Part 15 / Strand 15

Early Years Science Education

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Part 15. Early Years Science Education

Emergent science, science pedagogy and learning in the early years, cognitive resources for science learning, early years science and technology curriculum, innovative teaching practices in the early years, children's learning, preschool science, early years teacher education in science.

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Introduction

Strand 15 of ESERA is dedicated to science education in the early childhood years, and the 2021 conference featured 6 accepted paper presentations and one invited symposium. Authors that chose to share their research in Strand 15 represented Australia, Finland, France, Germany, Greece, and Spain. Session themes from the 2021 conference reflect several key trends in the field, including the role of digital technologies and play-based learning and early childhood teachers' inquiry-based practices. From the presentation sessions, there were three papers submitted for inclusion in these e-proceedings that also met the technical, editorial requirements. These are reproduced in the following sections; two paper presentations and one symposium.

The symposium was organized by the Early Childhood SIG coordinators on *Early Years Science SIG Nature of Science Invited Symposium*, which highlighted key results from three different research projects related to the Nature of Science (NOS) in the early years. The symposium introduced NOS pedagogy for the early years through four diverse foci. In the first part on "Bush kinders: pedagogically promoting the nature of science", Coral Campbell and Chris Speldewinde presented research data of teachers in bush kinders in Australia and examined their pedagogical approaches to highlight how NOS pedagogy could be expanded. The second part on "NOS For Young Children: the ATLAS project" by Fanny Seroglou, from Greece, explored different approaches to teaching NOS using creativity and art, including animations, children's books, theatrical play, e-books, online activities and Slowmation. The third part on "making elements of scientificity explicit for Kindergarten Teachers" by Estelle Blanquet and Éric Picholle from France presents a new tool for introducing Nature of Science at the pre-school level focusing on criteria of scientificity and examining in-service teachers' reflections on the potential impact on their practice. Lastly, a contribution by Lena Hansson, Lotta Leden and Suzanne Thulin, from Sweden, explores the ways in which "Nature of Science can be introduced through children's books". Collaboration between researchers and early childhood education teachers was used to introduce NOS in the early years through book-talks connected to trade books (narratives as well as expository books).

Papers were submitted by groups of researchers from Spain, that present intervention studies at the early childhood levels, each exploring complex science concepts with young children. In the paper *Working Thermal Conductivity in The Early Childhood Classroom*, Esther Paños, María-Antonia López-Luengo, Cristina Gil and Cristina Vallés elaborate experiences in the physical phenomenon of thermal conductivity through a structured intervention that involved four activities related to thermal conductivity, as they also emphasize the role of material resources. The first author of this presentation also submitted a second paper that is included herein, examining young children's biology-related conceptual understandings. In this contribution, titled, *Biology in the Early Childhood Classrooms: Plants also Die*, Esther Paños, José-Luis Gómez and José-Reyes Ruiz-Gallardo introduce the topic of living and non-living beings. The authors elaborate on an intervention for teaching the concept of death in plants in the early years and investigate children's responses in a post-test and a delayed post-test, drawing implications for teaching practice.

In organizing this contribution from Strand 15 to the ESERA 2021 conference e-proceedings, we note that all three groups of authors emphasize young children's capacities for understanding scientific concepts and for reasoning scientifically. It is evident that students at the early childhood levels benefit from opportunities to investigate phenomena close to their lives, supporting establishing links between children's everyday experiences and the focus of learning in the classroom. The papers featured herein demonstrate a commitment within the ESERA community to exploring the complexities of early childhood science teaching and learning. We hope you will consider submitting to Strand 15 in the future, and enjoy reading the papers.

EARLY YEARS SCIENCE SIG NATURE OF SCIENCE INVITED SYMPOSIUM

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Significant research world-wide has shown that a young child's successful learning in science depends on his teacher's grasp of the nature of science as well as on his pedagogical knowledge. However, there is much confusion about what constitutes science at kindergarten level. Yet, the nature of science (NOS) is poorly understood by many teachers and, without a strong guiding framework, early childhood teachers may miss opportunities to lead young children to an understanding of the nature of science. But how might the nature of science be expressed in such a context? The symposium explored various aspects of the nature of science. This article will deal with the main ideas resulting from three different research projects, selected in order to introduce the key aspects of NOS pedagogy in the early years while emphasizing the variety of possible approaches to early years science, namely:

Part 1 - Bush kinders: pedagogically promoting the nature of science (Coral Campbell & Chris Speldewinde). This part provides research data around the pedagogy of teachers as they work in bush kinders. Teacher pedagogy is interrogated for its promotion of the nature of science and discussion highlights ways that this could be further developed.

Part 2 - NOS For Young Children: the ATLAS project (Fanny Seroglou). This part presents a number of different approaches to teaching NOS using activities for children that involve creativity and art, including the creation of animations, children's books, theatrical play, ebooks, online activities and slowmation

Part 3 - Making elements of scientificity explicit for Kindergarten Teachers (Estelle Blanquet & Éric Picholle). This part reports on the development of a new tool for introducing NOS in pre-school. Trialled with a large group of early childhood teachers, the study shows that they considered the work on the presented elements of scientificity useful for their pupils and were receptive to the introduction of these elements to their classroom practice.

Furthermore, an additional presentation by Lena Hansson, Lotta Leden and Suzanne Thulin (Kristianstad University, Kristianstad, Sweden) dealt with the introduction of the nature of science through children books. The idea of this project, performed in collaboration between researchers and early childhood education (ECE) teachers, was to introduce NOS in the ECE setting through using book-talks connected to trade books (narratives as well as expository books). The empirical data reported consisted of audio recordings of book-talks (N=152) with children aged 2-6 led by five teachers, audio recordings of focus groups and workshops (N=9) with the teachers, documentation of children's drawings as well as of artefacts used by the preschool teachers. The results showed that discussions about a variety of NOS issues are possible in an ECE context. It also showed that attention can be directed towards NOS during book talks regardless of genre or if the books contain explicit NOS references or not. However, book-talks connected to books without explicit NOS references require that the teacher finds *other ways to direct attention towards NOS. The teachers involved in this project managed to do this with only a short introduction to NOS. The authors concluded that book-talks have great potential as an approach to introducing NOS to the youngest children. The results further showed that the teachers experienced that the NOS book-talks had spin-off effects such as increased curiosity, new questions, and engagement in investigations among the children. These results pointed to the potential for NOS teaching to contribute to empowerment and agency for the children, and positions NOS as an important part of science in ECE that values democracy and social justice as central.*

