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Beyond the university walls. The impact on university researchers of bringing science closer to vulnerable groups

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ABSTRACT

Science education is not equally accessible to all population groups. Adults in contexts of exclusion and with low education levels tend to be disconnected from scientific knowledge, and vulnerable groups of children and youth tend to present lower access to and interest in scientific content and develop less scientific vocations. Previous research has shown that activities addressed to bring science closer to vulnerable populations have a positive impact on reducing this inequality regarding their access to and interest in science. However, less is known about the impact that sharing scientific content with vulnerable people has on the university professors and researchers conducting these activities. Using a qualitative approach, this study analyses the perceived impact that a program aimed at promoting access to science to highly vulnerable people, including children and youth in residential care and adults deprived of liberty, had on the researchers implementing it. This study finds that participating in the program had a transformative impact on the researchers, including enhanced awareness of the participants' reality, empathy, developing engagement strategies, and overcoming prejudice, showing that not only do vulnerable groups benefit from participating in science-related activities but it also has a positive impact on the scientists engaged in the dissemination activities addressed to these populations. The study also shows that the dialogic approach used in the program contributed to overcoming barriers in the relationship between the academy and vulnerable sectors of society, revealing a feature other programs in different contexts can capitalise on to build more inclusive access to science.

1. Introduction

There is evidence that citizens' access to scientific knowledge is increasingly necessary for everyone's inclusion in current society. Citizens' science literacy has been highlighted as a crucial element in making public decisions on technology and health and building strong democracies (Solomon, 2021). At the personal level, scientific literacy has also been associated with less unwarranted beliefs,

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such as pseudoscientific beliefs (Fasce & Picó, 2019). In this regard, there are concerns that science education should be rethought to promote universal scientific literacy with an approach of "Science-and-Citizenship" (Solomon, 2002). School curriculums have a crucial role in it, but science literacy can also be promoted in alternative activities and contexts. In this regard, non-formal education settings, for instance in the form of educational science outreach programs, have been developed for children and youth to boost their motivation in STEM education as opportunities to advance towards the right of scientific literacy for all (Marques & Marandino, 2018).

Bringing science closer to citizens is especially important if we consider that scientific content is not equally accessible to all population groups. The approach of inclusive citizen science has made efforts to bring science closer to diverse backgrounds of people, including people with fewer resources, minorities and marginalised groups (Fiske et al., 2019; Paleco et al., 2021; Varga et al., 2023), while inclusive science education initiatives have focused on making STEM subjects accessible to diverse groups of students, with a special focus on underrepresented groups related to gender and ethnicity (Bianchini et al., 2002; Özkaya et al, 2023).

Among children and youth, those who are from vulnerable groups tend to present lower access to and interest in scientific content and develop less scientific vocations (Gairal et al., 2019). A particularly vulnerable group is children and youth in out-of-home care, both because of the abuse or neglect they often have been exposed to and the educational disruptions they experience that contribute to an increased risk of disadvantage in life (Crawford, 2006). Vulnerable adults in contexts of exclusion, with low education levels and minority populations (Dawson, 2014), and those in restrictive environments such as prisons (Heron & Williams, 2022), also tend to be disconnected from scientific knowledge. Taking this into account, scientific literacy can be performed from a transformative perspective, being sensitive to social and cultural diversity thus enhancing participation and emancipation of groups facing inequalities (Valladares, 2021).

Previous research has shown that activities addressed to bring science closer to vulnerable populations have a positive impact on reducing this inequality. Scientific workshops implemented with groups of children at risk of social exclusion (Salvadó, et al., 2021) and in the context of residential care (Gairal et al., 2019) helped improve their knowledge, develop more inclusive science identities and higher educational aspirations and scientific vocations. This is consistent with research pointing out that academic aspiration is a cultural aspect rather than an individual one, which is influenced by multiple social, cultural and experiential components (Bok, 2010), and therefore the capacity to realise these aspirations can be developed. Educational activities based on dialogic learning have also contributed to enhancing learning and reducing inequalities for these collectives. This is the case of dialogic gatherings, which have been conducted in diverse contexts of vulnerability such as residential care institutions (Salceda et al., 2022) and prisons (Álvarez et al., 2016), and have been also implemented focusing on science content, in the form of dialogic scientific gatherings with children (Díez-Palomar et al., 2022) and with adults with low educational levels (Buslón et al., 2020).

Although most of the research on public engagement with science focuses on outcomes for the public communities, bringing science closer to citizens can also have an impact on the researchers involved in such initiatives and in their institutions. In this regard, some studies identified positive impacts on researchers as a result of engaging in science outreach activities. According to these studies, scientists tend to perceive these activities as enjoyable; they motivate their desire to contribute to citizens and mostly experience outreach activities as positive (Andrews et al., 2005; Clark et al., 2016). Another of the benefits highlighted by research is that science dissemination activities entail an opportunity to improve researchers' teaching and communication skills (Andrews et al., 2005; Clark et al., 2016). Additionally, when science outreach activities are interdisciplinary, they entail an opportunity to improve researchers' communication abilities outside their own discipline. In interdisciplinary science communication contexts, the participant faculty members also benefit from informing and improving their teaching practices, improving their professional networks, and creating new research collaborations (Wallwey, Desing & Kaifez, 2023).

