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Article

Participatory co-design of science communication strategies for public engagement in the US and Ecuador around health behaviour change

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Abstract

Science communication research and practice currently promote strategies oriented towards creating audience engagement around scientific content. Consequently, science communication needs to continually explore new methodologies that enable audiences' participation in order to meet their interests and needs. The present study combines qualitative and participatory action research (PAR) methods guided by decolonial epistemologies to develop a co-designed project with public health, nutrition and sports science researchers to recruit young audiences from Albuquerque, New Mexico, USA, and from Cuenca, Ecuador. The main goal of this study was to create strategies to motivate young audiences' engagement and interest in adopting healthy habits. This article focuses on the study's research design in order to provide guidelines and procedural recommendations for facilitating a co-design approach for developing science communication initiatives targeting children and teenagers in Ecuador and the United States. As we demonstrate, the PAR approach for co-design leads to useful outcomes: (1) the incorporation of decolonial theory guidelines in participatory research; and (2) the

development of science communication strategies that combine online and offline activities to put in dialogue scientists and their audiences, ultimately resulting in mutual learning, thus allowing scholars and practitioners to explore in practical terms how to co-design improved strategies.

Keywords science communication; science communication for public engagement; health communication; participatory action research; decolonial theory

Key messages

- Participatory action research (PAR) constitutes a useful methodology for developing research and practice for science communication for public engagement that fosters collaboration among scientists and the non-expert audiences of their studies.
- Decolonial epistemologies represent an opportunity to guide researchers in exercising self-reflexivity in order to develop respectful practices for trust building and collaborative research with audiences.
- Science communication for public engagement must foster dialogue through communication conduits tailored to audiences. Combining online and offline strategies is crucial to success.

Introduction

Over the last three decades, science communication scholars have shown that to promote a deeper engagement with audiences and the broader public, it is necessary to develop research that empowers and includes audiences' voices and interests around different scientific disciplines (Bucchi and Trench, 2008; Holliman et al., 2009).

More frequently, science communication research and practice have used linear-communication theoretical models, such as diffusion of innovations (Rogers, 2010) and the transmission model (Leach et al., 2008). Similarly, the deficit model (Bucchi, 2008) has inspired research approaches that focus primarily, or even exclusively, on disseminating and transmitting, in a one-way fashion, scientific information from academia to the public. However, these models do not consider opening the discussion between academic researchers and members of the public. Thus, each of these research traditions has led to research and practice that explore unilateral communication of science, while ignoring the need to create deeper audience engagement.

Currently, science communication is defined as the use of appropriate communication skills, media and dialogue to produce audience awareness and practical responses around scientific information (Bowater and Yeoman, 2013). Yet, science communication needs to build sustainable science–society relationships, and it can benefit from exploring community engagement. More frequently, community engagement has been applied in health contexts, through communication and education to target populations, and it can be used alone or as part of larger strategies (O'Mara-Eves et al., 2013).

This article presents an alternative research design to establish an egalitarian research framework based on qualitative and participatory action research (PAR), decolonial epistemologies and media theories used in combination. Thus, such a framework can motivate collaboration among researchers and young audiences as co-researchers using egalitarian procedures to manage power relations. The overall goal of the study was to explore how to co-design engaging strategies around two already existing nutrition and physical activity programmes.

The evolution of science communication: from dissemination to public engagement

Science communication research movements have evolved from the deficit paradigm to dialogue models. In the 1990s, science communication was referred to as 'scientific literacy' (Gregory and Miller,

1998) or as 'public understanding of science' (Stilgoe et al., 2014), approaches using the deficit model as their theoretical foundation (Bucchi, 2008). The deficit model assumed that: (1) all scientifically relevant knowledge belongs to academics; (2) exposing people to scientific content will alone motivate its appreciation; and (3) the point of departure for science communication is the assumption that audiences do not have the knowledge or competencies to understand science (Bowater and Yeoman, 2013).

Consequently, science communication developed under the deficit model primarily were dissemination initiatives. Scientific findings were then passed along from researchers to communication practitioners at research institutes or universities, with the assumption that these communication co-workers would then relay the findings to the public – despite the fact that few practitioners had prior training in science communication (Friedman et al., 1999). Compounding the problem, researchers were involved minimally, if at all, in the communication strategy design or the actual content to be relayed to the public. As a result, not surprisingly, science content was frequently misrepresented by the media (Stilgoe and Wilsdon, 2009).

