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Including younger children in science-related issues using participatory and collaborative strategies: a pilot project on urban biodiversity

Rita Campos

Abstract

Young children are actors usually excluded from political decisions and also from many science communication projects. Participatory science communication models can help to connect their everyday life with both local policies and science-related content. Using visual methodologies for engagement, we aimed at understanding what preschool children prefer in the city landscape. Results show how young children envision a "better city" and how that construction might defy current scientific knowledge. It further illustrates how science communication can be used to co-produce new knowledge, contributing to the debate about people's needs and perceptions related to science-based options.

Keywords

Citizen science; Public engagement with science and technology; Visual communication

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Introduction

Science communication can be understood as a very powerful tool to active citizenship, as it favours the approximation between science and society, contributing to the participation of the public in science-related questions and decisions. As such, it should be guided from the perspective that public participation is a component of communication, and that communication is a participatory process trying to promote the involvement of people in issues that concern them [e.g., R. Cox, 2007; Walker, 2007]. In this sense, participation is understood as an end, achieved from the facilitated access to scientific information, and considering that this access will lead to a more relevant participation [Bucchi and Trench, 2014; Weaver, 2017]. Accordingly, the communication-engagement-participation triad forms the basis for active citizenship, as more informed citizens tend to engage more in civic and political actions [e.g., Bucchi and Trench, 2014; Burns, O'Connor and Stocklmayer, 2003; Lieberman, Posner and Tsai, 2014]. But participation can also be understood as a process, considering some approaches that amplify the voices of social actors

traditionally less listened to, such as younger children, i.e., children aged up to 10 years old [Davis, 2009; Shapiro et al., 2016]. Considering participation simultaneously as a process and as an end should enable a stronger interconnection between science (or scientific research) and society (or the ability to mobilize and/or transform scientific knowledge and use it in our daily life).

The development of participatory and collaborative projects can contribute to the construction of an extended "hybrid place", a place for expanded reflection, embedded dialogue and deep interdisciplinarity. This place would thus allow for different knowledge to emerge through the collaborative interactions established between the different participants in the project, and the relationship and critical connection with the surrounding environment and/or the research question. Collaboration is a powerful factor influencing public engagement with science [e.g., Hecker et al., 2018; Riedlinger et al., 2019]. Collaboration has been defined as the involvement and interaction between different people in a coordinated effort to think about a given problem and collectively build new knowledge about possible or alternative solutions [Fox, 1987; Roschelle and Teasley, 1995; Schrage, 1990]. As such, new ideas are elevated within the group, and the focus of the work is on the process. Collaborative work involves trust and the ability to allow for alternatives; it is always interdependent and, as a rule, is a long-lasting endeavour.

Collaborative and participatory science communication often results in the creation of a "hybrid space" where both theory and practice, and scientists and citizen, can meet [Gunnell et al., 2021]. Since social interactions are at the root of the collaborative construction of new knowledge [Fox, 1987], participatory and collaborative science communication projects can be considered a proxy to a deeply engaged and relational citizen science, close to a concept of engaged citizen social science [Campos, Monteiro and Carvalho, 2021]. This concept underlies the notion that engagement with science should be bidirectional, meaning that it not only seeks for an active public engagement with science but also that scientists have an active engagement with the public. Furthermore, this engagement must be free of hierarchical classifications of knowledge, meaning that all forms of knowledges must be put in dialogue. Identifying the issue around which the project will be developed can come from any intervening party and, following a dynamic and reflexive process, the project will be re-thought — and eventually changed — throughout its implementation. These projects can thus be that desirable "hybrid space", producing new knowledge, articulating different practices and languages, intervening in policies and in the public space, finding alternatives for the exercise of citizenship.

Urban green spaces, human health and well-being and the Biophilia Hypothesis

Most of the human population lives in urban environments. In 2018, about 55% of the world's population were living in urban areas and that number is expected to increase to 68% by 2050 [United Nations, 2019]. In Portugal, these numbers are higher, as 77% of the country's population is expected to move to cities by 2050 [United Nations, 2014]. As more and more humans move from rural to urban settings, there's a growing and renewed scientific interest in cities, and in understanding the relation between urban green spaces and human health and well-being. In urbanized environments, urban green spaces are key elements to the promotion of human health and well-being and social justice [e.g., Jennings et al., 2017; Keune et al., 2013; Wolch, Byrne and Newell, 2014]. The benefits of urban

green spaces to a healthier and sustainable living are numerous, and include the reduction of air pollution, noise and heat exposure; improvement of local climate, providing protection in severe climatic conditions; promotion of biodiversity conservation; prevention of child (and adult) obesity; improvement of sleep quality; promotion of foetal development; promotion of physical activity; promotion of the social contact and longevity; increase of concentration capacity; promotion of mental health and self-esteem; decrease of stress levels and promotion of tranquillity; increase of the sense of belonging (high historical and cultural value); increase the perception of good health; reduction of disease prevalence; decrease of cardiovascular diseases; promotion of the contact with the local biodiversity, motivating informal environmental learning [reviewed in e.g. Campos, 2019b].