Keywords: nature of science, early childhood education, teaching practices

PART 1. BUSH KINDERS: PEDAGOGICALLY PROMOTING THE NATURE OF SCIENCE

The Scandinavian and European approaches to teaching in forest schools have been influential in the development of Australian nature or bush kindergartens, often known as bush kinders (Christiansen et al. 2018). This type of early years' outdoor learning gained momentum, predominantly stemming from one pilot bush kinder that began in 2011 in a major metropolitan city. Since then, bush kinder programs have rapidly increased in their number and popularity. As bush kinders in Australia continue to proliferate, the research into bush kindershas found that there are a range of pedagogical approaches that guides teachers' practice with nature pedagogy. Important to this in Australia is the Early Years Learning Framework (EYLF) document (DEEWR, 2009) which provides a broad perspective on the benefits that learning in the outdoors has for children.

Bush kinder approaches and structures are emergent, depending on factors such as context, staffing and policy development. As this study illustrates, guidance provided to educators and bush kinder teaching approaches are not necessarily a focus in initial teacher education courses. This has the potential to leave a deficit in teacher understandings of how science learning can be enabled and enhanced in nature-based surroundings. Professional learning specifically for bush kinders is only just developing, suggesting that experienced teachers are reliant on their own knowledge and experience of teaching in the outdoors (Campbell & Speldewinde 2018). This is important because the bush kinder context is one that presents a range of challenges that differ from the traditional classroom environment. Limited teacher education in this area provides teachers with a predicament as they determine their pedagogical approach without the backing of empirical research. This creates the dilemma of what is appropriate pedagogically for bush kinders, particularly as elements of the nature of science such as;

- children's capacity to observe what is occurring around them in nature;
- children's ability to develop understandings of science through their inquiry and exploration;
- children's opportunities to hypothesise, theorise and validate science and;
- children's capacity to imagine and be creative with science in nature

The fieldwork led to consider the research questions:

- Do bush kinders, through the interactions that take place between teachers and children, facilitate learners' transition from being novices in their understanding of the science in nature to becoming experts?
- Do bush kinders facilitate children's understandings of the nature of science?

The fieldwork observations associated with this research project drew attention to the different pedagogical approaches used by the teachers we observed. The ethnographic research method drawn on for this study (Speldewinde, Kilderry & Campbell 2021), is one that allows for an emergent research design, drawing on the work from Stan and Humberstone (2011). This presentation examines those different pedagogical approaches in bush kinders using an ethnographic lens of how pedagogy translates into practice in this early years learning context. Ethnography was valuable here because it enabled us to observe bush kinder teacher behaviour as it occurred (Aubrey et al. 2000, p. 121). Ethnography also allowed to consider the potential and opportunities for bush kinder teaching as the analysis were not limited to one ongoing event, but rather many events occurring simultaneously. As this was the case, a number of ethnographic methods were employed to gather data, which included listening, watching, and participating. 'Being with people as they conducted their everyday duties' both regularly and fleetingly (Forsey 2010, p. 569) lent itself to considering ethnography as an appropriate methodology.

Design of the project

The study discussed in this part used ethnography (Green & Bloome, 2004) which is suited to research in bush kinder settings as the field site is open and requires the researcher to be mobile (Speldewinde, Kilderry & Campbell, 2021). The methodological toolkit used in the study applied a range of research methods including participant observation of teachers and children, and listening to conversations between teachers, between children and between children and teacher. At times, the researchers were drawn into these conversations as participant observers (Speldewinde, Kilderry & Campbell, 2021). They also were able to conduct semi-structured interviews, informal discussions, and capture images using photographic and video capture of play and teaching moments. The range of data allowed them to interrogate the teacher pedagogy. They regularly visited the site over two distinct periods of fieldwork, firstly in 2015 then again in 2017. These weekly visits took place over a two to three hour duration for three different five-week blocks in both 2015 and 2017. These data collection visits allowed to engage with the teachers and to understand what was happening over time. It gave a broader understanding of events, rather than a one-off snapshot of the site and teachers.

The fieldwork associated with this research project took place at three bush kinder sites in the Sandy Shore Shire (pseudonym) of south-eastern Australia, selected due to their close proximity to the researchers' University and each other. Chatlock bush kinder, was characterised by its limited area for play. Wickelsham bush kinder, was an open rectangular paddock with a strand of large cypress trees. Sunrise bush kinder was larger and had a mix of grassed areas, large trees suitable for climbing, exploring and hiding.

This short presentation focuses on three of the five teachers observed at the four sites. The teachers' pedagogy is considered using Edwards' (2017, p.4) Pedagogical Play Framework that consists of open-ended, modelled and purposefully-framed play (all being of equal pedagogical value). Play-based learning is considered the 'cornerstone of early childhood education provision' (Edwards 2017, p.4) and was influential in this analysis, guiding the researchers in their thinking of bush kinder pedagogies as they had observed some intentional teaching in some sites but not all.

Results

The researchers observed significant science experiences around physical, chemical and biological sciences, as well as skill development. For example, children grouped various objects such as twigs or gumnuts – classifying using attributes, they built with rocks, demonstrating persistence, and frequently they were balancing on tree branches, experiencing friction and force. When running and colliding they were involved in momentum and force. Ethically appropriate behaviour was observed as the children were careful in their handling and in awareness of small animal needs. Children observed and commented on changes to the environment due to weather and seasons. Teachers highlighted a biological concept or process to draw children's attention to science related ideas in the physical environment where the natural phenomenon was the catalyst for a child's play.

Teachers were observed being successful in their endeavours in the bush kinder, each with a very different approach to children's learning and teaching. Even though each approach was beneficial for children's learning and teaching, the researchers were left to ponder whether there should there be a specific pedagogical approach that facilitates children's understandings of the nature of science in a bush kinder? Although they do not consider this is necessary at this point in time, they do acknowledge that it would be beneficial for teachers to better understand the contextual limitations and possibilities afforded when teaching science in nature with preschool children.