Other studies have emphasised that activities of public engagement in science bring opportunities for mutual learning among community members and scientists (Stofer, Hanson & Hecht, 2023). Universities can benefit from meaningful partnerships with the local community, especially those individuals and collectives living with disadvantage, as it enhances the institution's capacity to contribute to educational and social change (Booth, 2023). In this regard, there is research which has focused on the so-called "responsible science communicators or researchers", referring to those who focus on their audience and impact, and take into consideration their audiences' starting positions, needs and values (Jensen, 2022), which is especially relevant when science dissemination activities are aimed at disadvantaged populations.

Besides the benefits that previous research on the topic identifies for researchers who develop science dissemination activities, these studies also find obstacles and drawbacks. The main obstacles perceived by the researchers are, according to previous studies (Andrews et al., 2005; Concannon & Grenon, 2016; McCann et al., 2015; Stofer & Wolfe, 2018), time constraints and the effort required to balance their outreach activity with other higher priorities of their academic activity. In this regard, these studies also show a perceived lack of support, resources, and value placed on outreach activities by the institutions (Ecklund et al., 2012). Other challenges are related to difficulties in connecting to nonscientific audiences and a lack of professional development in engagement techniques (McCann et al., 2015; Stofer & Wolfe, 2018). In this regard, it has been highlighted the need for scientists to be deliberately prepared for effective public engagement, which is not always obvious to researchers who are experts in their disciplines (Stofer, Hanson & Hecht, 2023).

Indeed, participating in public engagement training has been associated with improved involvement and commitment to public outreach, improved engagement skills and benefits that extend to researchers' university teaching and career development (Stylinski et al., 2018). Additionally, research has also highlighted that preparation for public engagement activities should be accompanied by enhancing the evaluation of these activities and by promoting awareness of the diverse factors (socioeconomic status, values, beliefs, experiences, etc.) that shape power dynamics between faculty and participants. These power dynamics influence people's participation in science-related activities; for this reason, participants' backgrounds can be considered for a more meaningful and inclusive public engagement that prevents researchers-citizens interactions based on deficit thinking (Stofer, Hanson & Hecht, 2023).

Therefore, although not without obstacles, science dissemination activities are overall beneficial both for scientists and the public. While scientists gain benefits such as their improvement in communication skills with diverse audiences, which can positively impact their university teaching and career development, and the enhanced social utility of the research institutions, the recipients of the outreach activities increase their engagement, knowledge and enthusiasm related to science. However, less is known about the impact that bringing science content closer to non-scientific audiences has on the professors and researchers conducting these activities when the public are vulnerable groups of population, who are especially distant from science. Vulnerable groups especially benefit from participating in science-related activities, but do scientists benefit from engaging with these audiences in science outreach activities? This study aims to contribute to fill in this gap.

2. Methods

2.1. Context of the study

A program of scientific workshops was carried out in the framework of the project *Extended Learning Time IV: Contributing to developing scientific vocations in residential care*, which had the objective of promoting scientific vocations among highly vulnerable children and youth, specifically children and adolescents in residential care centres. Later, adults deprived of liberty in prison were also included in the project as another highly vulnerable population.

The scientific workshops implemented within the project consisted of training sessions conducted by researchers and scientists in specific scientific fields, including prehistory, evolution, climate change, chemistry, and STEM. A total of 32 workshops were carried out in a 4-month period. The workshops were conducted in 3 residential care centres in Catalunya (Spain) (18 workshops), 1 group home (in Cantabria, Spain) (6 workshops), and 1 adult school in a prison (in Catalunya, Spain) (8 workshops).

The residential care centres (called Residential Educational Action Centres, CRAEs in Catalunya, Spain) are residential institutions for the care and education of children and adolescents (from 0 to 18 years old). Their objective is to respond to their educational and care needs as an alternative to their family of origin, in cases of a non-existent or deteriorated family environment or with serious difficulties in covering the basic needs of children and adolescents, while they are unable to return to their respective families. The group homes are a socio-educational service for the preparation for independent living for boys and girls aged 15 to 21 who are victims of domestic violence and neglect and who are at risk of social exclusion. The participation of the selected CRAEs and the group home was based on the consultation and acceptance by those legally responsible for these institutions.

Overall, the implementation of the scientific workshops in the residential care centres and the group home was aimed at the participation of children and adolescents between the ages of 10 and 19. All of them were enrolled in schools that teach Primary Education, Compulsory Secondary Education, Baccalaureate or Vocational Training. The selection of the participants responded to the objective of promoting access, interest and scientific vocation to a profile of young people who are usually distanced from scientific environments, and for whom the stage of childhood and adolescence is key to developing their abilities, skills and vocation towards science. The workshops were conducted after school hours, as a volunteer activity that entails the extension of learning time, which has been identified by research as a Successful Educational Action (Flecha, 2015). The aim was to offer high-quality education for children and youth in residential care institutions that contribute to enhancing their academic opportunities and encourage the participants to become closer to and more interested in science.

The workshops were also conducted in a prison school which had already been implementing Successful Educational Actions, particularly Dialogic Literary Gatherings (Álvarez et al., 2016). In the prison, the workshops were implemented in two classes of the adult school whose teachers agreed to participate in the project, after having the approval of the management team. All the inmates who were enrolled in these classes had the opportunity to participate in the workshops if they wished.

In the case of the residential care centres, the workshops were held in person, in the residential care centres' premises, while in the case of the group home and the prison the sessions were held online.

2.2. Methodological approach

The objective of this study is to analyse the perceived impact that a program aimed at promoting access to science to highly vulnerable people, including children and youth in residential care and adults deprived of liberty, had on the researchers implementing it.