The many positive impacts of urban green spaces on health, quality of life, social interactions and cooperative behaviours highlighted by several studies on the interconnection between urban biodiversity and human health and well-being seem to support the Biophilia Hypothesis [Wilson, 1984]. Biophilia means literally "love of life", both considering life as all living beings or as nature [Barbiero and Berto, 2021]. This Hypothesis, proposed by the biologist Edward O. Wilson, is based on the proposition that our connection to the natural world is a result from our evolutionary history [Kellert and Wilson, 1993; Wilson, 1984]. Because only a very recent part of our evolution is occurring in urbanized environments, affection for nature developed during most of our evolutionary trajectory and is thus part of our traits. Accordingly, our connection to nature is innate, genetically predetermine and emotional, and so we seek to maintain this link. The Biophilia Hypothesis tries to explain the positive influence that exposure to natural environments has on physical and mental health, and how detachment from these environments can impact negatively human health and well-being. Using this hypothesis as framework, and since living in cities is recent in human history, we are not fully adapted to urban environments. Thus, the propositions of the Biophilia Hypothesis can contribute to acknowledge that urbanization of the population affects both humans and non-human biodiversity, and that the predomination of urban experiences increases the gap between humans and the natural world (the nature/culture divide).

Although highly anthropocentric, and not consensual [Joye and de Block, 2011], the Biophilia Hypothesis advances an interdisciplinary framework to explore the implications of the increase urbanization of human populations, specifically in relation to a better understanding about the benefits offered by urban green spaces to urban living. Some studies have highlighted the importance of this framework in research projects focusing on human affiliation with nature, nature impacts on humans, and people's relation to the build environment [e.g., reviewed in Barbiero and Berto, 2021; Kahn, 1997]. Children, in particular, seem to express behaviours, attitudes and emotions congruent with this hypothesis, by expressing a tendency to being close to nature and a positive appreciation towards other species and natural elements, and, as such, would benefit from regular interactions with natural environments [Chawla, 2020; Hand et al., 2016; Kahn, 1997; Keith et al., 2021; Louv, 2005].

Children participation: designing a participatory and collaborative science communication project

Research shows that urban green spaces are fundamental to public health in urbanized environments, and, as such, the co-inhabitation of humans and green spaces in urban settings should be encourage in city planning. As more people move to cities, it would be expected that urban living would lead us to privilege urban spaces with high natural value to live, work or spend leisure time. Children, as city dwellers, are social actors who should be involved in the planning and management of these spaces. But younger children are usually excluded from political decisions [e.g., Mansfield, Batagol and Raven, 2021; Valentine, 1997], and, to some degree, also from many science communication projects (considering projects that recognize younger children's agency, i.e., that recognize their competence to make decisions based on their own knowledge and experiences and not just "recipients" of information). However, participatory science communication projects can help to connect their everyday life with both local policies and science-related content, empowering them in agenda-setting. Additionally, allowing the effective participation of children can facilitate the involvement of the rest of the community, incorporating their multiple knowledge and interpretations of the reality in the processes of co-construction of knowledge. With this in mind, we designed a participatory science communication project aiming at understanding what younger children prefer in the city landscape and how they relate to urban biodiversity. As such, in its initial design, the project aims at empowering younger children to voice their preferences in relation to different urban spaces by creating a "hybrid space" where knowledge was to be collectively constructed and not simply delivered to the children. The end goal is to evolve from this collaborative format to a co-creation model [Bonney et al., 2009; Gunnell et al., 2021], inspired by the theoretical framework of an engaged citizen social science [Campos, Monteiro and Carvalho, 2021], where children could take the lead in conducting the project.

The conceptual framework of the project was inspired in the dialogue and participatory science communication models [Trench, 2008] and the deliberative science communication type model [Palmer and Schibeci, 2014], which is based on the principle of bilateral communication between public and researchers in a democratic and mutually respected way, giving the same weight to both scientific and local or indigenous knowledge, with strategies used in participatory research [Cornwall and Jewkes, 1995], recognizing the involvement of the children as central. It also followed the principles underlying the "vowel analogy" of science communication, making use of a set of practices and strategies aiming at one or more answers to science: awareness, enjoyment, interest, opinions forming or transforming and understanding [Burns, O'Connor and Stocklmayer, 2003]. Particular attention was given to the dimensions of enjoyment, interest and (forming and expressing) opinions.

As a working methodology, approaches based on the collaborations between art and science were chosen, namely visual methodologies. Using art-based approaches to science have several valuable characteristics that include the facilitation of participation through a more dynamic, creative and meaningful involvement; allow for a greater understanding of different worldviews, thoughts and understandings; and are potentially more effective than traditional methodologies [Clark, 2010; Epstein et al., 2006; Johnson, Pfister and Vindrola-Padros, 2012; Pyle, 2013; reviewed in Campos, 2021]. After an initial literature review on the impacts of urban green spaces on humans, with an emphasis on human health and well-being [Campos, 2019b], the goal was to use

these approaches to listen to the children and understand what they prefer in the urban landscape, to build a new narrative about the importance of urban green spaces from their expressed perspectives and perceptions.

The initial project questions were: How do children relate to urban green spaces/urban biodiversity? What are their "significant spaces" in the city? What are their perceptions of these spaces?