Conclusion

Findings suggest that the bush kinder environment acts as an enabler for children to experience and improve their understanding of a range of science ideas, and the nature of science. However, there is an impact in the scope of children's learning based on the educator scaffolding. It is argued here that bush kinder, through the interactions that take place between teachers and children, facilitates learners to transition from being novices in their understanding of the science in nature to becoming experts. To date, research observations indicate that there is no particular way to adopt a pedagogical approach when it comes to teaching in bush kinders. What is important is for teachers to be cognisant of their practice. They need to adjust their practice from their everyday, regular kindergarten pedagogy to a different pedagogy more suited to the outdoor context. Teachers also need to understand the affordances that outdoor nature spaces provide for early years learning while being aware that children's learning can be dependent upon what a teacher is aiming to achieve through being in an outdoor bush kinder context.

Going forward, the opportunity exists for further research particularly as bush and nature kindergartens are proliferating. The variations between sites and teachers offers the prospects for further insights into pedagogical approaches. Because of this relatively new context, the impact on children's affinity with science has the potential to be further explored.

PART 2. NOS FOR YOUNG CHILDREN: the ATLAS project

Is it ever too early to introduce a child to the NOS perspective? From the very first time we speak to young children about science we should use the NOS context. Learning of and about science is a dual mode of approaching science knowledge that provides both appreciation of science concepts and an understanding of what science is and how it works, the latter being a pre-requisite for the former. A variety of NOS teaching applications are presented with a series of examples, while in all cases NOS is taught to young children using activities that involve creativity and art. These NOS teaching applications have been carried out by the ATLAS research group in Greece and follow the GNOSIS research model in their structure, while attempting to bridge education and entertainment for young children towards a science edutainment.

NOS Activities for young children: the edutainment approach

Science learning is one of the information exchange activities of our society and has to follow the multimodality and flexibility in communication and interaction characterizing all parts of our lives. If it doesn't evolve and adapt then it might gradually lose touch with its audience (Seroglou et al., 2019). Narratives in NOS edutainment sculpt and structure information through multimodal learning inputs into easily understood representations of abstract science concepts and theories guiding young learners' comprehension. NOS narratives that educate and entertain contribute to the understanding of abstract concepts and phenomena of science as they re-contextualize the traditional science content supporting a new image of science. Abstract science concepts, phenomena and theories as well as NOS aspects acquire form, image and sound (Seroglou et al. 2019; Avraamidou & Osborne, 2009; Brock et al., 2002). Children and teachers who take part in edutainment activities with NOS narratives co-operate with each other, talk about science and learn in a friendly and effective way.

With a series of examples, a variety of NOS teaching applications are presented, while in all cases NOS is taught to young children using activities that involve creativity and art:

a) Animations about science with NOS inputs have been developed by researchers using 4 young children as cartoon heroes that jump in and out of paintings and discuss about viruses.

b) Children books about science and NOS have been published to promote science teaching in the classroom and science learning for young readers in their time of leisure.

c) A theatrical play for children about climate change has been staged with interactive activities for the children.

d) E-books about science and NOS with on-line activities have been developed.

e) Slowmation (i.e., slow animation) movies have been developed by kindergarten teachers and/or young children presenting science in NOS context.

NOS edutainment approaches have a dynamic role not only in the classroom instead of the formal curricula, but also in parents' creative time with their children at home, in children's free time as leisure activities, on stage as a performance for children and adults, on-line for e-learning and m-learning learning activities for children. Science concepts and theories, nature of science aspects, values and attitudes fostered by science, contents and contexts of science, interrelations of science and society are re-contextualized in the developed stories, the on-stage performances, the classroom and on-line activities while children get both educated and entertained.

Discussion

The above NOS teaching applications have been carried out by the ATLAS research group in Greece and follow the GNOSIS research model in their structure, that emphasizes seven aspects of NOS teaching and learning: a) the nature of science contents, b) the nature of science contexts, c) the synthetic nature of science as a product, d) the nature of the evolution and methodologies of science, e) the nature of interrelations of science and society, f) the nature of attitudes expressed through science, g) the nature of values fostered by science. The attempt to bridge education and entertainment for young children towards a science edutainment is a huge but inspiring challenge for pupils and teachers, as well as a new milestone for science education researchers and curriculum developers. At the same time, the detailed study of the learner's interaction with the NOS edutainment approach provides critical information for the design of educational material and its use in formal, non-formal and informal learning environments. The encouraging results during the evaluation of the ATLAS case studies bring forward demanding questions on how to transform science teaching and learning to creative NOS edutainment that would support science learning and inspire all children to learn science.

PART 3. MAKING ELEMENTS OF SCIENTIFICITY EXPLICIT FOR KINDERGARTEN TEACHERS

Some countries encourage the teaching of NoS at every level, including Kindergarten. For instance, in the USA, the chosen approach of the NGSS (2013) is to define specific categories and to adapt the content of each category to the considered level in a top-down approach. Most Science Education researchers use a similar top-down approach when they propose frameworks for Kindergarten level (Lederman & al., 2013; Akerson & Donelli, 2009). Oppositely, some countries don't mention NoS, or even fail to mention science at all in their curriculum for Kindergarten pupils. In France, merely a very short section of the curriculum is dedicated to the "exploration of the living world, objects and matter "; French pupils are expected at the end of Kindergarten to '*recognize the main stages in the development of an animal or a plant and know the essential needs of some of them, locate and name the different parts of the human body, on oneself or on a representation, choose, use and know how to designate tools and materials adapted to a situation, to specific technical actions, build constructions, use digital objects, begin to adopt a responsible attitude in terms of respect for the them and the protection of living things*' (MEN, 2020). No further mention of science teaching can be found in the K1-

K3 curriculum either, nor is there any explicit mention of NoS at the upper level (K4-5) of primary school curriculum. A somewhat related section reads: "Practicing scientific and technological procedures" at K4-5 level and proposes a short list of items that pupils should master at the end of elementary school: '*formulate a question or a simple scientific or technological problem; propose one or more hypotheses to answer a question or a problem; propose simple experiments to test a hypothesis; interpret a result, draw a conclusion; formalize a part of its research in written or oral form*'. Considering the vagueness of the French curriculum about NoS, the rather minimal time dedicated to science in the initial training or teachers (which is supposed to allow them to teach both at Kindergarten and elementary school levels) and their lack of previous knowledge, it is not very surprising that French Kindergarten teachers tend to present a rather limited understanding both of how science work and of how to teach it.