To respond to this objective, a qualitative methodological approach was used. According to Creswell (2013), qualitative research is used when an issue needs to be explored and a complex and detailed understanding of the issue is needed. Among other features, qualitative research is characterised by an inductive-deductive, reflective and interpretive process, that focuses on the participants' perspectives, their meanings and subjective views, and provides a holistic, complex picture aimed at understanding the contexts or settings in which participants address a problem or issue, empowering individuals to share their stories.

Particularly, the strategy chosen for data collection was the semi-structured interview, which facilitates that participants focus on the topics proposed by the researcher, according to the objective of the study, while being open enough to allow the participants to connect themes, building more holistic and nuanced knowledge of reality.

2.3. Instrument

To guide the interviews, a pre-defined interview script was prepared with the topics to cover according to the objective of the study.

The script included questions about two main topics: a) their initial impressions of the collectives that participated in the program and of conducting the workshops with them, and b) the impact that the program had on them as researchers: changes in their perception of the participants in the workshops, in the way they approach science dissemination activities, and other potential impacts. The use of the script was flexible to adapt to the course of the conversation and open to other relevant issues that could arise.

2.4. Participants

Five semi-structured interviews were conducted, one with each of the participant researchers in the scientific workshops. Table 1 summarises the profiles of the participant researchers.

2.5. Data collection procedure and ethical issues

The interviews were all conducted after the workshops program had finished, to obtain a retrospective analysis of the impact that the workshops had. Some of the researchers had participated in previous editions of the workshops program, therefore in these cases, their reflections covered the entire experience of participating in these workshops, from the beginning.

Before starting each interview, the interviewees were informed that the information would be treated anonymously, and for this purpose, they would be assigned a pseudonym. All interviewees signed an informed consent including the terms and purposes of the data collection. The interviews were held in person or online, according to the convenience of the interviewee, and lasted between 30 minutes and 1 hour, approximately. All of them were audio recorded, and transcribed with automatic transcription software, and then the transcriptions were revised.

2.6. Analysis

For the analysis of the interviews, a system of categories was created inductively based on the review of the interview transcripts, which allowed identifying the main themes related to the workshops' impact on the researchers. Seven categories were created: 1) Approaching and knowing better a distant reality; 2) Overcoming wrong ideas and prejudice; 3) Building empathy; 4) Considering diversity to include everyone; 5) Recognition of their work in the university; 6) Awareness of the impact of their work; and 7) Personal satisfaction. After the first allocation of the transcription excerpts to the categories it was revised, and some excerpts were reallocated to another category that reflected better the content.

3. Results

The analysis of the interviews with the researchers shows that their participation in the program had an impact on all of them in different aspects: cognitive, attitudinal, and emotional, as well as in the development of their professional activity of science outreach. The main impacts identified are detailed as follows. These are impacts that show an agreement between different participants (at least two of them reflected on each of these topics in the interviews), and are presented following the order from greater consensus to lesser consensus (which does not mean disagreement but that the topic was mentioned by fewer participants): all five researchers agreed that the workshops had an impact on approaching and knowing better a distant reality (3.1); and that it contributed to overcoming wrong ideas and prejudice and developing empathy (3.2), four of the researchers agreed that it had an impact on the development of their science outreach activity, enhancing the inclusion of diversity (3.3); three of the researchers agreed that the program of scientific workshops contributed to a greater awareness of the impact of their work and enhanced their personal satisfaction (3.4), and two researchers shared reflections on the recognition of their outreach work in the university (3.5).

Table 1
Profiles of participant researchers.

Researcher pseudonym	Profile	Vulnerable groups involved in their workshops		Number of projects to bring science closer to vulnerable populations in which they have been involved
		Children and youth in out-of-home care	Adults deprived of liberty	
Manuel	Research socialisation technician at the IPHES (Catalan Institute of Human Paleoecology and Social Evolution)	X	X	3
Marta	University professor at the Department of Biochemistry and Biotechnology and researcher on didactics of experimental sciences	X	X	4
Nerea	University professor and researcher at the Department of Physical and Inorganic Chemistry	X		2
Luis	University full professor and researcher at the Department of Chemical Engineering	X	X	2
Lucia	Researcher at the Catalan Institute of Chemical Research	X	X	1

3.1. Approaching and knowing better a distant reality

The first impact we found is a novel issue taking into account the literature review and the limited existing research on science outreach activities with vulnerable populations and its impact on researchers.

All five researchers –Marta, Manuel, Luis, Nerea and Lucia– agreed on the fact that implementing the workshops with the vulnerable groups allowed them to get closer to the reality of these persons which, until that moment, was unknown to them to a great extent. Although all of them were experienced researchers in conducting activities of science outreach, either with children, adolescents, adults or with all age groups, all of them manifested that they had no previous contact with at least some of the vulnerable populations they worked with in the workshops. This occurred especially with the children and youth in the residential care centres, as none of the researchers had previous contact. Although researchers were aware of the existence of these children and youth, they knew little of who they were or how their lives were. For instance, Lucia explained that before going to the residential care centre she did not know what exactly it was, how it operated and what children did there. Engaging in the program entailed getting to know this part of the reality of our society.

> Lucia: Of course, I didn't know exactly how a residential care centre worked, I didn't know if it was more like... if it was a boarding school, (…) ... I didn't even know that they existed (…).
>
> Researcher: So, for you too, it has been like getting to know a new...
>
> Lucia: Getting to know a new world. Yes, yes, yes, yes.

Marta also explained that she did not know either about the residential care centres. In this regard, she reflected that children and youth in the residential care system tend not to be visible as a collective in society, and therefore people in general know little about them. Although they mix with other children and youth in the schools they attend, they are somehow apart, unnoticed, and ignored in most people's daily lives. Therefore, they as researchers encountered this reality, which was new for them, only after taking part in a program particularly aimed at this group.