However, by the 1990s, the alternative theoretical paradigm of dialogic models emerged, emphasising dialogue between scientists and the public. Dialogic models proved to be so successful that the Royal Society proposed its members set aside deficit models and adopt dialogic approaches to successfully promote public engagement (Holliman et al., 2009). Since the turn of the twenty-first century, science communication studies have regularly suggested that scholars explore methodological alternatives to overcome the barriers that the deficit model erected between scientists and society.

Additionally, practitioners of science communication for public engagement (Bucchi and Trench, 2008; Bowater and Yeoman, 2013), the newest research movement, suggest that PAR as a methodological paradigm can support the development of more inclusive research and, in so doing, can overcome many contemporary science communication challenges. Over the last two decades, most enquiry has addressed introduction of dialogical practices among researchers and their target audiences (Brossard et al., 2005), for example, through citizen science (Cooper, 2016), by focusing on media reporting on science (Dunwoody, 2014), or by exploring the effects on audiences of using social media to communicate science, as well as such effects on scientific content itself (Brossard and Scheufele, 2013; Lee et al., 2018).

Participatory action research in science communication research

PAR has its origins in two interrelated traditions: Kurt Lewin's (1946) action research and Paulo Freire's 1970s approach to co-learning processes (Freire, 2010). Lewin proposed a cyclical problem-solving process, through promoting people's participation in planning, analysing and implementing different solutions (Minkler, 2004), while Freire (2010) proposed a process whereby the researcher acts as a facilitator of dialogue and capacity building for empowering people through interaction, interchange and mutual learning. Following these traditions, PAR studies unite experts and citizens around topics of mutual interest, with the two groups working as co-researchers participating in an egalitarian framework to find solutions to a given problem (Chevalier and Buckles, 2013; Hacker, 2013).

PAR methodologies, then, can bring new opportunities to science communication, allowing scholars and members of the public to jointly explore the perspectives of society around science. Science communication studies can, and must, also consider creating resources and learning spaces (Davies et al., 2009) and promoting dialogue among scientists and audiences of different ages, cultures and education (Van Dijck, 2003).

Decolonial research and community engagement

Developing a decolonial enquiry means designing and conducting research from a community/society standpoint (Denzin and Lincoln, 2008; Smith, 1999). Researchers must be open to sharing voice and

agency with the people involved in research, doing so by facilitating the collaborative development of objectives, research questions, data collection and analysis.

In contrast to Western epistemologies, in decolonial research, people are not merely seen as human subjects of study from which to extract data but, rather, as equal co-researchers (Smith, 1999; Tuck, 2009). People participate in the research process by using their experiences, cultural history and local knowledge to discuss and address issues related to their needs and/or interests (Walsh, 2017). Here, the role of researchers is to facilitate and co-design along with the people a process whereby they dismantle their struggles and promote capacity building through tools to support participants (Smith, 2013).

In terms of epistemology, decolonial methodologies facilitate designing research procedures that reflect critically upon Western systems of knowledge and those systems' tools, and that set as priorities the participation of society and researchers (Denzin and Lincoln, 2008). The tensions between researchers and vulnerable populations are the result of decades of unequal relations dictated by knowledge extraction and appropriation (Jojola, 2008; Tuck, 2009). Therefore, significant challenges exist in terms of establishing relationships of mutual trust and openness to collaboration for researchers who aim to work with culturally diverse populations.

Decolonial scholars in the Global North (Porter, 2010; Smith, 2013) have applied the principle of humanising the enquiry process in culturally diverse populations affected by oppressive power structures that relegate them to vulnerable positions. Also, science communication researchers must always acknowledge the contextual reality of 'scientific rigour' and 'objectivity' as they affect people, and become aware of the harms inflicted through the very process of scientific research, in order to correct for these unintended effects. Consequently, researchers are challenged not only to create knowledge, but also to suggest practical solutions leading to tangible actions that people can take to overcome their problems.

Regarding community engagement, Chambers (1994) describes the conundrum faced by all academics attempting to employ PAR and development paradigms. Participation has three uses and meanings: cosmetic labelling, to look good; co-opting practice, for securing local action and resources; and empowering process, to enable people to do things themselves.

PAR methodologies have been shifting from a top-down paradigm towards a diversified, bottom-up approach. This implies a transfer of power from 'uppers', who have been dominant, to 'lowers' (people, institutions and disciplines) who have been subordinate. Participatory approaches to research and development tend to hide underlying changes in philosophy and practice. Empowerment of marginalised people requires reversals and changes in an egalitarian fashion. Thus, PAR approaches face significant challenges to their use as they require changes to bureaucratic procedures and cultures, including more participatory management (Chambers, 1994).