Previous studies (Blanquet & Picholle, 2017) developed a bottom-up tool based on an explicit set of criteria of scientificity (table 1) to provide a guideline to primary school teachers adapted to the French context but also to a wider public. This set doesn't need to be considered as a whole in school; to the contrary, arbitrary subsets of 2 to 7 criteria appear far more suitable to actual inquiries, allowing both some elbow room for the teacher to adapt his choice of subset to his own pedagogical priorities, and an evolution of the number of criteria with the age of the pupils, which gets more and more ambitious as their understanding of NoS grows. The formulation of the criteria doesn't change with the age of the pupils (instead of the formulation of the categories in the NGSS Standards for instance, 2013).

Table 1. List of the full set of 22 criteria of scientificity.

Scientific Method	Observation/Experiment	Discourse&Representations	Argumentation &Theorisation
Primacy of testing **Awareness** **Exploitation of the spectrum of generality** **Integrity** **Transmission**	**Opportunity** **Repeatability** **Replicability** **Robustness** **Completeness and Economy of documentation**	**Lexical Coherence** **Symbolic Coherence** **Internal Non-contradiction** **External Non-contradiction** **Non vacuity** **Relativity**	**Logical Coherence** **Non scolasticity** **Univocity (of a law)** **Robustness (of a law)** **Economy (of a law)**

A subset of 5 criteria most likely to be accessible to Kindergarten children was identified — namely, primacy of testing; reproducibility of an experiment (including repeatability and replicability); its robustness (i.e. a minor modification of the conditions of an experiment does not change dramatically its result); exploitation of the spectrum of generality (i.e. navigation between specific and general formulations); awareness (i.e. navigation between the real world and its representations). Do Kindergarten teachers consider this new tool useful for their practice? If so, how would they apply it? Among these criteria, which are consider by early-years teachers the easiest to implement in their classes?

Methods

Data collection Procedure: The data was collected as part of an in-service training program (duration: 3 to 6 hours) from a total of 87 kindergarten teachers separated in two groups, A (62) and B (25). The training courses focused on the teaching of science in kindergarten through an investigative process. Participants were told that the courses included a new approach based on scientific elements and that they would be asked to express honestly and anonymously at the end of the training their opinion on its interest in their practice. During these two training sessions, teachers were invited to quickly experience different educational sequences based on children's books (Blanquet, 2010). Then, they analyzed the issues in terms of content and scientific approach, with the trainer naming the various elements of scientificity explicitly worked with them (and their students potentially) during these sequences. The previously identified most likely five elements were included in the training of group A. Three somewhat more sophisticated elements — namely, lexical coherence, completeness and economy of documentation — were introduced as part of a longer training (6h) with very experienced teachers (group B). The two groups were asked to answer the open question "*Do these criteria seem useful to you for your practice? If so, in what way?*" They were also asked at the end of the training to rank the elements of scientificity presented from the easiest to the least easy according to them to set up in their class. Group A was being invited to classify all the elements of scientificity presented and to add free comments, group B left free to classify all or part of the elements of scientificity presented.

Analysis of data: It was possible to distribute the participants' open answers into four wide categories, in which 90% of the answers spontaneously fell: elements used as a frame of reference, preparation of sequences, regulation of the implementation, step back and evaluation of their practice. Certain elements could then associated to reveal subgroups of criteria selected selectively by the participants.

Results

1. Open question: almost all respondents (86 out of 87) consider that the elements presented are useful for their classroom practice. A single teacher considered them 'complicated for little ones except maybe for exceptional children'. Among the 86 teachers who found the presented elements useful, 34 did not provide examples of possible use. The practical uses envisaged by the 52 remaining teachers fell into four main categories: elements used as a frame of reference (n = 35), preparation of sequences (n = 20), regulation of implementation (n = 21), review and evaluation of their personal practice (n = 13). 44 of the 62 teachers who were offered to leave a comment took up the suggestion. All feedbacks turned out to be positive and focussed mainly on the pleasure and interest of working with children's albums to work on the experimental approach. Six comments related to the elements of scientificity: one teacher was a little worried not to have understood them well, three cited the importance or the interest of hindsight in connection with the work on the albums, including one who would henceforth test reproducibility and robustness with her students; and lastly a teacher who had previously participated to the same training indicated that she greatly enjoyed the additions made, namely *'the importance* of the different elements of scientificity.

2. Classification of the different elements: in Group A, 60 teachers (out of 62) actually ranked the criteria. Reproducibility turned out to be by far the easiest element of scientificity to implement, in the teachers' opinion (75% of the answers, rank 1 or 2), together with the primacy of testing (76% of the answers, rank 1 or 2) and well above the robustness test, followed by awareness and exploitation of the spectrum of generality. In group B, the 25 teachers classified

the elements of scientificity. They ranked an average of 4,3 items, with one teacher ranking only one and five ranking them all. Reproducibility was cited and ranked in first or second position by almost all teachers in group B, as is the primacy of testing.

Analysis, conclusion, implications and perspectives

The results obtained in the two groups appeared convergent. The test of reproducibility appears to be the element of scientificity most accessible to teachers, closely followed the primacy of testing, far ahead of the robustness test and awareness. The outright omission of economy and completeness in group B suggests that these elements are overwhelmingly perceived as too complex for kindergarten students. Providing teachers with a large number of abstract or sophisticated elements also seemed to focus their responses on the elements that are probably most familiar to them and for which they can easily consider implementation in their class (for example, try to know and verify that all students find the same result). The Kindergarten teachers participating to the study very widely considered that work on the elements of scientificity was useful to their pupils (86/87). The data collected therefore seemed to indicate that teachers were receptive to the introduction of elements of scientificity in their classroom practice despite a limited training time (3 to 6 hours). Providing explicit set of elements of scientificity to Kindergarten teachers could be an useful solution to develop the teaching of scientific inquiry by teachers, especially when the curriculum doesn't provide explicite information, the duration of training is as short as 3 hours and the teachers lack of knowledge about epistemology. A study in progress will assess, on the one hand, the appropriation by kindergarten teachers of the elements of scientificity presented and their implementation in classrooms; and, on the other hand, the effect of such teaching on the understanding in particular of the reproducibility by pupils from 3 to 6 years old with a longitudinal study. In conclusion, providing Kindergarten teachers with an explicit framework for the teaching of the Nature of Science appears as a powerful and easy to implement tool to help them form a positive self-image as legitimate early-years science educators, despite a too often rather minimal grasp of scientific issues.

