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CONNECTING SCIENCE COMMUNICATION RESEARCH AND PRACTICE: CHALLENGES AND WAYS FORWARD

Science Communication as a Human Right

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Abstract

This work discusses four practical science communication cases in which we worked with communities from different parts of Mexico in vulnerable situations. We analyze those cases from an interdisciplinary point of view, emphasizing the observation of human rights to propose a new inclusive definition of science communication and new strategies for engaging in horizontal dialogues with cultural groups. This perspective demands a change in methodological procedures, such as performing anthropological work and the co-creation of projects and materials together with all the members of the communities involved. We also propose using novel strategies to reach communities in vulnerable situations.

Keywords

Community action; Science communication in the developing world; Social inclusion

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Introduction

During a seminar in the postgraduate Philosophy of Science Program of the National Autonomous University of Mexico (UNAM), the authors of this work discussed four practical cases of communities in vulnerable situations that the members of the group were working with, looking to establish horizontal dialogues to generate science communication actions through new strategies. The goal was to address the issues relevant to the groups involved.

As a starting point, we revised science communication traditional views, in which science communication has been understood as a way to disseminate and support the work of scientists, as a vehicle for enjoyment, as a way to provide people with exciting pieces of knowledge that would change their worldview, among many others. However, considering the perspective of these communities, we decided to discuss the topic from a deeper perspective: considering science communication as a means to observe the human right to science, as a tool to empower individuals in vulnerable communities so they can make decisions about their lives and their environment.

Hence, in this work, we present the analysis of the four cases of communities in vulnerable situations analyzed in our seminar, in which we explore issues such as the importance of communicating science to the inhabitants of rural communities near technoscientific experiments and the relevance of individuals from different cultural groups to access their historical roots and ethnic identities. We also explore the importance of informing drug users about the risks associated with their practices and the elements to generate public participation strategies in communities that are in vulnerable situations.

To link theory and practice, we used an interdisciplinary framework, which includes revising the human right to science tools from philosophy, history, and the science of science communication. As science communicators, we must incorporate anthropology and sociology approaches, such as ethnography, for better and more successful practices. When working with these approaches, we must know that culture and language are inseparable concepts in anthropology. Authors like Basso [1984], Rymes [1996] and Duranti and Tena [2000] point out "the indexical relations" between arbitrary signs (like proper names) and cultural characteristics like places, stories, and events. We communicate within the context of our culture (or even the subcultures). It is essential to consider that subcultures have their specific use of language. As science communicators, we need to ask: How can we share scientific knowledge without knowing the use of language and culture of our target audiences? Hence, we must incorporate anthropology and sociology approaches, such as ethnography, for better and more successful practices. This approach is essential to understanding and addressing communities' needs from a human rights perspective.

At the end of this discussion, we present our conclusions, both from a practical and theoretical point of view, expecting to serve as a guide to implement new strategies within the communities we are working with or for other researchers to have an insight into our experience.

Human rights background

Access to science is a universal human right. The 1948 Universal Declaration of Human Rights and the 1966 International Covenant on Economic, Social, and Cultural Rights considered the right to science a universal human right. For Farida Shaheed, United Nations Special Rapporteur, "Science and culture are not only of great importance to the knowledge economy; they are also fundamental to human dignity and autonomy" [Shaheed, 2013]. In the Report of the Special Rapporteur in the field of Cultural Rights is stated that the right to enjoy the benefits of scientific progress and its applications includes, among other things, the following two essential aspects: 1) access for everyone, without discrimination, to the benefits of science and its applications, including scientific knowledge in general and not only to particular results or applications, and 2) the participation of individuals and communities in decision-making about subjects related to science and technology and the related right to information. It also includes the obligation to protect all people, including vulnerable populations, against the negative consequences of the applications of science [Shaheed, 2013]. We would also like to add to the latter point a particular case: the right to access technology and the risks that new technologies could entail for different communities. Sun comments:

> In an age of technology, what human right could be more important than the right to technology? Yet this right remains obscure, dormant, and ineffective. [. . .] A new understanding of the right to technology as a collective right is needed to address the issues that have caused it to languish under the existing human rights regime [Sun, 2020].

This human right includes cases such as the right of people to decide on the appropriateness of the use of a particular technology in their community, the right to enjoy scientific and cultural heritage, and the right to demand the enjoyment of technology in a violence-free manner.