> Researcher: What was your previous idea about children and adolescents in residential care before participating in the project?
>
> Marta: Well, it's like a black box, isn't it? it's like a part of society that you hear, that you understand, that you know exists. But it's really separated and encapsulated from the rest, no? (...) I knew they existed, but like something encapsulated and out of everyday life, out of the day-to-day. To think that they are boys and girls who go to a high school, who go to a school, who have their own reality. (...) I didn't have this experience and my vision was a bit... Yes, outside the system.

Manuel insisted on the same idea of unawareness of this collective. In his case, he reminded being especially concerned about the place where the children and youth lived and where he was going to do the workshop. He recalled that he did not know what to expect of that place, or how it would be, and that made him feel uncertain when he had to be confronted with the first workshop. This concern vanished at the moment he entered the place:

> Manuel: I didn't even know what [children in residential care] were. (...) I think the problem for me was the concept of the building, that's what bothered me because I had no idea where I was going. (...) I did imagine a more protective building, more isolated. And when I arrived first and saw that it was just another house, that's all. And then when I went inside, I did the demonstration in a living room, it was like...

This insecurity also made him at some point doubt his ability to do well in the workshop for those children, despite his long-standing experience in doing these workshops about topics that he mastered and with a public of similar age. The same as the concern for the place, this vanished in the following sessions.

> Manel: and I remember that when I finished that day I said to myself: "Today you have not done it very well Manel", like saying... and recalling what I had explained, if I had explained it right, if it was understandable or not, I don't know, I was thinking about it and finally I said, "Manel, you have done it 40.000 times, you have done it with this age profiles many times, and I am sure that it will be the same, so stop thinking about it, because they said they liked it."

Lucia had a similar feeling of insecurity before her first workshop with the prison inmates. In this case, the workshops were held online. In the case of prison, it is a reality people, in general, are more aware and knowledgeable about; probably because of this reason and the fact that prison is related to crime, Lucia recalls that she was nervous, she did not know what to expect, how the participants will be. Again, this feeling disappeared after the first session and turned into satisfaction as she perceived the inmates' interest and participation:

> Lucia: It is a prison school, so I didn't know what to expect, and it's true that the first time I found it a bit difficult to approach, apart from that I was... I was quite nervous (...) because I didn't know what I was going to find, nor the profile of the people who were.... well, we don't know this, do we? Why they are there (…) I remember being very nervous before the session. And then I finished it very happy, very happy to see how they had participated (...) And then later, the second one, it was all much better. I got more into the atmosphere, didn't I? (…) I wasn't nervous anymore, and well, addressing them was totally different and I also got them to participate a lot and this... you leave there with great satisfaction (…). It's that, it's another way of approaching different groups.

In the case of Luis, he had previous experience with vulnerable people, especially with people deprived of liberty, as he had collaborated in a prison. However, he agreed that the collectives they worked with in this program are distant from the general population, and particularly from the university. He reflected on the idea that developing activities such as scientific workshops has a positive impact on the university system and the researchers, as it helps to bring together these two distant worlds, emphasising that the university institution and its professionals gain awareness of the reality of sectors of society less visible in universities:

> Luis: This is an action from us to them, but also from them to us. So this part is also great, the listening part, because the professors, don't even know what's outside their bubble, don't they? When you bring closer to them a different bubble, like this one, it's also an impact, that is to say, an impact in both directions, (...) because now we professors will also be more receptive... just as you asked me if the kids will be more receptive to science, now we will be receptive when we are asked from prison, as I was asked the other day: "came to give us a lecture".

Therefore, this contact between academia and vulnerable populations via science dissemination activities becomes a venue not only for contributing to social change in these populations as previous research has already found (Booth, 2023) but also for promoting change within the research institutions.

3.2. Overcoming wrong ideas and prejudice and developing empathy

The second impact identified is related to the first one and likewise has not either been reported in the literature reviewed. Approaching these collectives and knowing them better was linked in the cases of all five researchers –Marta, Manuel, Luis, Nerea and Lucia – with the overcoming of previous wrong ideas and prejudices. Regarding the children and youth in residential care, some preconceptions of the researchers associated these children and youth with ideas of delinquency or pre-delinquency, probably aggressiveness, and misbehaviour. For instance, before the first session in the residential care centre, Manuel imagined a building with high-security measures. He also expressed his doubts about carrying cutting silex stones he usually uses in his workshops, because he was concerned about how the youths could react, and if it could be dangerous. After the workshops, he explained that he was surprised at how well-educated they were.

> Manuel: Well, I wouldn't say that I thought they were aggressive or anything like that, but I do remember that the first few days we were a bit... (…) I was a little bit worried. (...) And I'm frank, if I had any prejudice, it crumbled on the first visit, on the second visit I was going in a totally different way. (...) I also tell you something, eh? I was expecting to find children a bit more difficult than what I found. I've come across very normal children. And when I say normal, I mean the same as you can find in any school anywhere.

In the case of Luis, he expected adolescents and not young children. He explicitly explained that his expectation made him think of unaccompanied youth entering the delinquency pipeline. However, he found "normal kids", and "just kids", an idea that researchers repeated and that evidences the change in their perception of these children and the overcoming of their misconceptions based on their lack of knowledge of the collective.