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WORKING THERMAL CONDUCTIVITY IN THE EARLY CHILDHOOD CLASSROOM

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The science teaching and learning process should begin at the initial education levels, offering students experiences connected to their natural world. However, little science is accomplished in pre-primary education, especially when it comes to curricular content on physics. This research describes an intervention in early childhood education classrooms where six-year-olds work on a scientific phenomenon, thermal conductivity. Participants are 127 children aged 5-6. Data collection was right after and one year from the intervention. Results revealed that students could transfer what they have learned to other everyday contexts after the intervention –although they exhibited far more difficulties a year later. There were no gender differences found in the first posttest, although females solved the activity better one year later. Thus, more vast interventions should be considered to facilitate the inclusion of science as regular curricular content.

Keywords: early childhood education, science, thermal conductivity

INTRODUCTION

The early childhood education classroom offers a suitable environment to begin the science teaching-learning process; however, the scientific literature indicates that there is little authentic science intervention during this stage (Kinzie et al., 2014; Saçkes, Trundle, Bell, & O'Connell, 2011) –in which numerical, linguistic, and socializing skills are given preference (Nayfeld, Brenneman, & Gelman, 2011; Worth, 2010). Although the scarcity of research in this initial education level makes it difficult to define a clear pattern, some works show that preschool teachers, both in training and in practice, perceive science teaching as less critical than other domains, and they feel less confident managing science activities in the classroom (Torquati, Cutler, Gilkerson, & Sarver, 2013). Additionally, early childhood educators usually approach science through activities detached from reality and more tied to art or fiction than to science as such (Patrick & Mantzicopoulos, 2015).

Each school, particularly at the initial levels, should offer students multiple and varied science experiences connected to learners' real world. Such fact relies upon that the purpose of science training at schools must be for students to develop dexterities allowing pupils to understand their world's surroundings (García-Carmona, Criado, & Cañal, 2014). In this sense, solely an early approach to science might make students progressively develop scientific thinking permitting them to make truly informed decisions in the future. With these ideas in mind, this research exemplifies how a science experience on a physical phenomenon is implemented in some early childhood classrooms, evaluating how learners relate and transfer the learned to daily-life situations.

THEORETICAL FRAMEWORK

Pupils' first contacts with science are a determining factor in the relationship that students themselves establish with this discipline, and it can guide them to continue studying it in the future (Osborne & Dillon, 2008). Early science experiences are closely related to subsequent interests (Jones, Corin, Andre, Childers, & Stevens, 2017). Despite the limited number of studies in pre-elementary education, in general, there are no gender dissimilarities in the preference of learners for science (Paños & Ruiz-Gallardo, 2021) –although these disparities appear later on vocation choices (OECD, 2016). Hence, early education years may have a minimizing effect on those future differences.

When science interventions are meticulously planned to be implemented in the early childhood classroom, the designed activities must satisfy and prompt the targeted students' intrinsic curiosity. The reason is that such curiosity stands as an essential component of scientific inquiry (Jirout & Zimmerman, 2015). The designed instruction should also act as an activator of students' minds to develop their scientific competence early and in advance (Gómez-Motilla & Ruiz-Gallardo, 2016).

Although there is a particular debate about the suitability of including science at an early age, and opposite to traditionally believed, the truth is that children can understand scientific concepts and reason scientifically as they own more complex cognitive abilities (Eshach & Fried, 2005). At this age stage, students can establish cause-effect relationships and employ scientific thinking as a guide for their learning (Greenfield et al., 2009). Therefore, it is essential to work on nearby phenomena contextualized in the students' most immediate environment (Rubio, 2017). It will be just by this means when learners establish significant links between the learning generated in the classroom and other situations in their daily lives.

When teaching science, the goal should not just focus on children's learning but also on transferring the acquired knowledge to different settings or situations (Haskell, 2000). Moreover, the methodological approaches used in the classroom must be supported by purposefully structured activities considering the relevance of the teacher's guide and assuming the positive effect of this guidance on query activities and learning outcomes (Lazonder & Harmsen, 2016). Research reveals that these activities generate better results in science than others in which teachers opt for methodologies more based on free exploration for pupils' wisdom (Hadzigeorgiou, 2002; Hong & Diamond, 2012).

Apart from the above mentioned, it is also important to consider material resources when working with and on science in the classroom –because classroom resources play an essential role in the cognitive development of students and act as the mediating or catalyzing element between pupils' learning and the environment surrounding them (Ameijeiras, 2008). In this sense, the exploration and manipulation of the learning materials from the environment can offer infants rich opportunities to learn science, as shown by other research, for example, on buoyancy (Paños, Martínez, & Ruiz-Gallardo, 2021) or about the states of matter (Cruz-Guzmán, García-Carmona, & Criado, 2017).

Although science curricula in the early years increasingly emphasize the importance of students understanding the natural world and the phenomena that take place in it (French, 2004; Gelman

& Brenneman, 2004), little science is done in children's classrooms (as described in the initial sections of this paper). Additionally, educators teaching in early childhood and elementary education present more difficulties implementing physics activities and, contrarily, feel more comfortable working on biology or Earth science content (Harlen & Holroyd, 1997; Worth, 2010; Yilmaz-Tuzun, 2008). Yet, there is still scarce research on physics content in the early years of education (Hadzigeorgiou, 2015). Examples of phenomena on which research has been carried out in the early childhood period include magnetism (Christidou, Kazela, Kakana & Valakosta, 2009; Van Hook & Huziak-Clark, 2007) or floating and sinking (Hsin & Wu, 2011; Paños et al., 2021; Tang, Yaw & Woei, 2017), among others.

Considering the importance for childhood-staged children to know the world surrounding them and the scarcity of real science experiences in the classrooms (especially those linked to physics), the goal of this research is to carry out an intervention to work on the thermal conductivity phenomenon and to evaluate the ability of children to transfer the learning to real situations in two stages: just after the intervention and one year later. Through the activities, the intention is to make children explore and manipulate different kinds of materials and ascertain some of their properties, as their ability to conduct heat. In general, it is difficult for youngsters to understand thermal conductivity, a phenomenon that they justify, not by the property of the material, but by the action of the air that surrounds it (Ravanis, 2003).