In Mexico, the human right to science is stated in the Mexican United States Political Constitution and the General Law in the Fields of Humanities, Sciences, Technologies, and Innovation, proposed by the National Council of Humanities, Sciences, and Technologies (CONHACYT). However, for people who are part of vulnerable communities, the right to access science is not recognized. These vulnerable communities include drug users, indigenous people, inhabitants of rural or indigenous communities, migrants, young people who live in areas with high levels of violence, people experiencing homelessness, transgender people or other diversities, people with disabilities, and neurodiverse people, among many others. These individuals have been made invisible and lack the knowledge to make informed decisions about their lives and environment. However, in the 21st century, when science and technology continuously transform our world, scientific knowledge should be accessible to everyone as a universal human right. According to Chapman, "a human rights approach focuses on the status of the most disadvantaged rather than some societal average or the interests of the most advanced and affluent communities. Applied to the right to the benefits of scientific progress, this requires a form of affirmative action, that is, specific investments in science and technologies likely to benefit those at the bottom of the economic and social scale" [Chapman, 2009]. Also, Porsdam states the following:

> A human rights approach automatically adds a focus on disadvantaged groups in societies. Applied to the right to science, this requires a form of affirmative action, that is, specific investments in science and technologies likely to benefit those at the bottom of the economic and social scale [Porsdam, 2022].

Taking the above into account, science communication is not only a means to observe the human right to science, but also, ideally, it should be treated as part of the universal human rights.

Context

In a postgraduate seminar at the National Autonomous University of Mexico, we decided to discuss four practical cases that involved communities in a vulnerable situation in which the members of the seminar were working in a practical way. The Mexican communities that we studied are the following:

1. The inhabitants of Atzizintla, a rural community in the state of Puebla, are located between the Sierra Negra and Citlaltépetl volcanos. The HAWC Observatory of Gamma Rays was inaugurated in 2015 in the land of this community.

2. The inhabitants of the Jantetelco community in the state of Morelos live near the Chalcatzingo archaeological site.
3. The participants of the Pilares Program in Mexico City.
4. The communities of opioid users on the northern border of Mexico.

Even though these communities seemed dissimilar at first glance, we realized that in all cases, there was a violation of their human right to science in at least one of the essential aspects previously mentioned in the introduction of this work and that the members of those communities could be empowered by having access to scientific knowledge through science communication programs. We realized that more than traditional ways of treating science communication were needed to discuss the cases of these communities. Hence, we decided to study them from a human rights perspective and to propose a new definition of science communication for this purpose.

Defining science communication from a human rights perspective

Science communication is crucial for the observation of the human right to science. It exposes injustices and empowers the members of vulnerable communities so they can change and improve their lives. As Porsdam states, "Without dissemination, translation or curation, there will be no right to science. The public can benefit from scientific progress only when scientific knowledge, data, and expertise are made universally accessible and when the benefits of science are universally shared. Moreover, unless scientists have venues beyond the scientific breakthroughs that can be popularized and harnessed, the chance of showing the usefulness and importance of their basic research to the public is limited" [Porsdam, 2022].

In the last three decades, the field that studies the theory and the practice of the transmission of scientific knowledge has been defined using several terms, such as "popularization of science," "science and society," "public awareness of science," "citizen engagement," "citizen science," "open science." Among them, the one that most specialists prefer is "science communication." In the Latin American context, there is a significant diversity of perspectives in science communication, leading to the use of different concepts throughout the region. Previous analyses have explored its definitions, revealing variations linked to temporality, the authors' country, and the spatial context in which activities occur. Concepts such as "science outreach," "public communication of science," "popularization of science," "social appropriation of scientific knowledge," and "non-formal science education" have been identified [Rocha, Massarani & Pedersoli, 2017].

Additionally, communication models have been developed, often in tandem with the growth of science and technology social studies. These models incorporate dialogical and participatory tools, such as the "glocal model" in museums and science centers [Reynoso, Sánchez Mora & Tagüeña, 2005], the integral dialogical model guiding actions in science communication offices and scientific research institutes [Frías-Villegas, 2018], or the intercultural model grounded in the principle of epistemic equity for social appropriation of knowledge [García, 2019].

Outside of Latin America, with the advancement of the public engagement model, communication policies, analyses, and strategies integrating various science

communication models have also been developed. For instance, Hetland [2016] illustrates this in science communication actions in Norway by establishing hybrid forums where deficit, dialogical, and participatory models converge. Even though this and other definitions of science communication are adequate for more classical contexts, they are not adequate when working with communities in vulnerable situations. Hence, we propose the following definition from a human rights perspective:

> Science communication should always be the means to fulfill the human right to benefit, understand information, and participate in the construction of science. It is a process in which co-creation and dialogue occur between people or communities with specific knowledge. During this process, a common language and understanding are reached, and the conceptual frameworks and practices of those involved are transformed.

Our definition intends to add an ethical dimension to science communication in which carrying out science communication actions directed towards communities in vulnerable situations should be considered an obligation for governments and stakeholders.