> Luis: I thought they would be older, but they were children, the vast majority were young children, I thought they would be older and when they are older you think... in the pre-delinquents (…) ... I thought they would be teenagers, 14, 15, 16 years old, right? But I found young children. And little kids are little kids, full stop. They were little kids, little kids are not pre-delinquents, a godforsaken 17-year-old boy, maybe... But... a little kid is a little kid. Then, this was a great surprise for me, that we worked mostly with little kids. (...) And of course, what a little kid wants is to do things, do activities, have a good time, like any little kid, no.... I haven't found a difference...

Regarding the participants in the prison, Marta explained that she felt alleviated when she knew that the workshop was going to be held online, as she was frightened to approach that context: "The fact that it was not in person... (…) I must confess that it would have given me more respect (...). If it had been in person, it would have been more of a shock, I think". After the workshops, she highlights that she was surprised by the climate of respect that was created and the engagement and interest in the discussion about the topics proposed for the workshop, despite being very specific scientific content, distant from their daily lives.

> Marta: In prison, for example, I found a lot of respect there. People spoke to me with a lot of respect, (…) they valued the fact that I was there and that they could come and talk in those sessions and do the sessions. I mean, the respect was absolute and then the fact that there was discussion also encouraged it a bit that people participated and said their ideas and then talked to each other a lot, which I also liked because I saw that they were talking about this subject between them and I said, "Oh my God, we are talking about biochemistry (…)… modern biotechnology and people are talking about genes and... no?" And I saw (...) I felt a lot of respect and gratitude. (...) They were especially respectful, yes.

Particularly in the case of the children and youth in residential care, getting to know this collective that until that moment was unknown to them provoked in some cases an emotional impact due to the special situation of vulnerability these children face, and developed empathy among the researchers. Marta, Nerea and Lucia reflected on this idea. Marta highlighted that she was concerned about the hardship of these children's lives from an early age.

> Marta: I would say that one of the things that has had the biggest impact on me has been the CRAEs (residential care centres) (...). Those kids who are there, they live there, it's their day-to-day life and you go back the following year, and you find them

there again in their day-to-day life (...). It's a hard day-to-day life (...). It's not a centre where you have that shelter, you have shelter at home, in your place, on your sofa, with your blanket, you have a space of emotional security of tranquillity and that makes you feel at ease, (...). These kids don't have that, even though they are very well cared for, even though they are very well looked after, but they don't have that. So, I was surprised by the strength of these kids. The toughness of their lives (...). So, I have absolute admiration for these kids.

Nerea recalls a sentiment of injustice and pain after the first contact with these children. Although she found it difficult to leave these feelings aside from the scientific workshop, once engaged in the activity she found children interested in what she proposed and in learning, as she could find in other contexts.

Nerea: Above all, it had an emotional impact on me (…) this affects you emotionally because you don't know this environment, you know (…) a more or less stable family environment (...). And there you see that those children are disconnected from their families, and even if this has nothing to do with the dissemination activity, it affects you and you can't let go of this emotion... (...). But even so, you focus quickly on the work you have to do, and you see that children are children, like everywhere else, and that their interest, when you are doing an activity, is really like that of any other group, there is no... I didn't see a difference in that. But you get this emotional impact (...) and there, when I left, especially during the first sessions, I felt a little bit of pain, I mean, here there is something that is not fair, isn't it?

Previous literature has highlighted the need to prevent deficit thinking in researchers-participants interactions when engaged in science-related activities (Stofer, Hanson & Hecht, 2023). The reflections shared by the researchers in this study show that they did hold some negative expectations of the participants before starting to work with them. Still, these thoughts were overcome through the workshops' development, which means the workshops' positive impact on the researchers.

3.3. Impact on the development of their science outreach activity: Considering diversity to include everyone

One of the impacts of science dissemination activities according to the literature review is an improvement of the communicative and teaching abilities of the researchers (Andrews et al., 2005; Clark et al., 2016). In our study, being faced with audiences different to the usual ones, made the researchers revise the dynamics they proposed, thus enhancing their communicative and engaging ability. All the researchers were used to conducting activities of science outreach with diverse audiences, but the audiences found in this program were new to them. Knowing from a closer perspective different human and social realities compelled them to take their particularities into account –their personal characteristics and those of the context they were in– when conducting the activities. Three researchers –Marta, Manuel, Nerea and Lucia– manifested that they were aware that they had to be sensitive to this diversity and often developed strategies on-site to respond to it.

In the context of the residential care centre, Nerea explained that she noticed the importance of personalizing her intervention. She was entering the home of these children and youth; therefore, the conversation could not be anonymous as was often in the schools she visited. They had to introduce each other and call them by their names to create an atmosphere of closeness and start to know a little about each other. The fact that they were small groups facilitated this dynamic.

Nerea: Well, there is one thing that I did learn on the first day, when I went there, which was to personalise (…) When I work with a lot of groups, I don't always identify the children one by one with their name. I go there, I do the talk, or the workshop... (...) And there I realised and said: "Wait, wait a minute, first there has to be a phase of trust because I'm a strange person who is going to their land, which is their home". This is where I saw the difference. That house was their home (...). In a school, it could be a little more anonymous, but not there. And that was interesting because I said: "Wait, dedicate some time to getting to know each other first" (…) Then, that first link already gave me clues on how to go on.

Other strategies used by the researchers were aimed at motivating participation. For this purpose, most of the researchers explained that they gave the participants the liberty to ask any question they had and express any reflection that came to their mind, however unexpected it may be. As Manuel explained regarding the residential care centre:

Manuel: I start from one premise: All questions are good, all of them, and I must answer all of them, because I'm being asked by a girl or a boy, not by a guy while he's making fun of me, no, they are asking seriously...

