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Scientific workshops with a dialogical approach: an effective tool for introducing science into vulnerable educational contexts

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The literature shows not only that science communication excludes the most vulnerable groups in society but also that it is of the utmost importance to make it more inclusive and available to all citizens. However, the inclusive communication experiences that are having some impact on society by including vulnerable groups have yet to cover all aspects of the issue. This article shows the positive results of scientific workshops that take a dialogical approach from researchers from the Institute of Human Palaeoecology and Social Evolution (IPHES). The workshops on the "IPHES in the Local Area" program are designed to communicate science looking for scientific excellence in urban centers that are of special complexity. The data were collected using pre-and post-test questionnaires given to 117 pupils from three primary schools where the science workshops were held. The data analysis shows that, after the workshops, participants had a greater interest in and appreciation of science.

KEYWORDS

science workshops, dialogic approach, science communication, vulnerable groups, vulnerable educational contexts

1 Introduction

Although it plays an essential role in our societies, science is not equally accessible to everyone. As shown in the first guide on inclusive science communication published by the Spanish Federation of Science and Technology, only some have equal access to scientific evidence and advances (FECYT, 2022). Both the European Union (EU), through the European scientific research program Horizon Europe (European Commission, 2020), and the United Nations, through the Millennium Development Goals of the 2030 Agenda, are working to ensure that everyone can benefit equally from the contributions of science and participate in its advances. Today's unequal access to science means that many outreach practices are being implemented to bring science closer to privileged groups in society, which indicates a lack of inclusiveness in science communication (Dawson, 2019).

For Dawson (2019), the lack of equal access to science is because opportunities to interact, learn, engage, question, and critique science are marked by inequalities that reflect and reproduce social advantages and disadvantages. It is, therefore, crucial to understand how science communication operates to build practices that are more inclusive and egalitarian within and beyond science communication and education. Public practices that mediate between science and people are conditioned by three factors: gender (United Nations Educational, Scientific and Cultural Organization, 2015), socio-economic status (Lee, 2016), and ethnicity (Merolla et al., 2012). These factors can become barriers and act as determinants and restrict access to everyday science opportunities, which Dawson (2019) describes as a form of marginalization and oppression.

Reproductionist models justify unequal access to scientific or cultural capital based on concepts such as habitus (Bourdieu and Passeron, 1964), which establish a preponderance of economic, cultural, and scientific capital factors (Archer et al., 2012). These factors determine the boundaries between social classes and stratify them in terms of what the family transfers. This explains the need for inclusion. This approach conceives education as a system that reproduces inequalities by rewarding the knowledge and behavior of the dominant classes and elites (Bourdieu and Passeron, 1964).

Society needs to challenge reproductionist theories by promoting inclusive science communication that makes science available to all people equally, with particular attention to vulnerable groups at risk of exclusion. This article aims to contribute to this purpose by promoting inclusive science communication, which seeks to identify practices that counteract the link between social class and preferences. The aim is for all people to reach scientific excellence of scientific literacy (Torras-Gómez et al., 2019; Aiello et al., 2021). Therefore, it takes as reference studies that show that students who start with a low cultural level in their family environment benefit more from the acquisition of cultural capital than those who already have a high cultural capital in their family (DiMaggio and Mohr, 1985). This positively impacts academic success and is particularly powerful in low-achieving environments (Andersen and Jaeger, 2015).

2 Theoretical background

2.1 Learning opportunities to overcome inequalities

This study goes beyond reproduction approaches and helps to overcome the inequalities suffered by vulnerable groups, encouraging high expectations. One of the aspects that makes this process successful is high expectations because they change the perception that students have of themselves and have an impact on their academic trajectory. Studies of this process point out that it is a social one. This framework explains how the aptitude for and attitude to learning depends on interactions with other people with whom the activity is shared. Therefore, creating environments in which high expectations are paramount helps everybody build an identity that opens up new opportunities for improving their academic performance (Mead, 1934; Díez-Palomar et al., 2020). It also helps them to transform their attitudes to science and do away with ideas that science is for specific social and cultural groups (Dawson, 2019).

Studies on inclusive science communication point out the importance of high scientific quality. In other words, the activities are designed to be enjoyed and to give participants a role in communicating scientific evidence to develop strategies and actions to help them find solutions to their problems. Furthermore, this scientific evidence has a social impact on people's lives (FECYT, 2022).