In the context of this definition, we will not talk about "the public," meaning "every person in a society. [...] A very heterogeneous group; it is as multifaceted and unpredictable as the individuals that compose it" [Bucchi & Trench, 2016]. This concept needs to reflect the particularities of the communities we are working with, and it gives individuals who are not part of the science community a passive role. Hence, we will talk about "participants," "people who are involved directly in a science communication process" [Bucchi & Trench, 2016] that can be scientists, stakeholders, human rights activists, science communicators, and members of communities in a vulnerable situation, among many others. In all the science communication actions we are carrying out, we propose co-creating projects where all participants have the same hierarchy.

Also, in our work, we expect all participants to have a "strong appropriation of science." According to Mexican Philosopher León Olivé, the two following appropriations are possible:

> (...) the weak one, which consists of expanding the horizon of scientific and technological representations in the culture of different members of society. The strong appropriation goes beyond the incorporation of scientific and technological representations into the culture of those who engage in such appropriation to encompass — most importantly — various social practices (such as hygiene, health, production, or education) within which actions specific to those practices are guided by scientific and technological representations of the world, and to some extent, by norms and values also derived from science and technology [Olivé, 2008].

In this way, we expect a transformation in all participants, experts in different kinds of knowledge. For instance, those who are experts in science or communication and those who are experts "in their life experience," meaning that they are experts in the context of the members of their communities, their problems, their rituals, and costumes.

It is essential to point out that in science communication theory, several models are used to describe the practice of science communicators. Some were first defined in the classic Bruce Lewenstein's paper [Lewenstein, 2003]. The "deficit model" has been widely criticized, and the "dialogue model" has been presented as a reasonable alternative. In some countries, "the shift is often stated as an irrefutable fact: commentaries speak of the dialogical turn as a historical change that has taken effect across Europe" [Bucchi & Trench, 2016]. However, even though Mexican experts in science communication have proposed using dialogical models in many practical actions involving priority attention communities, in which communicators of science are not necessarily involved, the deficit model is still widely used. Hence, we are using a combination of models in our work, which will respond to the needs of each community, always using a human rights perspective.

The development of science is inextricably linked to federal and international institutions, which should guarantee strict adherence to human rights. Hence, scientific communication is an obligation for federal and international organizations. This right would be fulfilled through legislation and a sufficient budget that ensures respect for the rights of people who enjoy the benefits of science and those who do research and communicate knowledge. Also, it should be an ethical priority for the scientific community to build transdisciplinary networks where non-scientific audiences could access specialized information through bridges where knowledge would be shared (not just disseminated) considering their cultural context. Science communication should be a tool for a better and more informed human experience for those in constant danger. It should also impulse a transformation in the conceptual frameworks of all participants in practical actions, including people from vulnerable communities, science communicators, scientists, and other social actors who would learn from each other.

Premise

The human right to science should always be observed, especially for communities in vulnerable situations. Hence, when proposing science communication strategies, the needs of the community should be identified to co-create with its members an inclusive strategy that empowers people to transform their practices and to make informed decisions about their lives and environments. It is also crucial to decide which strategies and which media would work best for each particular community, taking into account its location, its problematics, the available budget, and the social and political limitations, among many variables.

Methodology

We researched the cases of four communities in vulnerable situations from an interdisciplinary point of view. We agree with Brian Trench when he comments, "our starting point is that thinking about characteristics and connections of different disciplines is not an optional extra in science communication education. It is a central part of what these studies address and how they are conducted. Science communication fundamentally concerns relations between and within communities, cultures, and institutions" [Trench, 2023]. Interdiscipline allows us to include different perspectives in our research.

To investigate the communities of interest for this work, we first used qualitative anthropological research methods, such as ethnography, to observe and record data

referring to the culture of the groups involved. As Ferrándiz has pointed out, the central methodology of ethnography is fieldwork [Ferrandiz Martin, 2011]. Hammerseley and Atkinson, on the other hand, define ethnography as "a set of fundamentally qualitative methods, belonging to anthropology, in which the researcher participates in the everyday life of the people being investigated" [Hammersley & Atkinson, 2019]. Marcus and Fischer, as well, state that "ethnography is a research process in which the researcher carefully observes, records, and integrates into the everyday life of people from another culture, and then writes texts about that culture, emphasizing descriptive detail" [Marcus & Fischer, 1999]. Apart from the observation, we interviewed the community members to learn about their problems and life experiences.

It is essential to integrate the relevance of language in the ethnographic approach because language is not only the way we interact with each other but also what we use to structure our lives. In other words, the cognitive process of the perception of reality is translated into words within our minds. Alessandro Duranti wrote about this idea on a broader argument:

> (…) language is in us as much as we are in language. By connecting people to their past, present, and future, language becomes their past, present, and future. Language is not just a representation of an independently established world. Language is also that world. Not in the simplistic sense that all we have of our past is language but in the sense that our memories are inscribed in linguistic accounts, stories, anecdotes, and names just as much as they are contained in smells, sounds, and ways of holding our body. If language is action, as proposed by Malinowski, and the ways we speak provide us with ways of being in the world, as suggested by Sapir, Whorf, and many others, linguistic communication is part of the reality it is supposed to represent, interpret, and evoke. If a language is, in Wittgenstein's words, "a form of life," then to have a language not only means to have an instrument to represent events in particular ways, it also means to have the ability to interact with such events, affect them or be affected by them [Duranti & Tena, 2000].