The idea was that they feel listened to, to engage them connecting the activity with their thoughts and previous experiences, and to transmit the idea that no question was wrong if they had the curiosity and that they all could make interesting contributions. In this regard, Marta explained that in prison it helped to build a more dialogic and argumentative atmosphere in a context usually characterized by more aggressive interactions.

My option has been to let them talk a lot, that is, to listen to them and all the questions they had, which were often challenging or often aimed at embarrassing me (…). I mean, give them arguments to see that they can be right, and they can also improve their positions, right? (...) If you let them talk and ask them questions and let them express themselves, in the end, it makes them softer because they are used to an immediate response and when you don't give them an immediate response, you let them have all the time in the world to talk. (…) so for me, it's been a challenge how to react to these profiles that I'm not normally used to working with.

In the residential care centre, Lucia and Nerea found some children who were more reticent to participate. They were concerned

about including them in the activity and achieving their participation. With this purpose, they were attentive to the reactions of each child and managed to find ways to engage them.

> Lucia: (…) the way they reacted, well, there was a bit of everything. Some were very involved and some were totally passive and played and withdrew and... And well, this makes you take out more tools and look for and think about that moment and see how I can reach them and how...

In this regard, Lucia reflected that this experience made her more sensitive to diversity and this will probably affect the way she will approach the diversity that there may be in other groups with whom she will perform science outreach activities in the future, to try to engage all of them.

> Lucia: These things you always know, but this maybe makes you have it more in mind, right? You can't treat everyone the same and everyone has their stories behind, and you don't know why maybe this child from a class in a school that you don't know anything about, is acting like this and why another one acts differently. Well, you know that there are many environments and many stories... You learn, don't you? To try to look for resources, especially to look for resources to... to be able to reach them and to be able to... to make them feel a certain interest, or at least that they remember something, right?

Considering particular interests, characteristics or profiles was also useful to engage the participants in the activity. For instance, Nerea explained that she was open to questions and comments that were raised by the children, for instance, related to their family contexts and origins. She embraced these interventions and then redirected the conversation towards the topic of the day. She learnt to be flexible in the way she presented the activity to embrace the diversity and engage all the participants, while she kept the focus on the scientific content of the session.

> Nerea: I adhered to the experimental part as much as possible, because that's what I had prepared, but of course, depending on… I don't know, for example, when I took the inflatable globe, right? This inflatable globe was just to talk about the poles, but, when children saw countries and geography, especially children who had family from other countries, more than being interested in the poles, they were interested in finding out where their origins were and then, the first thing we did was "I want to look for. ..." Morocco, Colombia, China... whatever, whatever country. (...) they already had the opportunity to share with their peers "I'm from here, so I'm from there", right? And then they pointed it out to each other, and they looked for it, right? (…) once you've done that, and you've already satisfied their curiosity, we redirect without being abrupt, right? (…) because in the end it's about doing science, but it's all related, isn't it?

Similarly, Marta learnt that in the prison it was crucial to look at the participants' profiles to include them. She made the effort to explicitly include in the session information related to the origins of some of the participants, which she understood was important for them to see that she was committed to including them in the activity and that they could make the most of it. She reflected that now she is more aware of the importance of acknowledging the diversity of the participants.

> Marta: Maybe I do give more importance to diversity in the audience (...) For example, I saw that there was a very large group of South Americans in my group. So, what I did in the following sessions was to give examples and look for information from their countries of origin to include in the tasks or the talk, so that they would feel appealed, and when they see that you have made an effort to talk about something that appeals to them, people thank you a lot.

Marta also highlighted the importance of being sensitive to the different communication styles he found in prison and the residential care centre. She identified that some of the participants were more aggressive in their communication. However, she understood that this was the way they used to communicate because they learnt it in their socialization process, it was not an aggressive communication with her but the way they expressed passion in their arguments, and she interpreted it positively as a sign of their implication and motivation.

> Marta: (…) he is like that, that is, his way of relating to each other, his way of talking is like that, it is nothing personal, I have never felt attacked, I know that is him, it is his structure, it is his dialogue, it is his way, it is his style, it is not personal, you could see it, (...) he comes and talks like that because he is involved. (...) he's talking like that because it's something that satisfies him, and he wants to share it and it is his way of doing it (...) and the truth is that he was the one who participated the most in class. Besides, he also made interesting arguments, it wasn't nonsense, I mean, a lot of the things he was... Well, he was right, wasn't he?

In the case of Manuel, his willingness to respond to the needs and interests of the children and youth he found went beyond the sessions he shared with them. He wanted to stimulate curiosity and broaden the learning opportunities of any child who wanted to know more after the workshops finished. Therefore, he brought first some of his books, and later he managed to get some books from his research centre as a gift for the residential care centre. Additionally, he offered the educators his email address so that they could ask him for more material in case some children had more interest. His objective was that the children in residential care could have all the information and material they wished to learn about prehistory.

> Researcher: And the initiative to collect the books and all that, how did it come about?
> Manuel: It was my idea after finishing one of the sessions when David [one child] came to the door asking me for more and more and more. And the first thing I thought was "OK, I'll take the books I have at home". But after carrying my books, I realised that it was not enough for them and I know very well that many of my friends and colleagues have the same problem as me, and I

> simply sent an internal mail that received a very good response. (…) And it has been established in our centre, when we edit a series of books for dissemination, not only for CRAEs, but also to have them in my car and if someday I find someone in love with prehistory, I can give them a book no matter who they are or how they are. (...) And, I said to the educators at the end that if any of the boys or girls showed more interest, they could write me an email and we would get more material. And it would be one of the objectives that these centres would not lack resources at least in the disciplines that we work on.