One example of this fact is the "IPHES in the Local Area" program, which tries to increase the participation of vulnerable groups while ensuring high scientific quality. It is a program aimed at bringing educational activities on prehistory to students from disadvantaged backgrounds in the peripheral districts of the city of Tarragona. The program designs high-level dissemination events by adapting the scientific content without losing the high quality and using a dialogic approach in the training sessions. Following this approach, the aim is to create a participatory environment for adults and children, based on a natural learning context, which seeks to break the power relations between the scientist and the participants. In this way, the scientist contributes accumulated scientific knowledge about a reality addressed in the workshop, while these contributions are taken up by the participants in a process in which the egalitarian and intersubjective dialog between the scientist and the participants promotes the construction and interpretation of this reality."

The program takes a great deal of trouble to adapt the content to the wide range of ages of the attendees while maintaining a high scientific level. The workshops cover such topics as human evolution, cultural and biological milestones, hominids, and social and technological advances (Paleolithic and Neolithic). The scientific level is high thanks to the material created by IPHES researchers from the various research departments: anthropology, lithic technology, molecular archeology, paleobotany, paleontology, geology, zooarchaeology, cognition, and palaeoclimate. All sessions are led by an experimental archeologist who makes stone tools in the classroom, produces fire, and brings self-made reproductions and replicas that the students can handle. This sort of practical demonstration is quite common in prehistory outreach activities, although the workshops in this program have the peculiarity that they adopt a dialogical approach (Flecha, 2000; Racionero and Padrós, 2010; Flecha and Soler, 2013; García-Carrión et al., 2020), the aim of which is to turn the occasion into a dialogical demonstration guided by the principles of equality, inclusion, an integrating vision and accompaniment in scientific reflection.

The "IPHES in the Local Area" program is based on dialogic learning, which has been widely demonstrated to improve children's learning (Flecha and Soler, 2013; García-Carrión et al., 2020). The European research program INCLUD- ED. CREA (2006–2011), funded by the European Commission's Sixth Framework Programme, challenged the Bourdesian model by implementing successful educational interventions (Flecha, 2015) and achieving outstanding scientific and social results. It claims that successful educational actions allow children to develop their potential by building scientific capital (Salvadó et al., 2021).

The science workshop approach involves all these aspects, which play an essential role. The staging, the reproductions and delivery, the attitude of those in charge, the vocabulary used, and many other aids make the activity a genuinely educational experience (Díez-Palomar et al., 2020).

2.2 The program: "IPHES in the local area"

2.2.1 Casts and reproductions: an integrative exhibition

The IPHES is a research institute in Tarragona (Spain) specializing in prehistory, paleoecology, and human evolution.[1] One of its many

1 Socialització IPHES | Evoluciona.

outreach and teaching activities is "IPHES in schools," the main program of educational, scientific activities that attempts to respond to different school profiles. In 2019, the program "IPHES in the Local Area" was created to focus on schools classified by the Department of Education of the Catalan Government as being of special complexity[2] (Resolució ENS 2466, 2018) (Department of Education, 2018). "IPHES in the Local Area" acts in these schools to improve the situation with activities in prehistory for high-level scientific dissemination with all the agents involved. The "IPHES in the Local Area" program provides unique science communication activities by combining high scientific quality with actions targeting vulnerable groups often excluded from science.

The program consists mainly of demonstrations that use many materials to make them a more interactive experience for the students. To this end, the person in charge is an experimental archeologist who uses his personal collection. He brings between one and two hundred pieces for the demonstrations, depending on the pedagogical approach. The pieces include eight cast skulls of Australopithecus and Homo as a sample of human evolution. All reproductions are handmade, with dozens of stone tools designed to explain technological evolution: for example, a set of arrows, a bow, a spear and spear-thrower or atlatl, a bone flute and other musical instruments, a pump drill, among others, have been chosen to reassess the intelligence of prehistoric populations. Most of them are carried in foam suitcases, easy to transport, and elegantly presented, and are the focus of the demonstrations.

Even though the stone tools are incredibly sharp and dangerous for children to handle, the scientists carefully select some suitable tools. So, they show some flint tools with blunt edges and examine them to ensure no sensitive parts can cause any damage. Antlers, bones, and rocks (unmodified materials) are some sensory resources the public can touch. The physical interaction is controlled by the team in charge and teaching staff, and the reproductions are passed from hand to hand during the presentation.