The project was designed to be open-ended, so that children could influence its design. Thus, it includes different phases that start by the researcher-driven questions and an initial proposed methodology and then unfold guided by children's suggestions. In the first phase, photo-elicitation interviews were used to invite a group of pre-school children to share their opinions, emotions and perceptions about the city of Coimbra, Portugal, from a set of images (photographs taken by the researcher; Figure 1). These interviews were complemented with drawings created by children, in two different occasions: following the interviews, and embedded in a storytelling about a utopian new city. Visual representations such as children's drawings can offer both cognitive and non-cognitive clues to their knowledge, perceptions, worldviews and affinities [e.g., Cherney et al., 2006; S. Cox, 2005]. The drawings were treated as Personal Meaning Maps [Falk, Moussouri and Coulson, 1998], to be analysed accordingly. Written informed consent was obtained from parents, and oral expression of interest to participate in the sessions was obtained from the children in the beginning of each session. The children were always aware that they could leave the session at any time without any consequence. The only personal information collected was the children's age at the time of the sessions. These sessions were part of a larger project about biodiversity-related knowledge [Campos, 2019a], and most children knew the researcher for more than three years. Eighteen children, ten aged 5 and eight aged 6, participated in this first phase of the project, pre-Covid-19 pandemic, all in the photo-elicitation interviews, and ten in the storytelling and free drawing sessions (three aged 5 and seven aged 6).

Figure 1 show the twelve photos used in the interviews. All were taken in the city of Coimbra, a medium-scale city in the geographic centre of Portugal. It has a National Forest (Choupal National Forest; top left photo) were most children spent some time while participating in an outdoor educational project, called Casa da Mata (House of the Forest) [Figueiredo et al., 2018], in the years before the interviews. Since 2015, this program is offered to pre-schools and elementary schools as a complement to their regular activities, and to families as a holiday activity, and participation can last from 1 day to 3 months (more information, in Portuguese, can be found here: http://limitesinvisiveis.pt/). Both the National Forest and the Green Park (Figure 2, left image), a municipal garden adjacent to the city centre, are highly popular spaces for families to spend leisure times, especially during the weekends. Part of the historical area of Coimbra is inscribed as UNESCO patrimony, which includes mostly building environment but also the University Botanical Garden. Some photos were taken in this area; others were either taken near the kindergarten or in potentially familiar places in the city centre. In small groups, of 3 or 4 children, and with complete freedom to handle all the photos and all the time they needed, the children were invited to choose the photographs they liked the most and the least. Afterwards, they orally explained their choices.

Figure 1. Photographs of Coimbra used in the photo-elicitation interviews.

"The photo I like the most"

The three photos that were chosen most often were taken in urban green spaces, including Choupal National Forest and the Green Park (Figure 2). However, the reasons behind their choices had little to do with nature. Only the photograph on the left in Figure 2 was chosen by three children because it had natural elements: "*It has these beautiful flowers. I like the colours*"; "*Because I like flowers*"; "*Has a beautiful nature. I like nature*". Two other children chose the same photo, but for reasons unrelated to nature: "*It's the road to my grandmother's house and I like to go to the garden walk my uncle's dog when he leaves it there*"; "*Because one day I went there, and I met R.* [the child that walks the dog] *and we both walked the dog and after that I went to R.'s house*".

Figure 2. Photographs chosen by the children as the one they liked the most.

Two other photos were chosen by four children each. One, on the centre in Figure 2, was chosen because children recognized the place as the area were they spent time while in the outdoor educational project Casa da Mata (House of the

Forest): "*I like Casa da Mata*"; "*It's in Casa da Mata and I like Casa da Mata a lot and has the swing that I like to use*"; "*Because I really, really, really like Casa da Mata*"; "*I don't like this tree here [fallen] but I like Casa da Mata, I like going there to play*". The other, on the right in Figure 2, was also chosen based on children's previous experiences in the place: "*I always play here*"; "*Because I like to go there to play*"; "*Because I've been here many times and I like the slide and I've seen ducklings*"; "*I like to go to the children's playground and I play football with my father, on the grass*".

"The photo I like the least"

There were fewer consensuses about the photos the children liked the least. Four photos were chosen most often (Figure 3), three of which had no or very few natural elements. The one on the top in Figure 3 was chosen by four children. The reasons for their choice relate to their aesthetic perceptions: "*I don't like drawings on the wall*"; "*Because it has the dirty underpants [hanging things]*"; "*Has the wall with graffiti and has this ugly wall with these dirty things, look like underpants*"; "*It has these ugly things*". Still, the same photograph was chosen by one child as the one "I like the most" because "*it has cars and I love cars*".

Figure 3. Photographs chosen by the children as the one they liked the least.

Three other photographs were chosen by two children each. The one on the left in Figure 3 was taken in a central city square that was recently renovated, with no trees or other green elements and used as a parking space. Again, this photo was also chosen by one child as "the one I like the most". Children explained their choice due to the building environment and the cars, attributing them both negative and positive values: "*It has a lot of cars and many stores and many buildings and has little space and all I want is to run*"; "*Because it only has houses and one person. But I like the car*"; "*The houses are beautiful*".