The accounts of the researchers accommodating themselves to the characteristics of their audiences recall the idea of "responsible science communicators or researchers" (Jensen, 2022), as those researchers who take into account the characteristics of the communities they approach, their starting positions, contexts, needs and values, and act according to them to have an impact. The scientific workshops with vulnerable groups allowed these researchers to move beyond traditional audiences and develop new abilities as "responsible science communicators and researchers".

3.4. Greater awareness of the impact of their work and enhanced personal satisfaction

One of the impacts identified in the literature review on researchers engaged in dissemination activities is their satisfaction, enjoyment and positive overall experience (Andrews et al., 2005; Clark et al., 2016). In our study, participating in the scientific workshops with vulnerable groups also had this positive impact on the researchers, as they were personally satisfied with participating in these activities. Additionally, they became more aware of the impact of their work, which enhanced their feeling of satisfaction. Three of the researchers –Manuel, Luis and Nerea– reflected on this aspect.

For instance, Nerea explained that it was very rewarding for her and that the contact with diverse realities new for her meant relevant personal learning. Luis explained that doing the workshops made him feel better and this personal satisfaction was the motivation to be involved in the project.

> Luis: Well, I always say the same thing. It's like when you donate blood. You feel better (...). People have to understand that you don't do it just to help others or to lend a hand, but that I also see a positive reinforcement in myself. That day I say: "Oh, it's like I woke up early and I've had to go I don't know where, I've arrived late…" and then you get home later and it's cold and it's raining or whatever, but well, but you're happier. (...) in my case, at the very least, it is the reason why I do it, because, of course, I don't do it either for money or recognition or anything else. I do it because I want to do it. After all, it satisfies me more than any other activity.

Manuel also explained that he felt very satisfied with the development of the workshops, and said: "I would be delighted to explain everything I have felt, and how it has changed everything. It's been a long time since I had been involved in dissemination, but I've never been part of a project like this". With this project, Manuel reinforced his conviction to strengthen the social dimension of his work and the work developed in his research centre: "In all the social issues, I would commit to it (...) I mean, seeing this and seeing the effect that we have had on these children...". In this regard, he recalled two examples of the impact he perceived on the children. The first example showed that the workshops provided knowledge that can help children fight racism: "You should have seen the face of an African boy in [one CRAE] when I said that until 10–15 thousand years ago, most Europeans had dark-coloured skin... it was magical... a huge smile! The other children did smile too...". The second example shows how the workshops promoted children's interest in scientific facts and the motivation to ask profound relevant questions when a climate of respect and openness was provided:

> Manuel: Another day, a girl was waiting for everyone to leave and at the end, she asked me: "Is it possible that there are still Neanderthals left today?" That is a delicate question to ask in public and she knew it. But she had to ask it, and she waited until the end to ask it, and when she asked it, it was like "wow" and she looked at my face and said: "It's silly, isn't it?" and I said: "No, it's not silly, in any case, it is a doubt that you have, right? And now I'm going to solve it: (...)". And I don't know, in the end, I think that you can't aspire to certain things in those short visits. However, it is with these small seeds, no? that you're going to...

Previous studies have found that univerisities engagement in activities with disadvantaged communities has an impact in terms of contributing to social change (Booth, 2023). In the case of these scientific workshops, the fact that they were conducted with vulnerable groups and that these workshops entailed new learning opportunities for these children, youth and adults, meant an additional source of satisfaction for the researchers.

3.5. Reflections on the recognition of their work in the university

Finally, two of the researchers –Marta and Luis– shared some reflections on the impact of this project in their institutions and the recognition of this work in the university, although they pointed out different aspects. On the one hand, Marta said that developing such projects is acknowledged as very interesting by her colleagues, and as something that should be done more frequently:

> Marta: In general, everyone finds it very interesting because it's like a niche of action. Also, from the didactics of science, eh? Because the collaborators that worked with me, have commented on it. (…) It is an area of didactics that is very focused on schools and the school environment. So, leaving the school environment and going to other collectives, well, it's not natural, it's not a first option, but everybody found it very interesting (...) everybody was very interested, and very much giving value, giving a lot of value to these actions.

However, according to Luis, this type of activity is still far from being officially recognized and valued by university professors in

their home institutions. His reflections coincide with the results of previous research which has highlighted the lack of support, resources and recognition of science dissemination (Ecklund et al., 2012). As Luis explains, it is the impact researchers themselves perceive and the personal satisfaction they obtain as the reason to engage in these activities, not the institutional recognition.

> Luis: I'm not saying this to my department or anything, I'm the one who's happy about it. I don't need my head of department... in fact, he doesn't know about all this. (…) because when my head of department congratulates people in departmental councils, he always congratulates them on their... and the rector, the board, they always congratulate them on their achievements, no? their scientific or teaching achievements. Full stop. They congratulate you if you're the best scientist, if you've got a great project, if you've published I don't know where… but for these things? Well, never, never means never.

4. Discussion

This study shows a new impact of bringing scientific knowledge closer to collectives that are normally more distant from it, because of their situation of vulnerability. Previous research has found that these vulnerable groups benefit from participating in science-related activities (Gairal, et al., 2019; Salvadó et al., 2021); our study shows that it also has a positive impact on the scientists engaged in the dissemination activities addressed to these populations, according to their accounts.