Chambers' (1994) work spotlights the shortcomings of traditional participatory research and development, and it sets the stage for an evolving PAR paradigm which seeks to eliminate the stark divisions between 'uppers' and 'lowers', to cast community members as co-researchers, and to bring PAR into the emergent realm of relational communication and relational dialectics 2.0; that is, placing PAR and health promotion squarely in the dialogic arena (Chambers, 1994; Halliwell, 2016).

The literature of community engagement privileges the role of those impacted by particular issues in the solution of those same problems. Proceeding from theories of marginalisation and its consequences, Aday et al. (2015) designed and implemented collaborative community health interventions in Central America, engaging undergraduate university students and community members to identify emergent health issues and their solutions. Having employed participatory and community action methodologies, Aday et al. (2015: 22–3) wrote:

we believe that the theory of marginalization and alienation helps us to better understand the context in which we find the observed problems of health and health care. This theoretical understanding prepares us to ask better, more focused questions about our own role in the communities in which we work.

The efforts of Aday and colleagues (2015) increased communication among community residents, facilitated the development of co-researchers' construction of community-endorsed five-year plans, and established partnerships with regional and international groups. This approach informed our own work with young students from marginalised communities as co-researchers.

Our work also comports with the *Ottawa Charter for Health Promotion* (World Health Organization – Europe, 1986: n.p.), which lists as prerequisites for health 'peace, shelter, education, food, income, a stable ecosystem, sustainable resources, social justice, and equity'. The two case studies described in this article sought to base their work in social justice and equity through the recruitment of co-researchers from the ecosystem being studied and by granting those co-researchers roles in all aspects of the studies, including the definitions of research questions and intervention methodologies.

Methods

Here we describe two case studies, including their functions and goals. We also discuss the methodological design for the study, and its research procedures, as guided by several decolonial theories, along with data collection tools and analysis.

Eat Smart to Play Hard

Eat Smart to Play Hard (ESPH) is a health promotion and research programme created and implemented by the University of New Mexico (UNM) Prevention Research Center, a research department affiliated with the UNM Health Sciences Center. ESPH is a four-year-old programme focused on reducing obesity and preventing chronic disease in children, families, schools and communities across the state of New Mexico. ESPH applies a social marketing approach, deployed through a series of interventions at elementary public and private schools and in households, which motivates children to adopt healthy nutrition and physical activities.

ACTIVITAL

ACTIVITAL is a health promotion programme that is the product of interdisciplinary research groups at the Biosciences Department at the University of Cuenca in Ecuador and at the VLIR Programme Cooperation Alliance, Belgium. Children in Ecuador face a variety of issues that fall under the heading of unbalanced nutrition. Among these are disproportionate food intakes, driven by cultural perceptions, and unhealthy cooking habits of parents and households that dramatically influence the health conditions of children and teenagers. ACTIVITAL developed a socio-ecological approach towards health behaviour change in order to educate children, teenagers and their families about healthy nutrition, using school interventions that included group games, workshops, medical controls and the collaborative development of a healthy eating recipe book.

PAR and qualitative research adapted to science communication

For this study, PAR and qualitative research were combined. The qualitative research framework used multiple case-study designs (Yin, 2012, 2017) with embedded units of analysis. This approach is regarded as more robust than that taken in single case studies because its results can be compared and thus can provide more generalisable data in two or more different scenarios (Herriott and Firestone, 1983). Consequently, the multiple case study enabled the researchers and co-researchers to identify differences, similarities and cultural considerations, and to develop science communication strategies, in two research programmes – one in the US and one in Ecuador – which have similar goals. The embedded units of analysis respond to each of the research questions. It is important to clarify that the design of the study was developed by the researchers. To follow the criteria of PAR studies developed using decolonial

guidelines, the researchers and co-researchers initiated their collaboration after their recruitment to discuss research questions and procedures for the co-design participatory workshops and data analysis.

Self-reflexivity practices and designing a participatory science communication study

This study was designed as a collaboration among researchers and young audiences; for this reason, it was crucial to incorporate self-reflexivity practices for the researchers. As the PAR framework promotes egalitarian agency and participation of audiences, researchers were required to acknowledge their privilege and power, and how they would position themselves in the study in relation to the audiences for the health programmes. For this purpose, we combined guidelines suggesting decolonial considerations by Andrea Smith (2013) in order to develop a practice of self-reflexivity prior to finalising the overall research design and approach to audiences. Decolonial guidelines were crucial in managing possible power imbalances among the interests of the researchers and the needs and interests of co-researchers. Consequently, the researchers developed a self-reflexivity exercise before the first contact with the co-researchers of each case study.