The demonstrations also include resources that attempt to respond to the diverse needs of the student body. To this end, the scientist always carries five rocks with a unique texture, a piece of elk antler with a delightful musky smell, and a piece of Juniperus oxicedrus wood (scented). These are used with pupils with hearing and visual impairments, autism, or other special needs. These resources give them all a sensorial experience, whatever their age, and allow everyone to take part.

The scientists also work on integration by giving information about South America and showing reproductions from North Africa (arrowheads). Many schools in Tarragona are highly complex and have a large proportion of Maghrebi descendants, mainly from Morocco. This information about their places of origin is incredibly well-received by the students. It often generates emotion when they recognize that prehistory is also essential in their country and culture. The lithic arrowheads from North Africa and South America are exceptionally creative and beautiful.

2 By centres of special complexity, we refer to the Catalan Norm that classify these centres according to indicators of social and economic disadvantage among others.

The activities of the public demonstrations are presented in terms of the main prehistoric periods: the Lower, Middle, and Upper Paleolithic and the Neolithic. They can be chosen by the teachers of individual schools so that the subject matter can be dealt with beforehand as part of the school curriculum, and the workshops function as curricular support.

2.3 Successful scientific activities for all

Inclusive science communication aims to prioritize scientific analyses of actions and strategies that contribute to inclusion. Previous studies (Gairal-Casadó et al., 2021; Salvadó et al., 2021) have shown that vulnerable groups can be attracted to science by implementing successful educational actions demonstrating that education has a more significant effect on scientific capital than socio-economic status. This is explained by understanding that the way science is approached and the extent to which students can relate to the topics presented can impact tastes, preferences, and skills (Garcia et al., 2018).

The present article builds on studies already responding to the urgency of reframing science communication to embrace the shift toward a more inclusive form of communication that encourages people to engage with science. For some authors, this is a future that is already here, so it is crucial to reaffirm those alternatives that advocate inclusive science communication by interrupting and transforming the processes of social reproduction and contributing to dismantling the structural inequalities embedded in our societies (Pulido et al., 2018; Dawson, 2019; De Botton et al., 2021; Troost et al., 2022).

The Spanish Federation for Science and Technology (FECYT), a body that fosters the relationship between science and society, has described the program by IPHES as successful inclusive science communication. In particular, it points to its capacity to increase the participation of groups at risk of social exclusion, which not only democratizes scientific knowledge but also generates better results, thus increasing social cohesion (Torras-Gómez et al., 2021; Bellavista et al., 2022).

The guidelines mentioned above, *Towards inclusive science communication: Reflections on successful actions* (FECYT, 2022), identifies four criteria for selecting and analyzing successful actions in inclusive science communication. The first criterion aims to move toward the inclusion of those groups excluded by the approach to scientific knowledge or participation in science, a European priority (European Commission, 2020). The second criterion requires actions to be based on scientific evidence of social impact or, in other words, that subset of scientific evidence that has already demonstrated social improvements. Social impact in science, therefore, refers to social improvements that respond to the needs and objectives of our societies (Bellavista et al., 2022). This social impact comes about after research results have been disseminated and transferred (Pulido et al., 2018). The third requires policies, strategies, and actions to be replicable and sustainable. This means that although they have been successful in one context, they must be replicable and sustainable in others. So successful actions are taken as the basis for successful policies or further actions (Aiello et al., 2021). Furthermore, the fourth criterion requires a bottom-up approach that goes beyond the hierarchical figure of science and promotes the co-creation of scientific knowledge between researchers and citizens. This type of approach ensures that

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citizens can participate in science, thus increasing social impact (Soler-Gallard, 2017) and trust in science.

These criteria help to give impetus to the many sectors that need it and make the most important scientific advances available to the general public and society as a whole. By working in this way, science is brought closer to the public in a more effective way, especially to all those who have been distanced from it for many different reasons (Gómez, 2021).

3 Materials and methods

This study discusses the advantages of using a dialogical approach that does not underestimate the impact of the educational system and its community on overcoming inequalities and democratizing the right to access culture and scientific knowledge.

The objective is to analyze the impact of the workshops designed to popularize science looking for scientific excellence, as part of the "IPHES in the Local Area" program, in three different urban schools classified as special complexity and assess how these workshops affect the interest in and appreciation of science among participants from vulnerable groups at risk of social exclusion.