Considering previous evidence on the impact that performing science outreach activities has on scientists (Andrews et al., 2005; Clark et al., 2016), the researchers' accounts in our study coincided with some of the already known challenges and benefits; these are the scarce institutional recognition in the academia as the main challenge, and the opportunity to improve communication abilities and an overall positive experience as the main benefits. However, in our study, the most significant impacts found are specifically related to the fact of conducting these activities with vulnerable audiences, who live harsh lives and tend to have more limited learning opportunities and outcomes; these groups are also distant from scientific content and are not typical audiences of science outreach activities.

Firstly, the most evident impacts for the researchers were related to the development of a better knowledge of a reality greatly unknown to them and, as a result, the overcoming of wrong ideas and prejudice. For instance, they discovered that children and youth in residential care are as eager for knowledge and discovery as any other child and that the vehement communication style of people in prison was a sign of interest and gratitude for the discussions that the scientists brought to them. The close interaction with these collectives helped overcome prejudice and the initial fear of disinterest in the topics they brought for discussion, and even the fear of aggressive behaviors. This enhanced knowledge of the participants' reality occurred together with the sentiment that these groups of people should have more learning opportunities such as the workshops they conducted, to compensate for their disadvantaged situation, and enhanced their motivation to contribute to it. These impacts have been identified for the first time, taking into account the literature review, and are the ones on which we found the greatest agreement between the interviewed researchers.

Secondly, the scientific workshops with these vulnerable groups entailed a change in the way researchers approach their science dissemination activities. On the one hand, they learned to be more sensitive to the diversity of profiles they encountered in their audience and developed strategies to engage them in the activity, thus becoming more capable of bringing science closer to diverse populations and taking into account diversity within a group, which can potentially have an impact not only in their subsequent science outreach activity but also in their classes as university professors. In this regard, the scientific workshops have contributed to developing the researchers' sensitivity and response to the diverse characteristics, contexts, needs and backgrounds of their audiences to maximise their impact on them (Jensen, 2022).

On the other hand, it is remarkable that the workshops entailed the assumption of a dialogic perspective, as researchers and participants engaged in discussions based on egalitarian dialogue and argumentation, bringing together scientific knowledge and knowledge from daily life. Dialogic teaching and learning create the context for inclusive education that does not exclude anyone and enhances opportunities for both academic achievement and social cohesion (García-Carrión et al., 2020). Previous research in the last two decades has demonstrated the positive impact of dialogic learning on vulnerable groups of learners, thus overcoming inequalities (Flecha, 2000; Flecha & Soler, 2013), and more recently has shown its positive impact on science learning (Díez-Palomar et al., 2022; Buslón et al., 2020), which has been now transferred to the scientific workshops with children and youth in residential care and adults in prison. The dialogic basis of the educational action presented in this study has contributed to challenging the science-lay dichotomy and overcoming deficit models that leave ordinary people excluded from knowing advancements in scientific and technological developments and their implications (Eden, 2010). Efforts are being made by researchers to build inclusive science communication with diverse populations including groups at risk of social inclusion, and successful cases and actions include, among others, dialogic scientific gatherings and scientific workshops (FECYT, 2022). The dialogic approach used in the scientific workshops has contributed to overcoming barriers in the relationship between the academy and vulnerable sectors of society, which can contribute to building more inclusive access to science and to having a twofold transformative impact: on participants and researchers. While participants in the workshops gain access to scientific knowledge necessary to fully exercise citizenship in today's society, researchers learn to make science more inclusive beyond the university walls.

This study is not without limitations. One limitation is related to the reduced number of participants. The qualitative methodological perspective does not intend to generalise but to deepen the comprehension of the reality study, and the study sample was composed of all the researchers who participated in the program. However, due to the small number of participants, we must be cautious with the interpretation of the results. A second limitation is that we did not gather information on the researchers' preparation to connect to non-scientific audiences and/or with vulnerable audiences, or their previous participation in professional development activities for science dissemination, which has been highlighted by previous research as a factor that could have an impact on the

quality of the science dissemination activities. Although it was not a focus of our study, we did not know to what extent having or not previous preparation could have influenced the workshops' impact on the researchers. Further research could continue analysing the development of this program of science dissemination –or other similar programs– to confirm or refine the conclusions of this study regarding the impacts observed, to identify further impacts and to assess the impact on researchers through time: if it is sustained and how, to what extent it has transformed their way of communicating science in the medium and long term, how it influenced subsequent opportunities to bring science closer to other vulnerable groups, whether it somehow transformed their academic activity, either regarding research and teaching, or whether the impacts can be enhanced with previous training.

Furthermore, taking into account its limitations, this study can inform policy and practice, as it can inspire similar actions in other areas of learning, and with other vulnerable populations, and can also contribute to recognising and encouraging activities of science dissemination from the academia. Finally, the topic addressed in this study is not related to the characteristics of a particular context, so this study can also inspire similar actions in other different contexts, to respond to the global challenge of advancing towards more inclusive dialogue between science and society.

Declarations

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Ethics approval

The study followed all ethical standards for research involving human participants included in the Declaration of Helsinki. The study was fully approved by the Ethics Board of the Community of Researchers on Excellence for All (CREA) (approval number 20,231,112).

CRediT authorship contribution statement

Silvia Molina Roldán: Writing – original draft, Investigation. **Laura P. Hernández-Egía:** Writing – review & editing, Investigation. **Laura Natividad-Sancho:** Writing – review & editing, Investigation. **Ana Burgués-Freitas:** Writing – review & editing, Investigation.

Declarations of interest

None.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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