The classical author of the linguistic turn, Ludwig Wittgenstein, said: "…to imagine a language implies imagining a form of life" [Wittgenstein, García Suarez, Moulines & Wittgenstein, 2004]. As we grow up, we are taught our language and our culture. These two concepts are bonded as the pillars of communication in our society and are our leading guide to get through our world. A perfect example of this is the word "saudade," a Portuguese word that means nostalgia and happiness at the same time. The words of a language are created upon the speaker's environment and, therefore, are deeply related to how they live, what they believe in, and their traditions. There is a dynamic process of language and culture among large groups of human beings. However, for individuals, it is slightly different. We join different social groups throughout our lives, depending on our age, hobbies, musical taste, and profession, among other reasons. These interactions with diverse groups of people imply that we learn different uses of language.

Hence, when working with a community, the science communicator must learn how its members use language and what meaning the words have in their context. It is also essential to learn about their lives, backgrounds, rituals, places of reunion, interests, and the problems they share in subjects related to science and technology.

Using ethnographic methods in each of the communities, together with research in specialized literature in areas such as the science of science communication, philosophy, history, and sociology, we created a diagnostic of the needs of each community and of how human rights to science were not observed in each case. Then, after discussions with all the actors involved, such as scientists, human rights activists, decision-makers, and community members, we proposed models to create cooperative communication of scientific actions. The methodology includes the perspective of science communication as a human right to overcome deficiencies in scientific communication models and guarantee access to science for different groups, recognizing the knowledge of these populations to co-create science communication initiatives based on their needs.

The media chosen to carry out each science communication action responded to a combination of factors, which were different in each case, such as the following: availability of the media, budget, and the media the community was more comfortable using, among others. The impact of technology in each of the cases is studied, and their implications, uses, benefits, and problems are explained.

Case studies

In this section, we explore instances involving diverse communities in vulnerable circumstances, focusing on denying their human right to science. The discussion is structured into two subsections for clarity and depth. Subsection 7.1 examines scenarios where communities were not recognized in the planning and decision-making of large science projects or were not consulted in how their historical heritage would be managed, affecting their everyday lives. Subsection 7.2 presents an analysis of cases where vulnerable target groups of science communication have not been treated equally but were instead devaluated, discriminated against, and excluded in the process of science communication campaigns.

7.1 Cases in which the right of individuals and communities in decision-making about subjects related to science and technology was not observed

The General Comment No. 25 (2020), regarding science and economic, social, and cultural rights of the Committee on Economic, Social and Cultural Rights of the Economic and Social Council of the UN states that:

> Indigenous peoples and local communities worldwide should engage in a global intercultural dialogue for scientific progress, as their contributions are valuable, and science should not be used as a tool for cultural imposition. States parties should provide indigenous peoples, with due respect to their self-determination, with the educational and technological means to participate in this dialogue. They should also take all necessary measures to respect and protect the rights of indigenous peoples, particularly their land and identity, and the protection of moral and material interests derived from their knowledge, of which they are the authors, individually or collectively. Genuine consultations for free, prior, and informed consent are necessary whenever a State party or non-state actors undertake research, make decisions, or formulate science-related policies that affect indigenous peoples or utilize their knowledge [U.N. Committee on Economic, Social and Cultural Rights, 2020a]

Taking this into account, we believe that in the following two examples, there was a cultural imposition on the members of the communities discussed because we think that they should take part in an intercultural dialogue to decide about scientific projects placed on their land or about the way their cultural heritage is managed.

7.1.1 The starting point: a technoscientific experiment near a rural community

The case of the Atzitzintla rural community near HAWC's Gamma Rays Observatory was the first one studied in the seminar and the eldest in a temporary line. It also allowed us to set relevant concerns about the lack of observation of the community's human rights. On March 23, 2015, one of Mexico's most critical technoscientific projects was inaugurated, the HAWC (High Altitude Water Cherenkov) gamma-ray observatory [HAWC collaboration, 2015]. Many of the critical members of the Mexican and North American physics community traveled to the slopes of Citlaltépetl volcano, also known as Pico de Orizaba, located between the Mexican states of Puebla and Veracruz, to attend the ceremony. After seven years of hard work, the observatory was working. It consists of 300 four-meter-high tanks and several supercomputer systems. Its goal is to study the gamma-ray showers that are the product of the most extreme cosmic events in the Universe.