Having clarified the main objective, the research question that guides this work is: Is developing scientific workshops with a dialogic approach an effective tool to bring science closer and awaken scientific interest in vulnerable educational contexts?

This communicative case study was carried out before and after the science communication workshops on the "IPHES in the Local Area" program had been held in three schools in Tarragona in 2019. Each school participated in one session. The aim was to analyze the impact the workshops have on the students participating in the program, which takes place during school time, and on the construction of scientific capital. Our analysis focuses on students aged between 10 and 13 but does not pretend to identify inequalities or compare the results from each school; it is not a comparative case study.

This communicative case study follows the precepts of the communicative methodology (CM) (Gómez et al., 2019). CM is oriented toward social transformation and seeks to improve the living conditions of the people involved. Several competitive projects that have used this methodology have shown results of enormous social impact. Therefore the CE has recognized this methodology as one of the most suitable for working for and with vulnerable groups (Redondo et al., 2020).

Our claim is that scientific activities that tend toward the more inclusive communication of science can benefit vulnerable groups for gender, ethnicity, or socio-economic status by increasing the interest and value of science. The communicative orientation applies an egalitarian and inter-subjective dialog among all participants. This fact has facilitated and enhanced the workshop results in the schools because there is a creation of meaning when dialog is enhanced, and scientific knowledge is built with them (Roca et al., 2022).

3.1 Description of the scientific workshop

The scientific workshop was held in one session in each of the three schools that participated in the study. During the 60–80 min of its duration, an expert in scientific communication of science, who is also an expert in lithic carving, addresses content on prehistory and human evolution. The topics covered include human evolution, cultural and biological milestones, hominids, and the Neolithic. All of them are perfectly adapted to the age of the target students but with the indispensable condition of maintaining a high scientific level. Blocks of content that form part of the curricular subject matter are included in the social and natural sciences lessons of 5th and 6th grade of primary school (the target pupils' grades). Before the workshop, teachers are asked to present these contents, in this way it is intended to connect and extend this knowledge with significant scientific data about prehistory, paleoecology, and human evolution. Despite being a playful session, the academic content is maintained because it is aimed at vulnerable groups. On the contrary, the most up-to-date information from international research on the topics covered is always provided.

The activity is carried out in the classroom or the playground, as this is the students' everyday space, trying to make them feel comfortable and close to the scientist and thus reach out more. The use of space is taken care of in great detail, asking the teachers to make the students sit as an "amphitheater." Children with special needs are offered the most suitable place to ensure that they can follow the activity closely accompanied by their educator so that he/she can provide the necessary support for their participation and interaction. This arrangement allows the scientist to have direct eye contact with the students as he/she tries to be at the same level, favoring a peer-to-peer dialog and non-verbal communication through the reading of glances that allows for detecting needs or interests among the participants.

The dialogical approach in which the session takes place creates a climate of closeness to science, allowing participants to establish a dialog with the scientist by learning about his work and breaking down stereotypes that may be held toward scientists. The scientist uses an egalitarian dialog that facilitates proximity between the scientist and the students while creating an environment of respect and curiosity toward science. This aspect is essential to allow students to feel that scientific work is a possible option for them. To this end, the scientist asks open questions, such as: How do you imagine the first humans two million years ago, or how do you imagine the prehistoric people? Questions that, in turn, help to elicit information from the group to address their concerns and interests better. The workshop's main objective is to encourage the collective construction of new meanings about prehistory as a science. To do this, it uses dialogical interactions to stimulate interest and curiosity among students throughout the session.

The elements that come into play to foster dialogical interaction are diverse. First, making tools during the workshop, using the attraction of knapping, provides the group's attention. This is accompanied by the presentation of a personal collection of approximately two hundred handmade pieces. These are pieces of various shapes, colors, and materials that can be manipulated in a controlled manner. For example, lithic arrowheads, a bow, a spear and spear-thrower or atlatl, bone flute and other musical instruments, and bomb-drill were chosen to impact and revalue the intelligence of prehistoric populations. Among the materials, there are integrating resources that favor sensorial participation aimed at the great diversity of pupils, such as five textured rocks, a piece of elk antler with a pleasant amizclic smell, and a piece of perfumed Juniperus oxicedrus. This is an interactive experience that aims to include all students.