The photograph on the centre in Figure 3 was taken in a place with no public green elements, although it is possible to see a municipal garden at far. It is a very busy street, not far from the kindergarten. Four children chose this image, again attributing both negative and positive values to the building environment and the cars, but no mention to nature, or lack of it, was made: "*It has a broken car* [the front part of a car that appears on the bottom left of the photograph] *and there is a STOP*

sign"; "*It lacks a crosswalk, only has one road, there are things missing, an electrical bus* [because the wires are there]"; "*Because of the cars, I love cars*"; "*the houses are beautiful*". Despite being one of their favourites, the photo taken in the National Forest was chosen by two children because of their negative appreciation of the trees' aspect: "*Because the trees are fallen*"; "*It has fallen trees and trees without leaves*".

"*My utopian city*"

The drawings made by the children following the interviews mostly depicted the images in the photos or they familiar places (e.g., their houses or a football stadium). However, in a separate set of sessions, children engaged in a debate about the development of a city, and the different aspects involved in urban planning. These sessions used a visual storytelling and debate approach, based on the book Popville, by Anouck Boisrobert and Louis Rigaud (Roaring Brook Press; edited in Portugal by Bruaá). This wordless pop-up book illustrates urban growth from a single building surrounded by trees to a busy city crowded with buildings, streets and other constructions. Because it has only (2D and 3D) images, the interpretation of this growth depends on the readers. These sessions unfold in three stages: 1) a conversation with drawings about what the children think could be a "perfect", imaginary, city for them; 2) an exploration of Popville creating a collective narrative for that place and debating what elements appear and disappear during the narrative; 3) a final drawing of the imaginary city (Figure 4).

Figure 4. Example of children's drawings of their "utopian city" before (top) and after (bottom) the storytelling and debate.

Figure 4 illustrates four personal meaning maps before (top) and after (bottom) the book-driven debate. The initial drawings were consistently simpler, with fewer elements and no or few natural elements. The debates allow for an exchange of

scientific and non-scientific knowledge, creating narratives where the development of the city and the appearing of different type of constructions were mixed with perceptions and science-based evidence related to urban biodiversity: how urban green spaces can be home for biodiversity, such as insects, trees or small mammals; how the flowers are so beautiful and smell so good; how the trees can cancel traffic noise, and give shadow, and oxygen. These debates clearly influenced children's representations of the imaginary city, as drawings made after using the book revealed more elements as a whole, and more natural elements in particular.

Children's drawings are complex constructs that mobilize cognitive processes and elaborate their unique perceptions [Dentzau and Martínez, 2014; reviewed in Cainey et al., 2012] They need to be considered symbols or signs that translate children's experiences and emotions, and should be interpreted with the children [Søndergaard and Reventlow, 2019]. Giving the opportunity to the children to explain their drawings allowed understanding the meaning of the elements that were present and absent from the drawings. Absences can have different meanings, as simple as the lack of time to complete the drawing, and that meaning should inform the overall interpretation of the drawings [Dentzau and Martínez, 2014]. For example, the dog is absent in the second drawing (after the debate; Figure 4, bottom left) because the child wanted to leave the session to have a meal with the friends. Children's explanations also allowed for a preliminary qualitative analysis of the drawings, considering the dimensions extent, breadth and depth [Falk, Moussouri and Coulson, 1998]. Extent reflects the number of elements in the drawings, breadth the number of categories that the elements represent (e.g., buildings, roads, people, trees, flowers, sun) and depth the elaboration on the use of the elements that can express a mobilization of the scientific content debated. To measure depth, an adaptation of the original methodology was adopted [following the adaptation proposed in Costa et al., 2021, for perception]: the 3-point quantitative scale evaluated the degree of mobilization and use of elements representing nature, in order to evaluate if children would give preference for a green city (as predicted by the Biophilia Hypothesis). The low number of drawings prevented a statistical evaluation of the "before" and "after" drawings, but, overall, the ones created after the book-induced storytelling and debate exhibited a higher level of elaboration (more elements and more categories) and of presence of nature (from a medium of 1 in the "before" drawings to 4 in the "after").

Some preliminary considerations and future directions

Participatory and collaborative processes take time, as trust and deep respect between all participants are a requirement to these projects [Chandanabhumma et al., 2019; Gunnell et al., 2021], and need time to develop. This is especially true when working with younger children, where the power dynamics between adults and children may interfere with children's effective participation [reviewed, e.g., in Clark, 2005]. The aim is to work horizontally with the children, allowing and encouraging them to actively communicate their perceptions, feelings and understanding of the project's topic [Christensen and James, 2008]. The Covid-19 pandemic interrupted the project, as schools and kindergartens were either closed or didn't allow visits. Nevertheless, the first results showed that children's perspectives offer new and somewhat defiant ways to look at the urban ecosystem, to the boundaries between nature and culture and to the Biophilia Hypothesis.