METHOD

The research consists of a quasi-experimental study with an intervention –posttest– delayed posttest design, involving 127 children (64 girls) from 6 classrooms pertaining the third level of early childhood education (students aged 5-6), in the city of Albacete (Spain). In the delayed posttest 27 students participate as a group of control.

Procedure

The intervention consisted of the following activities:

- *Activity 1.* Classifying common objects. The activity begins in the assembly, with the whole group. A set of nine everyday items from the environment is shown to children –where three of these objects are made of metal, three of wood, and three of plastic. Students are asked different criteria to classify the materials. The teacher leads the dialogue so that the classification is reached according to the material from which everyday items/objects are made of. Through the use of questions, the participation of the whole group is encouraged.
- *Activity 2.* Looking for objects in the classroom. In small groups, children have to identify three things in the classroom made of each of the materials mentioned in Activity 1.
- *Activity 3.* The whole group is proposed to carry out an experiment. The researcher shows three types of rods (metal, wood, and plastic) that the students can manipulate. There is also a container that the researcher fills with hot water, into which she inserts all the rods. Through questions such as 'What will happen to the rods? Why do they get hot? Are they all just as hot?', the researcher guides the learning process. After that, students are asked to make predictions about whether some type of rod will be

hotter or will all be the same. Students make their predictions individually and go on to check the result of them (figure 1). When they check it out, they are asked to say nothing to the rest of their peers until everyone has finished. Once all have finished, the results are shared and discussed in the assembly.

- *Activity 4.* Finally, students are asked to touch objects of these materials in the classroom, especially those near the window, to perceive the studied phenomena.

Notwithstanding two evaluations were implemented, an evaluation is carried out right after the intervention (posttest-1). Both evaluations were designed to verify if the students could relate the activities carried out in the classroom with other situations of their daily lives (being at home or in a playground), and the assessments were done through an individual interview. Besides, to check if the learning in students was retained over time and, thus, not obliterated, a delayed posttest was performed a year later.

Figure 1. Children manipulating the rods.

Posttest-1: students were given a template with two inquiries: Which material do you think a radiator is made of to be able to conduct and transmit heat? Which material is the handle of the pan made of, so that you do not burn yourself when you pick it up? (to facilitate their identification, a drawing of each of these objects was included). They had to choose between these options: metal, plastic, or wood in the first question; and metal or plastic in the second one (figure 2).

Posttest-2: children were shown two images of a playground, containing one them a wooden swing and the other a metal one. Then they were told and asked the following: Imagine that it is a sunny day of summer, in which of these swings would you play? Why? The answer options were as follows: in the metal one, in the wooden one, in either of the two. They also have a picture of a saucepan with a boiling stew, and the question is: Imagine that you have to turn a stew that is boiling, what spoon would you use? Why? The options were: a metal one, or a wooden one.

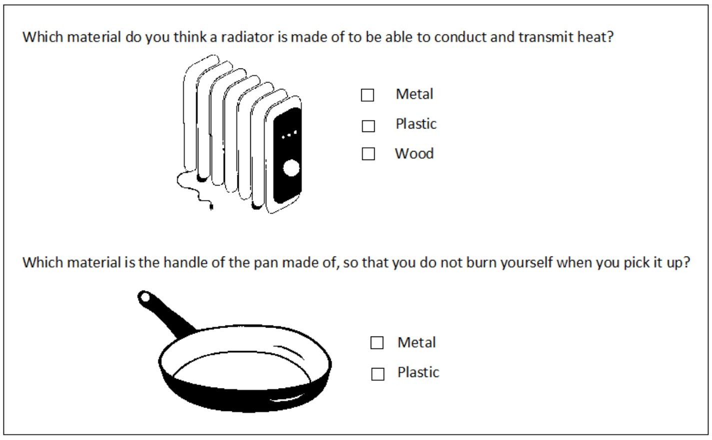

Figure 2. Template employed in the Posttest-1.

Data analysis

The contrast between groups (experimental vs control and boys vs girls) is carried out using contingency tables and the chi-square ($\chi 2$) test. This information is complemented with descriptive statistics.

RESULTS AND DISCUSSION

In the posttest-1, 75.59% of the participants correctly solved the two questions raised (table 1). Results reflect that addressing a physical scientific phenomenon with 5-6-year-old students favors their understanding, as Hadzigeorgiou (2002) also points out when working on mechanical stability. Children were able to transfer what they had previously learned about the property of thermal conductivity of materials to other contexts related to their daily life. The use of standard material resources from the environment may have favored these results. There are no statistically significant differences concerning gender, a fact that seems to fit with the trend identified in the scientific literature.

It is noteworthy that only 33.86% of the students answered the two questions correctly in the posttest-2, that is, one year later (table 1). Correct answers employ reasoning like ‘metal gets very hot and you burn’, ‘wood does not heat as much as metal’, ‘iron burns’, or ‘the heat rises through the metal spoon and you get burned.’ Students who do not correctly solve the activity mostly argue that the wooden one can break, burn, or even melt in the case of the spoon. Regarding the swings, 27.56% of participants selected the metal one, justifying it mainly because it was more robust or more rigid, and 16.54% chose both swings.

Although there are no statistically significant differences between the resolution of posttest 1 and 2 by the experimental group, the percentage of students who correctly solve the evaluation one year later is much lower than the previous year, which shows that the positive effects of the intervention have diminished over time, as other studies point (Kang, Duncan, Clements, Sarama, & Bailey, 2019).

When contrasting participants by gender in the delayed posttest, statistically significant differences appear between boys and girls –being the latter the ones that best solved the activity (table 1). Despite such differences, and considering the absence of differences in posttest-1 and the fact that this is a punctual activity, results cannot be generalized.

Significant differences do also appear when contrasting data with the control group, which corroborates the intervention's positive effect (table 1).

Table 1. Correct answers in the evaluation activities. Group contrast.

	Posttest-1			Posttest-2		
	Boys	Girls	Total	Boys	Girls	Total
EG[1] (n = 127)	34.65	40.94	75.59	11.03	22.83	33.86
CG[2] (n = 27)	-	-	-	7.41	0	7.41
Gender differences posttest-1 (EG)				χ^2 (1) = 2.240 / p = .135		
Gender differences posttest-2 (EG)				χ^2 (1) = 7.558 / p =.006		
Posttest-1 and posttest-2 contrast (EG)				χ^2 (1) = .047 / p = .829		
EG/CG contrast				χ^2 (1) = 7.532 / p = .006		

[1]Experimental group. [2]Control group.