Second, the use of specific questions marks in prehistory that are fundamental to explaining science and evolution. One of them is: What kind of parentage do chimpanzees and humans have, or how do we know how old they are? By formulating these questions, the aim is to arouse interest in finding out how scientists know, to show prehistory as a science. It shows how the age of a site is dated by offering accurate data on a scientific basis. The resource "the questions" is linked to two very current issues on which the aim is to provide knowledge from prehistory: gender and multiculturalism. Regarding gender, by showing prehistory as a stage of humanity in which there is no gender, the activity seeks to provide examples in which women and girls are more visible to society. For example, the use of images of a Neanderthal girl or a woman making a spear. It also shows how new DNA studies make it possible to identify gender more clearly and to find kinship within the female/male marriage migration system, etc.

Another example of thought-provoking interrogations is asking about human origins and Africa. At this point in the session, the scientist opens a window to formulating hypotheses that he does not try to resolve but instead answers with more questions. This helps to stimulate curiosity for knowledge and to activate the curiosity to construct a more approximate vision of the first humans, deduced by the pupils through the questions formulated by the scientist. This leads to dealing with the physical and cultural differences between the world's populations, one of the most popular topics being schools located in multicultural neighborhoods with significant cultural, religious, linguistic, and ethnic diversity, which becomes an excellent opportunity for learning that always involves managing human origins with extreme respect.

Finally, another component is the interest *per se* in prehistoric peoples related to the learning process of the planet, the formation of the human being, the keys that prehistory offers to explain some issues of life in society, coexistence as part of human evolution, or technological devices and skills in survival and social evolution. The degree of attraction that prehistory plays with provides the ability to attract the attention even of pupils with adverse educational backgrounds. It supports the idea that prehistoric science can generate a perfect environment to help pupils in many aspects of their lives, changing their relationship with science and contributing to overcoming school dropout rates. Even to overcome discriminatory patterns, be it gender or ethnicity, or to reject any violent behavior.

In brief, these actions have already been carried out in the framework of other projects, demonstrating their internationally recognized impact, the results of which have been published in scientific journals that highlight the quality of the actions developed and the relevance of being implemented in vulnerable groups. Thus proving to be a sustainable project and replicable in other spaces, such as residential centers for educational activities taken on institutionalized children (Gairal-Casadó et al., 2019; Salvadó et al., 2021).

3.2 Study participants

A common feature of the workshops is that they are all designed for students who are highly vulnerable because of their family profile or the context in which they find themselves. Therefore, three schools with a high percentage of vulnerable students were chosen in three different areas of the city of Tarragona. They all have numerous highly vulnerable students at risk of social exclusion. In total, 117 students participated (see Table 1). The three schools are in different parts of the city: one in the center and two in suburban areas of low socio-economic status and high risk of social exclusion. The areas where the schools are located are characterized by ethnic and religious diversity, as reflected in the data obtained from the groups participating in the study. The distribution of participation between sexes was equal, with 53.8% of males.

School 1: This school is located in the center of the city of Tarragona and has a wide diversity of pupils and family types. About 15% of the pupils are foreigners of various nationalities, including those from Latin America.

School 2: This school is located on the outskirts of Tarragona. It has a wide range of pupils, mainly immigrants from other countries. The most abundant population is from Morocco, but there are also students from other parts of Africa, Central America, and Europe.

School 3: This school is located in a peripheral neighborhood of Tarragona, and at least 50% of its pupils come from different cultural backgrounds.

Before being involved in the research, all participants and their families were informed by the school management teams. Researchers provided all ethically required information to the management teams, including the main objectives of the activities and how all information regarding the participants would be anonymous. In that way, first the school management teams informed all families regarding the study and later, researchers explained everything to the students.

3.3 Data collection and analysis

A questionnaire was used to collect information from all the people who participated in the workshops and analyze how the project impacted them. It was designed based on the theoretical review carried out in the study and reviewed and validated by an advisory board. The advisory board plays a role in communicative research methodology, and its members contribute knowledge and review documents (Gómez et al., 2011). This study consisted of two scientists involved in science communication, one of whom was directly responsible for the "IPHES in the Local Area" program. Its primary function was to validate the questionnaire used in the research.