Children, in their perception of the public urban space and in their preferences, are mostly guided by aesthetic and emotional values. Aesthetics values were classified through the identification of positive and negative attributes. The positive attribute was "beautiful" (*beautiful flowers*; *beautiful nature*); while the negative attributes were "dirty" (*drawings on the wall*; *dirty things*; *ugly things*) and "imperfect" (*things missing*; *fallen trees*; *trees without leaves*). On the other hand, the attributes identified as underlying emotional values were all positive. These were "family" (*the road to my grandmother's house*; *walk my uncle's dog*), "friends" (*I met R.*; *I like Casa da Mata*), "playfulness" (*the swing that I like to use*; *I like to go there to play*; *I play football with my father*) and "familiarity" (*I've been here many times*). Overall, there were almost no direct references to nature, or urban green spaces.

Framing these results in the context of the Biophilia Hypothesis, it appears that it does not hold for this group of pre-school children, and that urban living can challenge the expected innate affiliation with nature. This result adds to previous observations that children prefer less biodiverse urban gardens [Hand et al., 2016], supporting the suggestion that the diminishing time children spend outdoors and in contact with nature may enlarge the nature/culture divide [Chawla, 2020; Clements, 2004; Dutcher et al., 2007]. The participation in the outdoor educational program Casa da Mata seems to only slightly influence children's preferences, probably because this is a short-period program, not providing the regular contact with nature advocated by these authors. However, results also showed that urban biodiversity triggers positive memories and interest and curiosity for environmental-related issues that can be used to foster co-construction of significant knowledge. Other authors have argued for science awareness programs as a way to stimulate children's innate affiliation with nature [e.g., Cohen and Horm-Wingerd, 1993]. Preliminary results from the book-induced storytelling and debate here related support this latter premise, as children designed greener cities after discussing the potential benefits of urban biodiversity.

Taken together, these results show how young children envision a "better city" and how that construction can defy current scientific knowledge on the positive impact of urban biodiversity on human health and well-being. In particularly, children seem to be well adapted to the building environment. From their perspective, the city emerges as a space that offers multiple opportunities to establish meaningful relationships with friends, family and space. Also, except for the National Forest where they have spent time in outdoor education, children's preferences in the city don't exhibit any particular link with urban green spaces and render urban biodiversity largely invisible. As such, contrary to expectations, young children envision a city that does not necessarily include urban green spaces. These results further illustrate how science communication can be used to produce new knowledge on issues that usually exclude the targeted public — younger children — and how participatory science communication strategies can contribute to the social conversation around science [Bucchi and Trench, 2021], including people' needs and perceptions, and helping formulate (or transform) science-based options. Moreover, applying the principles of an engaged citizen social science [Campos, Monteiro and Carvalho, 2021], all participant actors can benefit from the project. Such projects take one step forward from co-created citizen science [Gunnell et al., 2021] or tailored communication [Villar, 2021] to a deeply engaged, open-ended communication strategy, allowing not only the inclusion of relevant information for the target audience but also the establishing of a horizontal relation

between all participants and their knowledges. The goal is not just the co-existence or reinforcement of scientific and non-scientific knowledge [Sharma et al., 2019], but rather the emergence of a new, different knowledge.

Concluding remarks

Participatory science communication stimulates curiosity and autonomy in the construction of knowledge, seeking to understand how and for what purpose the construction of an individual meaning-making path is encouraged. This "learning to learn" process is also a powerful exercise for critical sense, something particularly valuable nowadays, where the absence of critical sense is a fertile ground for the dissemination of false information (fake news). But the construction of these "hybrid spaces" — these wider collaborative ecosystems, of intertwining between research, communication and practices situated in local and global realities — leads us to some questions: Should we promote "other forms" of knowledge within the research space and in science communication tools? And how should we do it? What ways to promote critical thinking autonomy can we use? What are the barriers that we may create even (or so much) by language? Listening to, consulting with and including young children's perspectives on science-related topics, and issues related to their own lives, in open-ended projects such as the one here described can be challenging, but can also offer valuable insights on how to address these (and other) questions, and help build a truly collaborative praxis between scientists, science communicators and society.

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References

Barbiero, G. and Berto, R. (2021). 'Biophilia as Evolutionary Adaptation: An Onto- and Phylogenetic Framework for Biophilic Design'. *Frontiers in Psychology* 12. https://doi.org/10.3389/fpsyg.2021.700709.

Bonney, R., Ballard, H., Jordan, R., McCallie, E., Phillips, T., Shirk, J. and Wilderman, C. C. (2009). *Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education*. A CAISE Inquiry Group Report. Washington, D.C., U.S.A.: Center for Advancement of Informal Science Education (CAISE). URL: http://www.informalscience.org/public-participation-scientific-research-defining-field-and-assessing-its-potential-informal-science.

Bucchi, M. and Trench, B., eds. (2014). Routledge Handbook of Public Communication of Science and Technology. 2nd ed. London, U.K. and New York, U.S.A.: Routledge. https://doi.org/10.4324/9780203483794.

— (2021). 'Rethinking science communication as the social conversation around science'. *Journal of Science Communication* 20 (03), Y01. https://doi.org/10.22323/2.20030401.

Burns, T. W., O'Connor, D. J. and Stocklmayer, S. M. (2003). 'Science Communication: A Contemporary Definition'. *Public Understanding of Science* 12 (2), pp. 183–202. https://doi.org/10.1177/09636625030122004.