The observatory's construction was technically complicated since the trees in the area had to be cut down, but also in ethical terms, since the Pico de Orizaba was proclaimed a national protected area with endemic species of plants and animals. In addition, three hundred aluminum tanks had to be built and transported to the site, along a dangerous path and assembled individually. Finally, thousands of liters of water, taken from the nearby springs, had to be transported to fill the containers. These tanks aimed to detect gamma rays generated in cosmic events through the Cherenkov effect. This construction was only possible with the work of the inhabitants of Atzizintla, a poor rural community of farmers and shepherds that live near HAWC. They were responsible for preparing the land, transporting the material, and assembling it. They also provided food and transportation services to the scientists and technicians who participated in the project.

Through ethnographic work that included observations and a series of interviews with the community members, carried out by Gabriela Frías-Villegas as part of her Ph.D. dissertation [Frías-Villegas, 2018], it was clear that the inhabitants of Atzizintla were not informed about the purpose of the experiment and they did not have the power to raise their voice about their concerns about the project. They had several misconceptions about the site. Among other things, they were convinced that the tanks that were placed in the land they grew up in were a present of the government to help them store water for the drought season. During the site's inauguration, the community was excluded from the celebration, except for those members who worked as drivers for the guests or as waiters.

In a case like this, we believe that, as part of their human rights, the community members should have been included from the beginning of the project in an intercultural dialogue to discuss the relevance of the project that would be implemented on their lands. Moreover, the locals should be informed about the

project's objective and environmental dangers, such as the site's deforestation, the scientific interest of the experiment, and its possible benefits.

Hence, after the diagnosis, it was decided that science communication actions should be designed so the members of Atzizintla's community could participate in the debate about the relevance of scientific research. Initially, it was proposed to construct a small museum about HAWC to inform the locals about the relevance of the science it was carrying out. This project was not implemented due to the lack of funding. Then, scientists involved in the construction of the site proposed creating a series of videos that would be placed on an online platform so both the possible investors of the project and the inhabitants of Atzizintla could learn about the experiment. However, there was a problem: the rural community members did not have computers or access to the Internet. Finally, as part of her Ph.D. dissertation, Frías proposed to carry out a series of reunions with the rural community members to co-create a series of science communication actions with them and the members of the scientific communities involved. This initiative could not be completed due to political disagreements between scientists, science communicators, and government decision-makers. Also, due to the control that drug cartels began to exert in the region, which at some point made it impossible to access Atzizintla.

When studying a case like this one, we should ask ourselves: How can we create projects to observe the right to science of communities in vulnerable situations? How can we create science communication actions in which all the involved members of all the communities involved actively participate? What problems does a science communicator face when working with vulnerable communities often discriminated against? We decided to address these and other questions in the following cases we worked with.

7.1.2 Community rights: When preservation arguments are used to justify the disruption of a community

There is no doubt that science is essential. Human history reminds us how we transformed our way of living in the world and, in some cases, space. However, this characteristic should not be an indisputable argument to make impositions or, in this case, an invasion of an ample and symbolic space of a community's territory. Science should be a cause that integrates people where different knowledge builds new horizons instead of discriminating and creating borders.

As in the previous case, the research for Kathia García-Gómez master's degree thesis [García-Gómez, 2020] was an anthropological case study where she analyzed how the community of a small village like Chalcatzingo (settled in the southeast of Morelos state, 90 km from Popocatepetl volcano) related with the archaeological site located in their geographical space. The site's stewardship is exclusive of the National Institute of Archaeology and History (INAH for its Spanish initials).

This institution is the main line of protection, preservation, administration, and research of Mexico's historical and cultural heritage. Almost every archaeological site in the country is administered for INAH. In Chalcatzingo's case, archaeologists began the historical research back in the 1930s decade and officially inaugurated the site in 1974 [García-Gómez, 2020] . The site is located at the base of three

significant and symbolic mountains, and its borders are closed with concrete walls and metallic fences at some segments. The safer access to climb two mountains is a path in the middle of the site.

The author did extensive ethnographic work (interviews, participant and nonparticipant observation, focus groups, among others) with numerous members of the community, and with the information she got, she found out that the people of the village were not happy at all with the site but specifically, with the interactions with the members of the INAH.

Before the site opened its gates, under the control of INAH, villagers spent time in the mountains; their daily lives were linked to it. They went to it to get firewood, picnic, hike, and even visit the Guadalupe Virgin altar they have at the top of the highest mountain. The entire place is important because they consider it as their own, as part of their history and identity. After the INAH came in and the stewardship of the place, villagers felt like they were robbed, like their mountains had become a forbidden territory. As the rules of the INAH indicate, the site can be visited from 9 am to 5 pm. Outside of this time, no one is allowed to get in. One of the most significant troubles is that the institution did not consider the community's traditions; they imposed the rules prioritizing the "preservation and care of archaeological heritage."