The questionnaire is structured in two parts. The first collects socio-demographic data on the students participating in the workshops (age, gender, ethnicity, country of origin, and religion). The second focuses on compiling content that identifies the workshop's impact on the people who have taken part. The questions follow a rating scale in which respondents were asked to select the option that best reflected their opinion on the question: Strongly disagree, disagree, agree and strongly agree. The central aspect is the personal

TABLE 1 Schools participating in the study.

School	Number of pupils
1	23
2	83
3	10
Total	117

TABLE 2 Variables analysed in the study.

Variable	Description
Interest in and preference for science.	Positive attitude to activities with scientific content.
Perception and appreciation of science. Interaction with science.	Relationship with science and shared experiences. Constructed images about science and the importance of the knowledge it brings to society.
Personal expectations toward science.	Aspirations to become a scientist.

TABLE 3 Defined items of each analysed variable.

Variables	Items
Interest in and preference for science.	I like the subject of the natural environment.
	I like reading books and magazines about science.
	I like it when we do science experiments.
	I would like to do more hours in the natural environment.
	I am interested in observing and learning about how nature works.
	I would like to go on a field trip to a museum.
	I like to watch science TV programs.
	I like to do activities about animals, nature, tools, etc.
Perception and appreciation of science. Interaction with science.	I am interested in the history of my territory.
	I am interested in watching videos on the internet to learn more about science (e.g., YouTube).
	I tell my parents about the activities we do at school.
	I want to attend a talk or presentation on science by a researcher.
	I think that studying the past of humans is important.
	When we talk about science, what comes to mind?[1]
Personal aspirations toward science.	I want to be a scientist.
	I see myself capable of working as a scientist.
	People like me work in science.
	Anyone can become a scientist.
	I see myself as a scientific person.

[1]Multiple response question: difficult to understand, fun, necessary, motivation, indifference, important, boring, wisdom, future profession, distress, other.

perception of science so that the attitudes it inspires in the participating students can be identified. It also collects information on interests and preferences in scientific activities and on the valuation of scientific knowledge. Each of these aspects is reflected in the variables reported in Table 2, which were defined after the theoretical review had been analyzed, specified in the form of various items, and agreed on with the advisory board, as set out in Table 3.

For the statistical analysis, SPSS (version 24) was used to quantify the responses obtained in both the pre-test and the post-test and identify the most remarkable changes that occurred after participation in the science workshop session, thus allowing a descriptive analysis of the impact on the participants' improved interest in, and appreciation of, science. The post-test was immediately implemented after the workshop. This is not a limitation, but with another one session and more time, it could be reached a longer-term impact.

It is important to note here the role played by the advisory board in validating the questionnaire since the comments they provided were used to establish the blocks of content directly related to the main variables of the study. The results faithfully reflect this previous work on the data collection instrument and these essential study variables.

4 Results

Three main results have been obtained: (1) change in personal expectations toward science; (2) increased interest in science; (3) increased appreciation of scientific knowledge.

4.1 Signs of change in personal expectations toward science

The results indicate a change in personal expectations toward science. In particular, the participants state that they are more likely to become scientists because their close and direct contact with a scientist in the workshops has encouraged them to consider a career in science (9.4% in the pre-test and 17.1% in the post-test). At the same time, the results show that becoming a scientist requires considerable effort, which can be seen in the lower post-test value when the participants were asked whether they could work as a scientist (21.4% in the pre-test and 17.9% in the post-test).

Key to these results is the attitude of the scientists, who try to remain on the same level as the pupils so as not to hierarchize the relationship. The use of jokes, smiles, expressive faces, mimicry, and a clown-like demeanor (for children under 6 years old) are critical points in creating a good atmosphere. At first, students ask whether the scientist has made the reproductions. This is often the case because they want to identify whether they are bought or made by themselves. At first, the scientists usually answer the same two questions in this order: Are the reproductions and replicas authentic? Did you make them yourself? Students need to recognize authenticity and expertise and like to talk to scientists in general. They manage to do this because the scientists control the excitement but allow conversation among the students as they finish setting the scene, following the precepts of an egalitarian and intersubjective dialog among all participants. At this point, they reflect on their pupils and try to spot whether they are irreverent, curious, hyperactive, withdrawn, or, above all, need more attention, such as those who retreat to the back, are more solitary, or have special needs. Finally,

TABLE 4 Comparison of the most salient pre-test and post-test results obtained for the variable "personal expectations toward science."