Cainey, J., Bowker, R., Humphrey, L. and Murray, N. (2012). 'Assessing informal learning in an aquarium using pre- and post-visit drawings'. *Educational Research and Evaluation* 18 (3), pp. 265–281. https://doi.org/10.1080/13803611.2012.670400.

Campos, R. (2019a). 'Diálogos sobre evolução e biodiversidade com crianças na educação de infância'. In: Atas do XIV Congresso SPCE — Ciências, Culturas e Cidadanias. Ed. by A. M. Seixas, A. G. Ferreira, I. Menezes, A. J. Afonso, A. Matos, M. Figueiredo, C. C. Vieira and I. Moio. Coimbra, Portugal: Faculdade de Psicologia e de Ciências da Educação da Universidade de Coimbra, pp. 517–527.

— (2019b). 'Participação pública na tomada de decisões políticas sobre desenvolvimento sustentável e saúde pública — uma proposta de investigação e disseminação'. *CES Contexto* 25, pp. 33–47.

— (2021). 'Na fronteira das palavras: a ciência, as histórias e os públicos'. In: A Investigação e a Escrita: Publicar sem Perecer. Ed. by P. Sequeiros, M. J. Carvalho and G. Capinha. Coimbra, Portugal: Imprensa da Universidade de Coimbra, pp. 397–423. https://doi.org/10.14195/978-989-26-2156-2.

Campos, R., Monteiro, J. and Carvalho, C. (2021). 'Engaged Citizen Social Science or the public participation in social science research'. *JCOM* 20 (6), A07. https://doi.org/10.22323/2.20060206.

Chandanabhumma, P. P., Duran, B. M., Peterson, J. C., Pearson, C. R., Oetzel, J. G., Dutta, M. J. and Wallerstein, N. B. (2019). 'Space within the Scientific Discourse for the Voice of the Other? Expressions of Community Voice in the Scientific Discourse of Community-Based Participatory Research'. *Health Communication* 35 (5), pp. 616–627. https://doi.org/10.1080/10410236.2019.1581409.

Chawla, L. (2020). 'Childhood nature connection and constructive hope: A review of research on connecting with nature and coping with environmental loss'. *People and Nature* 2 (3). Ed. by R. Gould, pp. 619–642. https://doi.org/10.1002/pan3.10128.

Cherney, I. D., Seiwert, C. S., Dickey, T. M. and Flichtbeil, J. D. (2006). 'Children's Drawings: A mirror to their minds'. *Educational Psychology* 26 (1), pp. 127–142. https://doi.org/10.1080/01443410500344167.

Christensen, P. and James, A., eds. (2008). Research with Children: Perspectives and practices. 2nd ed. Routledge.

Clark, A. (2005). 'Listening to and involving young children: a review of research and practice'. *Early Child Development and Care* 175 (6), pp. 489–505. https://doi.org/10.1080/03004430500131288.

Clark, A. (2010). 'Young Children as Protagonists and the Role of Participatory, Visual Methods in Engaging Multiple Perspectives'. *American Journal of Community Psychology* 46 (1-2), pp. 115–123. https://doi.org/10.1007/s10464-010-9332-y.

Clements, R. (2004). 'An Investigation of the Status of Outdoor Play'. *Contemporary Issues in Early Childhood* 5 (1), pp. 68–80. https://doi.org/10.2304/ciec.2004.5.1.10.

Cohen, S. and Horm-Wingerd, D. (1993). 'Children and the Environment'. *Environment and Behavior* 25 (1), pp. 103–120. https://doi.org/10.1177/0013916593251005.

Cornwall, A. and Jewkes, R. (1995). 'What is participatory research?' *Social Science & Medicine* 41 (12), pp. 1667–1676. https://doi.org/10.1016/0277-9536(95)00127-s.

Costa, M. K. B. da, Araújo, M. F. F., Campos, R. and Freire, E. M. X. (2021). 'Demystifying ophidism: bridging school and society to develop educational resources'. *Ambiente & Sociedade* 24. https://doi.org/10.1590/1809-4422asoc20200148r1vu2021l2ao.

Cox, R. (2007). 'Nature's "Crisis Disciplines": Does Environmental Communication Have an Ethical Duty?' *Environmental Communication* 1 (1), pp. 5–20. https://doi.org/10.1080/17524030701333948.

Cox, S. (2005). 'Intention and meaning in young children's drawing'. *International Journal of Art & Design Education* 24 (2), pp. 115–125. https://doi.org/10.1111/j.1476-8070.2005.00432.x.

Davis, J. (2009). 'Revealing the research 'hole' of early childhood education for sustainability: a preliminary survey of the literature'. *Environmental Education Research* 15 (2), pp. 227–241. https://doi.org/10.1080/13504620802710607.

Dentzau, M. W. and Martínez, A. J. G. (2014). 'The development and validation of an alternative assessment to measure changes in understanding of the longleaf pine ecosystem'. *Environmental Education Research* 22 (1), pp. 129–152. https://doi.org/10.1080/13504622.2014.930728.