The second main problem in this case is that the strategies to communicate archaeological knowledge, like the information about the monuments on the site, are insufficient. The text at the site's entrance just depicts the piece's name. Three more texts expose the history of Chalcatzingo with technical language, which non-specialists could not understand. The people of INAH did not incorporate the villagers' history or culture in any of them. Finally, instead of creating a communication strategy for the people of Chalcantzingo's community so they could understand the site's historical importance, they offered them tickets to visit the place free of charge.

Towards the end of her research, García-Gómez concluded that INAH underestimated the importance of the community's opinion and imposed rules that created a problem with the villagers. As time passed, the community moved away from their mountains, physically and symbolically. INAH and villagers have a history of conflicts where the most severe episode included violent attacks with guns, but even with this, the institution keeps making the same imposition in this and other sites, with the argument that they are just following the rules, and as an obvious reaction, the villagers are losing interest in the archaeological site and missing their freedom to enjoy their mountains.

As part of her PhD dissertation, which is now in progress, García Gómez has proposed the creation of a documentary, with the participation of the critical members of the village. The primary purpose of the documentary, which has been filmed in Chalcatzingo, is to promote the engagement of the community with the site. The first screening of the video will take place during the main religious festivity of Chalcatzingo, and all the members of the village will be invited and encouraged to discuss the historical importance of the site and the way they could be part of the preservation of their heritage.

7.2 *Cases in which the right of access for everyone, without discrimination, to the benefits of science and its applications*

The General Comment No. 25 (2020), regarding science and economic, social, and cultural rights of the Committee on Economic, Social and Cultural Rights of the Economic and Social Council of the UN states that:

> Without prejudice to the duty of states to eliminate all forms of discrimination, special attention should be given to groups that have experienced systemic discrimination in enjoying the right to participate in scientific progress and its applications and to benefit from them. Such groups include women, persons with disabilities, lesbian, gay, bisexual, transgender, and intersex individuals, indigenous peoples, and those living in poverty [U.N. Committee on Economic, Social and Cultural Rights, 2020b].

In the following cases of this section, we believe that the members of the communities we studied are being discriminated against because they live in poverty and belong to communities in vulnerable situations.

7.2.1 Science communication as a human right to ensure the inclusion, participation, and recognition of people who use drugs

Throughout history, people have lived with drugs, but specifically, opioid use has posed many challenges. According to Cruz, opioids have profoundly impacted people's lives medically, socially, and economically. The term opioid includes opiates and other substances that work similarly to morphine but have different chemical structures. Among these chemical changes, we get semisynthetic opiates such as heroin, hydrocodone, and oxycodone, among others. Inside the synthetic group, we have methadone, fentanyl, and fentanyl analogs sold in the illegal drug market [Cruz, 2022].

In Mexico, Fleiz et al. studied heroin use in Tijuana, San Luis Rio Colorado, and Ciudad Juarez. They found that the local population consumes heroin five times more than the average, that the primary way of use is injection, and that it is combined with crystal and cocaine. The people who use injected drugs have higher rates of discrimination and marginalization. In Tijuana, 46.5% of the users mentioned that they had been rejected or offended, 33.5% had been rejected from jobs due to drug use, and 16.5% had left rehab centers due to verbal or physical abuse from the staff. Among this population, 2.7% have human immunodeficiency virus [Fleiz-Bautista et al., 2023].

In the Mexican border, the use of heroin adulterated with fentanyl is a growing health problem due to the overdose deaths associated with it. In the cities of Tijuana and Mexicali, a recent study reported the presence of fentanyl in heroin and crystal use. Fentanyl was consumed without the user's consent or knowledge of its presence [Fleiz et al., 2020].

People who use drugs have been excluded from national health programs and policies. They do not get treatment for their addiction, their healthcare access is insufficient, and they lack the medicine needed to revert an overdose. Women,

migrants, HIV, and LGBTTTIQ populations are amongst the ones most affected since their human rights are constantly violated due to the intersectionality of marginalized conditions. The information on the consequences of drug use and the associated risks are limited, and most of the population lacks access to it, so they lack the knowledge of how the product will affect them.

In Mexico, the initiatives and programs from the federal government are focused on drug use from a deficit model that works linearly. The "Scientific literacy" model, where experts work to correct the knowledge deficit of the public [Lewenstein, 2003], promotes stigmatization and discrimination of people who use drugs. The campaigns violate their human right to knowledge and exclude active drug users' knowledge, environment, and social context. Campaigns also lack gender perspective and place women who consume drugs in an even more vulnerable condition. The mix of social, economic, and scientific contexts shows that any program that works with drug users must have an interdisciplinary effort. Science communication can contribute not only to keeping the population of opioid users aware of the potential risks and consequences but also integrate the knowledge of the same users to create communication models designed in conjunction with their necessities.

