific events. An example of this is that, after the proposal was finalized, a conversation was spontaneously generated between them that included statements such as:

“The street is all dirty, that’s why the plants don’t grow.”

“The Planet is becoming increasingly sad because we don’t take care of it.”

“I once saw a man throw a piece of paper on the ground.”

“My street is full of cigarette butts on the ground.”

“If we don’t take care of the Planet, the plants get sick.”

## CONCLUSIONS AND IMPLICATIONS

The fundamental purpose of this work was to develop a scientific-environmental proposal for the second cycle of Early Childhood Education (3-4 years), implement it and evaluate its impacts on children’s learning and environmental awareness. Furthermore, according to the review carried out, no similar learning sequences have been found about insects, climate change and the



Figure 3. Planting process and green area created, daisies

During the eighth session, there was a marked disparity in their responses to the “What do we know?” compared to the responses from the first session. This evidenced the acquisition of knowledge and the significant understanding of what was learned. Likewise, a similar pattern was observed when creating the drawings for Poli during session 9. Some examples of the creations made by the students are shown in figures 4 and 5.



Figure 4. Student Drawing 14: Poly with pollen balls

problem of the loss of pollinators at that stage. Therefore, this proposal could function as a source of inspiration for future developments of educational sequences and studies focused on this topic. Based on the results presented, some of the conclusions obtained are summarized.

It is important to highlight that the planning carried out has been adequate. This is due to the selection of scientifically relevant content, the consideration of children's achievements and limitations, the construction of knowledge of various typologies, the use of media and resources close to children, and the implementation of an integrated evaluation in the learning process. All of this is always done taking into account both the interests and emotions of the children, as evidenced by previous research (Barrow, 2002). Acquiring knowledge about bees, plants, pollination interactions and the effects of climate change implies understanding fundamental characteristics of these organisms, their vital functions, the importance of pollination and the functioning of the environmental system. To achieve this, it is essential to carry out activities that facilitate the connection between both types of organisms and their relationship with the environment, through observations, identifications and various classifications.

Regarding the execution of the activities, from the beginning it was sought that the children were the protagonists of the entire learning process and although the initially planned structure was followed, adaptations were necessary due to the participation of the children. This became evident, especially, in the ideation phase of design thinking, since they were in charge of defining how the problem defined in the previous phases was going to be solved. They were encouraged to experiment, a necessary step to address situations of greater cognitive complexity, an

aspect often neglected in some classrooms due to the teacher's insecurities. Therefore, following the perspective of Scheer et al. (2012) and Henriksen et al. (2017), it is essential that teachers have training in this methodology, so that they can promote both its application and the development of creativity in their students.

The problem associated with the decline in bees and other pollinating insects represents a complex socio-scientific challenge, the understanding of which involves the use of data related to the various causes that generate it. It is essential to address these issues from children, as illustrated in this experience, being feasible to undertake actions adapted to their educational capacities, raising awareness about the challenges of sustainable development, promoting responsible consumption practices, savings and taking part in solving the problem. Thus, children will be able to connect data with conclusions, facilitating the construction of arguments. However, always with the help of the teacher.

Regarding the results derived from the experience, it is important to note that no obstacles have been evident in the identification of the aspects addressed. The children have been able to identify, name and represent elements of the bees' environment, their anatomy, the pollination process and environmental problems. For this reason, signs of environmental awareness and sustainable behaviors have been observed in children, identifying harmful behaviors in their environment or among their peers and collaborating in correcting them through expressions such as "Turn off the tap that saddens the planet!" Likewise, the use of the phrase "The planet gets sad", previously introduced and, therefore, familiar to them, has contributed to the learning of appropriate and inappropriate behaviors, serving as an element to strengthen environmental awareness.

Finally, the children have enjoyed the learning process, and the time dedicated to the topic has seemed short to them. They have developed empathy towards the figure of the bee, modifying their previous perspective, and have demonstrated commitment to preserving the environment to avoid damage to the planet and its surroundings. It is considered that the theme and the common thread of The Poli Bee have been motivating for the children since they have expressed their interest with questions, phrases, gifts for Poli that they have made at home such as drawings, paper pollen balls, etc., throughout it and also once it is finished. For example, once the proposal was finalized, they carried out an activity with the school in which they went on a picnic in the backyard, full of vegetation. Without previously reminding them or mentioning Poli, they constantly asked about her: where is she, maybe we can see her, is she doing pollination, etc.

Furthermore, one of the smallest students in the classroom, who, consequently, may have had the most difficulty understanding the pollination process, found flowers and detected the pollen in them, without anyone prompting him to do so.

Consequently, it can be stated that the children have achieved significant and rewarding learning, since they have managed to discuss and reflect beyond the experience itself.

In summary, the proposal was positive and beneficial for the entire educational community, despite the work and dedication necessary to plan and carry it out. In fact, it is hoped that this experience will serve to inspire and motivate other teachers, encouraging them to provide quality environmental education from the early stages, instilling in children appropriate habits for care and respect for the planet.

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