Dutcher, D. D., Finley, J. C., Luloff, A. E. and Johnson, J. B. (2007). 'Connectivity With Nature as a Measure of Environmental Values'. *Environment and Behavior* 39 (4), pp. 474–493. https://doi.org/10.1177/0013916506298794.

Epstein, I., Stevens, B., McKeever, P. and Baruchel, S. (2006). 'Photo Elicitation Interview (PEI): Using Photos to Elicit Children's Perspectives'. *International Journal of Qualitative Methods* 5 (3), pp. 1–11. https://doi.org/10.1177/160940690600500301.

Falk, J. H., Moussouri, T. and Coulson, D. (1998). 'The Effect of Visitors' Agendas on Museum Learning'. *Curator: The Museum Journal* 41 (2), pp. 107–120. https://doi.org/10.1111/j.2151-6952.1998.tb00822.x.

Figueiredo, A., Coelho, A., Duque, I., Bigotte, E., Migueis, M. and Vale, V. d. (2018). 'Projeto Limites Invisíveis: Programas casa da Mata (PCM)'. In: II Fórum CIDTFF: construindo um compromisso com a Ciência Aberta. Ed. by M. H. Araújo e Sá. Aveiro, Portugal: UA-Editora, p. 61.

Fox, B. A. (1987). 'Interactional Reconstruction in Real-Time Language Processing'. *Cognitive Science* 11 (3), pp. 365–387. https://doi.org/10.1207/s15516709cog1103_5.

Gunnell, J., Golumbic, Y., Hayes, T. and Cooper, M. (2021). 'Co-created citizen science: challenging cultures and practice in scientific research'. *JCOM* 20 (05), Y01. https://doi.org/10.22323/2.20050401.

Hand, K. L., Freeman, C., Seddon, P. J., Recio, M. R., Stein, A. and Heezik, Y. van (2016). 'The importance of urban gardens in supporting children's biophilia'. *Proceedings of the National Academy of Sciences* 114 (2), pp. 274–279. https://doi.org/10.1073/pnas.1609588114.

Hecker, S., Luckas, M., Brandt, M., Kikillus, H., Marenbach, I., Schiele, B., Sieber, A., van Vliet, A. J. H., Walz, U. and Wende, W. (2018). 'Stories can change the world — citizen science communication in practice'. In: Citizen science. Innovation in open science, society and policy. Ed. by S. Hecker, M. Haklay, A. Bowser, Z. Makuch, J. Vogel and A. Bonn. London, U.K.: UCL Press, pp. 445–462. https://doi.org/10.14324/111.9781787352339.

Jennings, V., Floyd, M. F., Shanahan, D., Coutts, C. and Sinykin, A. (2017). 'Emerging issues in urban ecology: implications for research, social justice, human health, and well-being'. *Population and Environment* 39 (1), pp. 69–86. https://doi.org/10.1007/s11111-017-0276-0.

Johnson, G. A., Pfister, A. E. and Vindrola-Padros, C. (2012). 'Drawings, Photos, and Performances: Using Visual Methods with Children'. *Visual Anthropology Review* 28 (2), pp. 164–178. https://doi.org/10.1111/j.1548-7458.2012.01122.x.

Joye, Y. and de Block, A. (2011). ''Nature and I are Two': A Critical Examination of the Biophilia Hypothesis'. *Environmental Values* 20 (2), pp. 189–215. https://doi.org/10.3197/096327111x12997574391724.

Kahn, P. H. (1997). 'Developmental Psychology and the Biophilia Hypothesis: Children's Affiliation with Nature'. *Developmental Review* 17 (1), pp. 1–61. https://doi.org/10.1006/drev.1996.0430.

Keith, R. J., Given, L. M., Martin, J. M. and Hochuli, D. F. (2021). 'Urban children's connections to nature and environmental behaviors differ with age and gender'. *PLOS ONE* 16 (7). Ed. by T.-K. Clarke, e0255421. https://doi.org/10.1371/journal.pone.0255421.

Kellert, S. R. and Wilson, E. O., eds. (1993). The Biophilia Hypothesis. Washington, D.C., U.S.A.: Island Press.

Keune, H., Kretsch, C., Blust, G. D., Gilbert, M., Flandroy, L., Berge, K. V. den, Versteirt, V., Hartig, T., Keersmaecker, L. D., Eggermont, H., Brosens, D., Dessein, J., Vanwambeke, S., Prieur-Richard, A. H., Wittmer, H., Herzele, A. V., Linard, C., Martens, P., Mathijs, E., Simoens, I., Damme, P. V., Volckaert, F., Heyman, P. and Bauler, T. (2013). 'Science-policy challenges for biodiversity, public health and urbanization: examples from Belgium'. *Environmental Research Letters* 8 (2), p. 025015. https://doi.org/10.1088/1748-9326/8/2/025015.

Lieberman, E. S., Posner, D. N. and Tsai, L. L. (2014). 'Does Information Lead to More Active Citizenship? Evidence from an Education Intervention in Rural Kenya'. *World Development* 60, pp. 69–83. https://doi.org/10.1016/j.worlddev.2014.03.014.