In the master's project of Fabiola Vazquez-Quiroz, a citizen science approach was used to generate a better public understanding of drug use. One of the main characteristics of citizen science is the active participation of actors inside academia but also part of the affected population. This element integrates their knowledge with the research, enables them to own it, and increases their receptiveness. Another element that works in citizen science for this problem is its constant evolution, with new definitions, classifications, and practices, enabling a collective knowledge of the research topic [Vohland et al., 2021].

It is essential to include people who use drugs in the communication process because they are directly implicated and affected by the use of opioids. Their knowledge of how drug use affects them, their experiences of their social context, and the current reality of drug use is a crucial part of developing new strategies. For example, the Prevencasa Non-Governmental Organization in Tijuana, Baja California, has a risk and harm reduction program where people who use opioids can access health services [Fleiz et al., 2020]. Prevencasa staff also works with people who consume these substances, listen to testimonies about their risk practices and other factors associated with consumption, recognize their knowledge, and based on this information, build instruments for scientific research and generate communication actions according to the needs of people who use drugs, to improve their health and collective well-being. Scientific communication with a human rights perspective can be a means to share knowledge according to their context, culture, and needs, and thus open a dialogue between scientists and people who use drugs, promoting the active participation of this population to generate knowledge that benefits them and guarantees their human rights.

7.2.2 Science communication in social programs as a vehicle for the fulfillment of human rights in vulnerable communities in Mexico City

According to the Economic Development Secretariat of Mexico City, marked differences exist among the 16 city boroughs regarding the Social Development

Index (SDI), reflecting access to basic services and education (Secretaría de Desarrollo Económico, 2020). The current administration has implemented social programs to address local issues in communities with lower SDI. These programs include the "Points of Innovation, Freedom, Art, Education, and Knowledge," abbreviated as "PILARES," and the "Units of Transformation and Organization for Social Inclusion and Harmony," known as "UTOPIAS." PILARES are distributed across all boroughs based on the SDI of each borough. Consequently, boroughs with higher SDI, such as Benito Juárez, only have 4 PILARES. In contrast, Iztapalapa, with a lower SDI, has 60 [PILARES: Puntos de Innovación, Libertad, ARtes, Educación y Saberes, 2024].

As stated in its operational guidelines, this social program aims to align with Article 6 of the Political Constitution of Mexico City, focusing on the defense of human rights by promoting the protection and exercise of social rights to create more equitable conditions for residents in the most vulnerable communities. Specifically, the program emphasizes exercising rights related to education, science and technological innovation, good public administration, indigenous identity, and equality among individuals. In particular, the program seeks to impact the population that has not had the opportunity to access formal education systems, giving priority attention to women, older adults, people with disabilities, LGBTTTQ+, Afro-descendants, and members of indigenous communities in the city. This is achieved through activities facilitated by individuals from the same communities with lower SDI who possess theoretical and practical community education experience [Subsistema de Educación Comunitaria, 2023].

Since 2019, science communication activities have been conducted within these spaces as part of the program's strategy to uphold the right to education and science and technology. An analysis was conducted on science communication activities in 40 PILARES distributed across 14 of the 16 boroughs of Mexico City between 2022 and 2023 to determine how these activities are carried out. This analysis aimed to identify the communication models used, the attendance of individuals from communities with lower SDI, the facilitators' knowledge of social issues within these communities, the established objectives, and the difficulties they identified in achieving them.

It was found that 80% of individuals attending science communication activities belong to communities with lower Social Development Index (SDI) in Mexico City, confirming that the intended audience within these spaces was indeed being reached. This paves the way for developing dialogical and social participation strategies to benefit communities in vulnerable situations. However, it was also noted that in 38 of the 40 analyzed PILARES, only the deficit model is incorporated into science communication activities, focusing solely on learning concepts through playful activities without considering dialogical and participatory processes in subsequent stages. In these later stages, local issues could be addressed through co-created projects that integrate local knowledge with scientific understanding, guided by the principle of epistemic equity. This principle does not prioritize one form of knowledge or practice over another, acknowledging the value of everyone's ideas and contributing to consensus-building based on various epistemic frameworks for problem-solving [Gómez, 2016]. This approach not only fulfills access to education and science but also recognizes and fortifies the identity of these communities.

The 92.5% of facilitators engaged in these activities reported possessing university-level education in science and technology. Additionally, 87.5% claimed to have experience in science communication, serving as guides in science museums or as workshop leaders in science outreach groups affiliated with faculties, university institutes, and independent civil associations. Nevertheless, within the framework of the current social program, the deficit model persists in the practices of many facilitators despite the prior theoretical foundation of participatory models and public engagement in science at both global and Latin American levels. Hernandez-Arellano [Hernández Arellano, 2020] points out that in Mexico, one of the most recurrent activities in science museums and centers involves science workshops designed for elementary school students. These workshops, consisting of 50-minute sessions aimed at grasping a particular concept, tend to overlook the social dimension, generating a biased and partial perception of science. This scenario underscores the role of science museums as facilitator training grounds for science communication activities. Integrating theoretical and practical elements from dialogical, intercultural, and participatory models within these spaces is crucial, benefiting the visitors and the guides who may evolve into future leaders of science communication activities. Furthermore, all facilitators acknowledged being aware that the objective of the PILARES program is to promote the exercise of human rights for communities in vulnerable situations in Mexico City. They indicated difficulties incorporating this objective into their workshops, attempting to do so by introducing science and technology themes into the monologues presented in these spaces.