	Pre-test		Post-test	
	Frequency	Percentage	Frequency	Percentage
Anyone can be a scientist.	26	22.2%	34	29.1%
I see myself as a scientist.	11	9.4%	20	17.1%
I see myself as capable of working as a scientist.	25	21.4%	21	17.9%

TABLE 5 Comparison of the most salient pre-test and post-test results obtained for the variable interest in and preference for science.

	Pre-test		Post-test	
	Frequency	Percentage	Frequency	Percentage
I like the subject of the natural environment.	34	29.1%	50	42.7%
I like it when we do science experiments.	77	65.8%	72	61.7%
I would like to do more hours in the natural environment.	27	23.1%	31	26.5%
I would like to go on an excursion to a museum.	62	53%	70	59.8%
I would like to watch science TV programs.	23	19.7%	33	28.2%
I like doing activities about animals, nature, tools, etc.	54	46.2%	57	48.7%

they sit in a chair surrounded by many exciting things in front of a group of pupils, each interested for different reasons (Table 4).

Sitting in a circle around the materials the expert brought created an egalitarian atmosphere. The person leading the workshop encouraged an egalitarian dialog with all the students, showed them every one of the pieces he brought with him, and answered all the questions they asked. The expert sought to motivate participation even among those who usually did not participate due to shyness, fear or any other reason. He had them take the materials, and they helped him by showing them to the others while he explained how they worked.

4.2 Signs of increased interest in science

One of the "IPHES in the Local Area program topics that helps awaken interest in science is the discussion of the skin color of the first *Homo sapiens* and especially of the last European hunter-gatherers. Palaeogenomic DNA studies provide valuable information on the appearance of prehistoric peoples and evidence that the last hunter-gatherers in Europe were dark-skinned with a high frequency of blue eyes. Such statements as "If we all came from Africa, we were dark-skinned" have a substantial impact on the demonstration and sometimes encourage changes in views of migration and different understandings of human origins and diversity. These themes lead to exciting discussions about racism with the students.

One of the rules to follow when dealing with reactions to such statements is to manage the dialog very carefully by bringing students into the dialog and intervening only occasionally to provide scientific information or to correct a statement or description.

A comparison of the data provided by pupils in the pre-test and the post-test shows that the analysis of the variables on interest in and preference for science was positive. Some of the items have more remarkable results: interest in scientific activities (54% in the pre-test and 57% in the post-test) or the importance of accessing scientific knowledge to understand our past better (59% in the pre-test and 64% in the post-test).

Almost all of the post-test results are better than the pre-test results, indicating that the sessions positively impact and increase interest and preference for science (see Table 5).

4.3 Evidence of increasing appreciation of science and scientific knowledge

There is an improvement in those items related to the importance given to science, the valuation of scientific knowledge, and positive attitudes toward science, such as motivation or considering it fun and necessary. For the question "When we talk about science, what comes to mind?," the comparison shows that post-test results are higher than pre-test results, and particularly that it is perceived as necessary (38.5% in the pre-test versus 46.2% in the post-test) and fun (33.3% in the pre-test versus 46.2% in the post-test). These data show that, after doing the scientific activities, practically half of the students perceive them as necessary and fun. It is also important to point out that the value of science as a form of knowledge increased from 32.5% in the pre-test to 44.4% in the post-test. Finally, the value of the importance of science increased from 68.7 to 71.8%, as shown in Table 6.

The activities on the "IPHES in the Local Area" program on prehistory explain aspects of life in society and coexistence (for

TABLE 6 Comparison of most salient positive pre-test and post-test items obtained from the question "When we talk about science what comes to your mind?".

Item	Pre-test		Post-test	
	Frequency	Percentage	Frequency	Percentage
Importance	80	68.4%	84	71.8%
Wisdom	38	32.5%	52	44.4%
Motivation	34	29.1%	39	33.3%
Fun	39	33.3%	54	46.2%
Necessary	45	38.4%	54	46.2%

TABLE 7 Comparison of most salient pre-test and post-test negative items obtained from the question "When we talk about science what comes to your mind?".

Item	Pre-test		Post-test	
	Frequency	Percentage	Frequency	Percentage
Indifference	8	6.8%	6	5.1%
Boredom	15	12.8%	13	11.1%
Anxiety	8	6.8%	4	3.4%

TABLE 8 Comparison of the most salient pre-test and post-test results obtained for the variable "Perception and evaluation of science. Interaction with science."