Louv, R. (2005). The last child in the woods: saving our children from nature deficit disorder. Chapel Hill, NC, U.S.A.: Algonquin Books.

Mansfield, R. G., Batagol, B. and Raven, R. (2021). '"Critical Agents of Change?": Opportunities and Limits to Children's Participation in Urban Planning'. *Journal of Planning Literature* 36 (2), pp. 170–186. https://doi.org/10.1177/0885412220988645.

Palmer, S. E. and Schibeci, R. A. (2014). 'What conceptions of science communication are espoused by science research funding bodies?' *Public Understanding of Science* 23 (5), pp. 511–527. https://doi.org/10.1177/0963662512455295.

Pyle, A. (2013). 'Engaging young children in research through photo elicitation'. *Early Child Development and Care* 183 (11), pp. 1544–1558. https://doi.org/10.1080/03004430.2012.733944.

Riedlinger, M., Metcalfe, J., Baram-Tsabari, A., Entradas, M., Joubert, M. and Massarani, L. (2019). 'Telling stories in science communication: case studies of scholar-practitioner collaboration'. *JCOM* 18 (05), N01. https://doi.org/10.22323/2.18050801.

Roschelle, J. and Teasley, S. D. (1995). 'The Construction of Shared Knowledge in Collaborative Problem Solving'. In: Computer Supported Collaborative Learning. Ed. by C. O'Malley. Springer Berlin Heidelberg, pp. 69–97. https://doi.org/10.1007/978-3-642-85098-1_5.

Schrage, M. (1990). 'Shared Minds: The New Technologies of Collaboration'. In: ed. by R. House. New York, NY, U.S.A.

Shapiro, H. G., Erickson, K. A., Peterson, M. N., Frew, K. N., Stevenson, K. T. and Langerhans, R. B. (2016). 'Which species to conserve: evaluating children's species-based conservation priorities'. *Biodiversity and Conservation* 25 (3), pp. 539–553. https://doi.org/10.1007/s10531-016-1067-0.

Sharma, N., Greaves, S., Siddharthan, A., Anderson, H., Robinson, A., Colucci-Gray, L., Wibowo, A., Bostock, H., Salisbury, A., Roberts, S., Slawson, D. and van der Wal, R. (2019). 'From citizen science to citizen action: analysing the potential for a digital platform to cultivate different ontologies of nature'. *JCOM* 18 (01), A07. https://doi.org/10.22323/2.18010207.

Søndergaard, E. and Reventlow, S. (2019). 'Drawing as a Facilitating Approach When Conducting Research Among Children'. *International Journal of Qualitative Methods* 18, p. 160940691882255. https://doi.org/10.1177/1609406918822558.

Trench, B. (2008). 'Towards an analytical framework of science communication models'. In: Communicating Science in Social Contexts. New models, new practices. Ed. by D. Cheng, M. Claessens, T. Gascoigne, J. Metcalfe, B. Schiele and S. Shi. Dordrecht, Netherlands: Springer, pp. 119–135. https://doi.org/10.1007/978-1-4020-8598-7_7.

United Nations, Department of Economic and Social Affairs, Population Division (2014). *World Urbanization Prospects. The 2014 Revision. Highlights (ST/ESA/SER.A/352)*. URL: https://population.un.org/wup/Publications/Files/WUP2014-Highlights.pdf.

— (2019). *World Urbanization Prospects. The 2018 Revision*. URL: https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf.

Valentine, G. (1997). '"Oh Yes I Can."" Oh No You Can't": Children and Parents' Understandings of Kids' Competence to Negotiate Public Space Safely'. *Antipode* 29 (1), pp. 65–89. https://doi.org/10.1111/1467-8330.00035.

Villar, M. E. (2021). 'Community engagement and co-creation of strategic health and environmental communication: collaborative storytelling and game-building'. *JCOM* 20 (01), C08. https://doi.org/10.22323/2.20010308.

Walker, G. B. (2007). 'Public participation as participatory communication in environmental policy decision-making: from concepts to structured conversations'. *Environmental Communication* 1 (1), pp. 99–110. https://doi.org/10.1080/17524030701334342.

Weaver, D. (2017). 'The Aarhus convention and process cosmopolitanism'. *International Environmental Agreements: Politics, Law and Economics* 18 (2), pp. 199–213. https://doi.org/10.1007/s10784-017-9369-6.

Wilson, E. O. (1984). Biophilia. Massachusetts, U.S.A.: Harvard University Press. URL: https://www.hup.harvard.edu/catalog.php?isbn=9780674074422.

Wolch, J. R., Byrne, J. and Newell, J. P. (2014). 'Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough''. *Landscape and Urban Planning* 125, pp. 234–244. https://doi.org/10.1016/j.landurbplan.2014.01.017.

Author

Rita Campos is researcher at CES-UC, with a PhD in Biology by the University of Porto. After several years working on evolution and population genetics, starts in September 2016 a path dedicated to research on Science Communication and Non-Formal Science Education. The aim is to develop communication tools that emphasize the benefits of protection and rational use of biodiversity on health, using results from current research on these topics and formats that privilege an approach between public and researchers. E-mail: ritacampos@ces.uc.pt.

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