CONCLUSIONS

Through the structured intervention, early childhood education students can learn about the scientific phenomenon of thermal conductivity. Also, they can transfer what they have previously learned to other contexts connected to their daily lives. However, participants have more difficulties with it one year after the intervention. This difficulty suggests that long-term interventions would be advisable to address this topic. The more satisfactory results obtained by females in the second posttest –although considered, as previously described, with caution– can be a stimulus to reverse current gender differences in the job market, where women are underrepresented in scientific departments, especially those of physical sciences (Funk & Parker, 2018).

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BIOLOGY IN THE EARLY CHILDHOOD CLASSROOMS: PLANTS also DIE

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Biology contents usually begin to be addressed in pre-compulsory education, and the early childhood education classroom remains a suitable environment to work on science. Thus, this research describes a task where early childhood students must transfer the meaning of death to living beings. Because of its abstractness, this biological concept is difficult for pupils to understand –particularly in the case of plants. Concerning the sample, participants are 114 children aged 5 to 6. Children are assessed twice after the intervention: once the activity ends and the year afterwards. Results reveal that most students do not consider grass as a living being that might die. Learners also struggle to relate the concept of death to trees. These difficulties disappear when children are 6 to 7, so results imply that teaching the concept of death in plants during this age stage might help them form the concept quickly and accurately. No gender differences are found in the results of the two tests.

Keywords: early childhood education, living beings, death

INTRODUCTION

Children's innate curiosity and their need to discover and understand the world in which they live and the phenomena taking place in it make them connected to science from an early age (Spektor-Levy, Baruch, & Mevarech, 2013). The early years of infants' lives undoubtedly involve a continuous learning process in which, through observation, exploration, asking questions, et cetera, they try to make sense of the environment around them (Trundle, 2015). At the commencement of pre-primary school enrolment, children already possess considerable knowledge about the natural world due to their previous experiences; hence, schools' immediate challenge is adapting these initial ideas to the scientific knowledge (Duschl, Schweingruber, & Shouse, 2007).

The early childhood education classroom reveals itself as a favourable environment for initiating the science teaching-learning process. Here, the students will satisfy their needs to manipulate and explore the settings where they will find answers to their first intuitions and interpretations concerning such natural environments. To this end, the role of teachers is vital, generating motivation and myriad opportunities to acquire scientific concepts and procedures and offering children multiple and diverse material resources that stimulate learning. These early experiences will lay the foundation for future learning, and play an essential role in developing positive attitudes toward science (Bruce, Bruce, Conrad, & Huang, 1997).

Although, in general, the scientific literature reflects that little science is done in early childhood levels (Kinzie et al., 2014; Saçkes, Trundle, Bell, & O'Connell, 2011), real science activities can be planned to bring students closer to the natural world around them. Thus, for teachers, when planning and designing the instruction, it is necessary to consider that structured activities prompt in children a more in-depth learning and better results in science than those in which free exploration is used as a teaching resource (Hadzigeorgiou, 2002; Hong & Diamond, 2012; Paños, Martínez, & Ruiz-Gallardo, 2021).

Concerning the information above, this paper presents some classroom experiences to work on a biological sequence about living and non-living beings –a common topic in early childhood education progressively deepened within throughout the school years.

THEORETICAL FRAMEWORK

Notwithstanding that scarce science is accomplished from early childhood education levels, it is yet known that pre-primary education teachers prefer teaching biology content (Worth, 2010) –unveiling the differences between living and non-living beings as one of the most common topics considered from the science curricula (Akerson, Weiland, & Khadija, 2015). Remarkably, teaching the referenced matter is usually performed from a zoocentric perspective, and teachers give less value to botanical contents (Balas & Momsen, 2014). Thus, when children are asked to name plants and animals, they tend not to name plants as often as they reference animals (Patrick & Tunnicliffe, 2011). This omissive fact is interconnected to a phenomenon already identified and conceptualised in the scientific literature as plant blindness –which means the inability to notice the presence of plants or value their importance, considering them inferior to animals (García-Berlanga, 2019; Wandersee & Schussler, 1999).

Students begin to have an adequate biological conception about living beings during early childhood education; however, this is still not complete and precise (Dargett & Witherington, 2011). They cannot give accurate definitions of living beings, limiting themselves to offering examples to describe them (Garrido, García-Barros, & Martínez, 2002). Generally, early childhood students keep anthropomorphic ideas about animals and plants, a state that disappears during the early primary education years. To reduce this conceptions owned by children, authors suggest using scientific texts in the classroom (Petrova, Siderova, Stefanova, & Nikolova, 2010). Likewise, when making distinctions between living and non-living beings at the beginning of the early childhood education span, students tend to rely on the physical movement of the entities for its classification as living or non-living things –although they progressively acquire a more precise mental image of this topic as they progress towards the upcoming primary education stage (Villarroel, Antón, Zuazagoitia, & Nuño, 2017).

Apropos of research by Nguyen and Gelman (2002), children begin to consider plants as biological entities when they are between 4 to 6; however, although they relate the concept of death with living beings, they face more difficulty understanding the same concerning plants. Such fact could be attributed to the absence of salient features of the entities, such as plants' lack of motion or sounds. This lack of movement or sound would make it difficult for infant students to consider them as beings that might die, as it happens to the rest of living beings. Nguyen and Gelman (2002) also identified that, when they are 6 years old, children can understand all of the components of plants death: universality, inevitability, finality, and causality.

In sum, the concept of death in living beings and its biological characteristics can be a suitable topic for pupils during their first learning and education years. Considering the difficulties that 5-6-year-olds have to understand that plants, as living beings, sooner or later will die, this research goal is to present a structured activity to explain the idea of death as something inherent to all living things. This research also aims to evaluate the acquisition of the studied concept considering the gender variable throughout two evaluations: one after the intervention and another one year later.

METHOD

Design and sample

The research design is quasi-experimental, with an intervention, a posttest, and a delayed posttest implemented one year after the intervention. The sample consisted of 114 participants encompassing 55 males and 59 females. Participants were chosen from five third-level classrooms of early childhood education schools (pupils aged 5 to 6) at Albacete, in the Autonomous Region of Castilla-La Mancha, Spain. In the delayed posttest, 27 infants were assigned to the control group.