	Pre-test		Post-test	
	Frequency	Percentage	Frequency	Percentage
I am interested in the history of my territory.	44	37.6%	51	43.6%
I explain to my parents the activities we do at school.	49	41.9%	54	46.2%
I want to attend a talk or presentation by a researcher who talks about science.	32	27.4%	41	35%
I think that studying the past of humans is important.	59	50.4%	64	54.7%

example, human evolution, the origins of differences in skin color, shape, and culture) and show the value of scientific knowledge.

Scientists try to be inclusive in all senses and select content to provide a complete education. For example, they discuss the human brain and the enormous complexity of assessing intelligence as a multifactorial fact. They use the differences in the capacity of the human brain and its replicas to address this issue. They explain scientific conclusions about the evolution of the human brain, but also specific cases about the value of any intelligence. This is particularly important to the scientists who teach the sessions and give a broad conception of cognitive diversity.

Likewise, the fact that there is usually considerable cultural, religious, linguistic, and ethnic diversity among the participants at all the "IPHES in the Local Area" sessions is an excellent opportunity to show that the evolution of modern humans is complex, long-lasting, and planet-wide. From Africa to Asia to Europe to the Americas, the "*Homo sapiens* adventure" can be used to show the emergence and development of the differences, and the enormous similarities, between humans today.

Bringing science closer to everyday reality, as the "IPHES in the Local Area" program does, causes the negative items on the questionnaire (such as indifference, boredom, or anxiety) to be conceptualized as less negative. As seen in Table 7, the pre-test values are already low (in all three cases, they are below 13%), but all the post-test values are lower. In particular, the perception of anxiety is halved. It should also be noted that after the scientific activities have been carried out, the pupils rate the scientific topic as more complex (29.9% pre-test versus 35% post-test), partly because they have a clearer perception of the difficulty that scientific activity can entail when they see it being carried out live.

This change in how science is perceived also has an impact on how it is assessed. The most remarkable of these items are the increase in the initiative to share the science workshop experiences with their families (41.9% in the pre-test and 46.2% in the post-test) and the importance of scientific knowledge for society, in particular, the importance of studying the past of humans (50.4% in the pre-test and 54.7% in the post-test), as shown in Table 8.

5 Discussion and conclusions

This article discusses the impact of the science communication workshops on the "IPHES in the Local Area" program designed to bring students at risk of social exclusion in three schools in Tarragona into contact with science.

The evidence shows that school interventions have led to an increase in interest in scientific activities and learning science. As previous research has shown (Gairal-Casadó et al., 2021), high-quality science communication activities contribute to building scientific capital and positively impact communities of low socio-economic status that have traditionally been excluded from this type of learning activities (Dawson, 2019). This is key to arousing interest and motivating people to engage with scientific knowledge. Working in this way can reduce the barriers that discriminate and oppress vulnerable groups and prevent them from accessing scientific knowledge.

The study also shows that the children who participated in the science workshops improved their perception and appreciation of science. Previous studies have determined that dialog on equal terms with scientists in science communication activities arouses people's interest in science by building relationships of trust and security and minimizing social inequalities. Communicating science in this way makes participants see science as more genuine, reveals the complexity of scientific knowledge, and shows them the importance of science in society (Salvadó et al., 2021).

The present research demonstrates that communicative science workshops can increase preferences for scientific activities by increasing the appreciation of science and scientific knowledge in vulnerable groups. Two fundamental components have played a decisive role in obtaining this increased interest in scientific activities: the scientific evidence on which the whole process was based and the process itself, since it revealed a dialogic learning process (Rodríguez-Oramas et al., 2021).

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the study involving humans in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was not required from the participants or their legal guardians/next of kin in accordance with the national legislation and institutional requirements. The educational centers involved in the fieldwork informed the participants' families about the project.

Author contributions

MG-F: Conceptualization, Data curation, Investigation, Supervision, Writing – original draft. AG: Methodology, Writing – review & editing. LN-S: Writing – original draft. RG-C: Investigation, Writing – review & editing.

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In memoriam

We dedicate this article to Miquel Guardiola, who carried out all the training sessions with the children in the schools and who has promoted this line of research. He visualized and worked on the beginning of this article that we now publish. Miquel, although you are not physically with us, your work and your desire to improve the lives of all the children with whom you have interacted will always be with us.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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