A perspective that could reshape the structure of these activities to achieve their previously outlined goals effectively is to consider science communication not as the ultimate objective but as the vehicle. Instead of assuming that exposing science and technology topics fulfills the right to access scientific knowledge, consider it as a tool enabling the establishment of intercultural dialogue-driven actions. This transformation can reshape community practices by incorporating functional elements depending on the context of each community, facilitating their integration for the fulfillment of human rights.

On another note, facilitators highlighted several obstacles hindering the fulfillment of this objective in their activities. These obstacles include a need for more materials, a low number of training sessions in science communication, and instances of corruption and proselytism within the program, impeding community organization processes. As a theoretical proposal, science communication actions within PILARES serve as a valuable tool for realizing the right to democratic, informed, and effective participation of individuals in vulnerable situations in the formulation and execution of a national science and technology policy aimed at restoring the social fabric of their communities. However, for this and future social programs, it is imperative to consider that the structural and sociopolitical issues within institutions are integral to the gap preventing the implementation of actions that enable the exercise of human rights and the development of the communities they seek to impact.

Discussion of the cases

Across all the study cases, we see the problem of relying on the deficit model, how the implementation of scientific projects can be disjoined from the populations it affects, and how better science communication models can improve social issues. Our definition of science communication from a human rights perspective aims to

benefit the situations where human rights intercede with science projects and populations, in a project similar to HAWC or Chalcatzingo, where it involves changes or locations related to a community. Using a human rights definition for science communication in preparing such projects would enable scientists to interact with the communities they are affecting. The potential of technoscientific projects would be made known to the populations, facilitating dialogues and benefits for the communities. In addition, one common problem when working with communities that are separated from academia is the potential for distrust [Bucchi, 2009; Grasswick, 2010], which could impact the continuation of the project. A better understanding of the communities prevents an ivory tower from forming and creating a schism within the populations. Involving the communities can be approached differently with citizen science projects or social projects involving the community to benefit them.

In projects that involve vulnerable populations like the communities of opioid users and the PILARES initiative, a definition emanating from human rights prevents potential abuse. It enables the projects to consider the implications of their work. Vulnerable populations are the most vulnerable to human rights violations [Fleiz-Bautista et al., 2023], and using a definition for science communication that strays from deficit models and includes them as individuals could enable the projects to improve on their reach and impact. Projects that work in vulnerable populations must strive to create dialogues that prevent othering the people they are working. Including their specific knowledge of how their situation impacts them can allow them to be more receptive to the information they are getting and to promote them to their peers.

The definition works when the science communication projects involve other communities, especially those of marginalized backgrounds. Considering the social backgrounds of different populations and involving them in the scientific process enables the communities to take ownership of the knowledge and appropriate it for their benefit. The definition has limitations when the projects are not involved in communities or are abstracted from the general population, preventing large-scale implementation. A core issue that can arise is that despite aiming for a horizontal understanding or collaboration, power dynamics and representation of those working in the field can prevent it from being fulfilled.

Conclusions

After revising the cases previously discussed, we conclude that it is crucial to consider science communication not only as an information source but as a way to observe human rights, particularly in the case of vulnerable communities. While it has been over 70 years since access to science was declared a human right, it is necessary to establish new strategies in current science communication projects within vulnerable communities to ensure its fulfillment. The goal is to ensure access to the benefits of scientific and technological progress and enable communities to appropriate and transform scientific knowledge for their development while maintaining recognition of local knowledge through intercultural dialogue. We believe that to create science communication actions with a strong inclusion point of view, it is of utmost importance to include the participation of the target population in the science communication processes, contemplate their language, social, and cultural context, and recognize the knowledge of all those involved to jointly co-create projects and materials of more

comprehensive communication, according to the interests and needs of the public to which it is directed. This perspective demands a change in methodological procedures for anthropological work and, therefore, interdisciplinary and transdisciplinary research cooperation. There are many ways to communicate scientific knowledge and to share it with others. Nevertheless, these strategies must recognize our goal community's language and cultural code.

We hope that in the future, local and national Mexican authorities ensure the observation of the right to science and technology for vulnerable communities and that they support the implementation of co-created science communication actions that transform the practices of all the actors involved and improve their lives and environments.

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