Procedure

The intervention implemented in each of the early childhood education classrooms develops and is structured as follows:

Stage I. The researcher shows four common objects (e.g., a toy truck, a book, a box, a toy animal) and four living-beings (silkworms, a plant with flowers, a plant without flowers and a terrarium with ants), and classify them into two groups (living/non-living beings). Then she asks students, '–Why have I classified them this way?'

Stage II. Once the children have the two groups identified (living/non-living beings), the researcher asks the students for more in-depth information on the topic. The information encompasses some characteristics of living beings, especially those that differentiate them from non-living things. As the students identify and mention such differences, the researcher notes down the students' answers on a piece of cardboard and the blackboard (Figure 1).

Stage III. If during Stage II of the training process the students have not the concept of death mentioned, the researcher reformulate new queries To say, '–What would happen to silkworms if we don't give them mulberry leaves to eat?' and '–What would happen if we don't water the plants?'

Stage IV. Having Stages I, II, and II accomplished, the researcher explains participants two main characteristics of death: universality (all living things, humans, plants, animals, and others die) and inevitability (death is an unavoidable fact) (Nguyen & Gelman, 2002).

Figure 1. Researcher and students during the intervention.

Data collection

After the activity, students are individually assessed with the sole purpose of identifying if they have the biological conception of death acquired (Posttest-1). Such assessment includes inanimate objects, animals, and different types of plants. Considering Nguyen and Gelman (2002) research results, the chosen plants are a flower (because of its fragility) and a tree (because children can consider it as something sturdy and challenging). Since it is something so familiar that sometimes it is not paid attention to, the grass was added to the activity. Hence, in a template with the eight pictures displayed in figure 2 (butterfly, kite, spider, sunflower, grass, fork, mobile phone and tree), children were asked to circle those pictures whose images include things that one day was –predestined– to die. Individually, students took the same evaluation a year after (Delayed Posttest).

Figure 2. Data collection template.

Data analysis

The contrast between groups (experimental *vs* control and boys *vs* girls) was carried out using contingency tables and the chi-square (χ^2) test. This contrasting information is complemented with descriptive statistics.

RESULTS AND DISCUSSION

Posttest-1

In none of the classrooms involved, the idea of death arose spontaneously as a common characteristic of living beings during the intervention. Children predominantly mentioned biological features such as growth, breath, movement, and reproduction –the most salient and visually perceptible animal characteristics. The use of questions helped students identify that they might die. The specific questions asked to students did also help them identify the lack of food (in the case of worms) or the lack of water (when talking about plants) as factors that would cause living beings to die. Therefore, it is evident how asking questions (especially using open-ended queries) in the context of science teaching in early childhood education can guide children in learning scientific concepts (Hamel, Joo, Hong, & Burton, 2021).

Just after carrying out the activity with the children to work on the concept of death in living beings, and deepen in the aspects of universality and inevitability, only 39.47% of them correctly solved the proposed task, which means to select the butterfly, the spider, the sunflower, the tree and the grass (see table 1). Except for seven succeeding in the task accomplished, the rest of the unsuccessful students did not identify the grass as something that would die. The vast majority of students also exhibited difficulty acknowledging that trees might die as well (38% of those who failed); this same characteristic was far less remarkable in the case of sunflowers (only 13% of those who failed).

This first posttest clearly shows the difficulties children have to assimilate that plants, such as grass and trees, are living beings and, consequently, they will die one day. The trees' physiology, their static appearance, and the fact that they are usually long-lived, as mentioned by Nguyen and Gelman (2002), might cause these results. And we note it down as 'might' because these results contradict other studies pointing out that it is less complicated for children to conceptualise grass as a living thing than it is for them to conceptualise trees (Villarroel & Infante, 2014).

Table 1. Results from Posttest-1 and Delayed Posttest (correct answers in percentages).

	Posttest-1			Delayed Posttest		
	Males	Females	Total	Males	Femal es	Total
Experimental (n = 114)	17.54	21.93	39.47	27.19	33.34	60.53
Control (n = 27)	-	-	-	40.74	14.81	55.55

Delayed Posttest

One year after the intervention and Posttest-1, the Delayed Posttest is implemented. Having the Delayed Posttest accomplished and the answers scrutinised, it was observed that most of the students correctly identified all the images representing something that will die (60.53%). Furthermore, the results dissimilarities between the immediate and delayed posttests in the experimental group revealed statistically significant differences (χ^2 (1) = 7.029 / p = .008). It was observed that, in the delayed posttest, most children aged 6-7 had considered all of the plants (including grass) as 'things' that will die. Therefore, it seems that the age variable and the not participation in the activity determined that they understand the studied phenomenon. This aspect is also corroborated when verifying that there are no statistically significant differences in the activity resolution between the group that participated in the previous year and the control group (χ^2 (1) = .224 / p = .636).

Gender

Regarding gender, there are no statistically significant differences either in the Posttest-1 (χ^2 (1) = .430 / p = .512) or the Delayed Posttest (χ^2 (1) = .771 / p = .380). These results are congruent with the research carried out by Villarroel et al. (2017), where the authors did not find differences in the way females and males aged 4 to 7 classify different entities in living or non-living beings. However, research opposes gender disparities in science, technology, engineering, and mathematics (STEM) fields pinpointed in scientific literature, although these studies usually focus on older students (Wang & Degol, 2013).

CONCLUSIONS

In conclusion, although children aged 5-6 comprehend living beings and the characteristics differentiating such entities from non-living beings, they display difficulties relating the concept of death with plants. Also, the intervention factor of carrying out an activity with students aged 5-6 does not prompt in them the extrapolation of the idea of death to some plants (mostly grass and trees). However, having gone by a year –once they are in the first level of primary education– the results displayed are far better, and most students consider plants as beings that one day will die.

The results, as mentioned earlier, may well have implications when planning science activities or instruction in the early age-stage education levels. Displayed results might be a referent for instructional designers, teachers, and practitioners to focus on the particular features of plants as living beings and pay special attention to those characteristics that learners cannot perceive through the senses (as it happens in the case of animals). These results can also serve future research as the stimulus to welcome more activities related to plants to mitigate what is yet known as plant blindness in the initial educational levels.

The lack of gender differences when solving the activity suggests that these disparities may arise at higher educational levels.

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