The self-reflexivity exercise was conducted by one of the researchers of this study as a one-hour session with the researchers at ESPH in Albuquerque, and later separately with the researchers of ACTIVITAL in Cuenca. We combined the notions of co-learning processes (Freire, 2010) and the critical approach of self-reflexivity (Smith, 2016) for balancing power and agency. Before the session, the researchers were asked to bring a clear written statement acknowledging their privilege in terms of socio-economic characteristics, and describing their personal identifications in terms of gender, race, culture and ideology. During the session, the researchers were asked to disclose how they would use the emerging data to ensure mutually beneficial outcomes for the co-researchers and their programmes, focusing not only on scientific outcomes, but also on activities that would promote healthy habits with young audiences, and provide voice and agency to the co-researchers in the co-design process.

As a result, researchers agreed to the following procedure:

- In the first of the four co-design workshops, dedicate time to set the rules with the co-researchers to enhance egalitarian agency and decision making.
- Include the co-researchers in refining the research procedures, in order to promote their agency in the co-design process.
- Respect the opinions, needs and interests of co-researchers by supporting their ideas and suggestions for replacing specific interventions with new ones oriented to improving the audience's engagement around the scientific content.
- Promote capacity building by teaching co-researchers about the use of participatory data collection tools, addressing co-researchers' concerns, and countering any emerging misinformation about healthy habits with scientifically validated information.

Ethical considerations

It was crucial to work with former programme participants so that they could provide their suggestions and ideas based on their experiences. Drawing on decolonial practice, it is crucial to understand the reality of audiences, as well as the researchers' beliefs, to counter power imbalances that might affect the participants, and to reflect on how to address these (Tervalon and Murray-Garcia, 1998).

To practise cultural humility with the purpose of arriving at a deeper understanding of the audiences, we reviewed the formative research studies of each programme to identify the socio-economic characteristics, race, culture and education of each group, as well as their current knowledge about healthy habits in order to reflect on how to create inclusive and egalitarian research procedures (Chevalier and Buckles, 2013).

The protocols for the study were approved by UNM's Institutional Review Board. All sessions were audio-recorded and documented through a registry of the overall strategy proposal. To protect identities, participants were asked to create nicknames to participate in the study. Data indicated which programme each participant was associated with, but did not indicate personal identifiers.

Research procedures

Here we describe the methodological considerations that research procedures followed.

Co-researcher recruitment and trust building for creating a safe space for co-design

After developing an initial understanding of the audience contexts, we approached each programme in order to request access to the participants. In the case of ESPH, this involved writing to the principals of several Albuquerque high schools; ultimately, we were granted approval for research participation of the students of the Health Leadership High School, a charter school oriented to promoting health sciences careers. During our first visit, we explained the study and made clear to the students that our goal was to promote science communication around health programmes. At the conclusion of our visit, we provided informed consent/assent forms to the students who expressed interest and explained that, since they were underage at the time of the study, they would need the permission of their parents or legal guardians to participate as co-researchers. In the case of ACTIVITAL, the participants were already at least 18 years old. Consequently, we approached them through email; in our initial message, we presented information about the goals of the study, and we invited them to participate voluntarily.

Figure 1. Rules for teamwork for Eat Smart to Play Hard (Source: Authors, 2022)



We recruited 10 co-researchers for each health programme. From that point on, all decision making was participatory, to create trust. Together, co-researchers and researchers were guided by the authors of this study to work together to refine the research questions, select the dates and locations for the participatory co-design workshops, and create the policies that would guide the co-design process, as described in Figure 1. The co-researchers were invited to also provide the researchers with their questions of interest about healthy habits and about the scientific content of the study (that is, concepts, data collection methods, and any other doubts that they had). Responsibilities for the facilitation of the workshops were shared among the researchers and co-researchers.

Compensation for co-researchers

This study compensated each co-researcher with US\$40 in cash, as well as healthy snacks and materials for co-designing strategies.

Research questions

To develop the research questions, the researchers consulted with the co-researchers of both health programmes to agree on questions that addressed their interests. This practice was crucial to ensure a PAR design, reinforce collaboration and put in practice the decolonial guidelines created in the self-reflexivity sessions. The resulting research questions were:

- RQ1: How can researchers/scientists of health behaviour studies develop better science communication strategies for public engagement from the perspective of teenage/young-adult audiences?
- RQ2: How can teen audience engagement with science/health communication be improved?

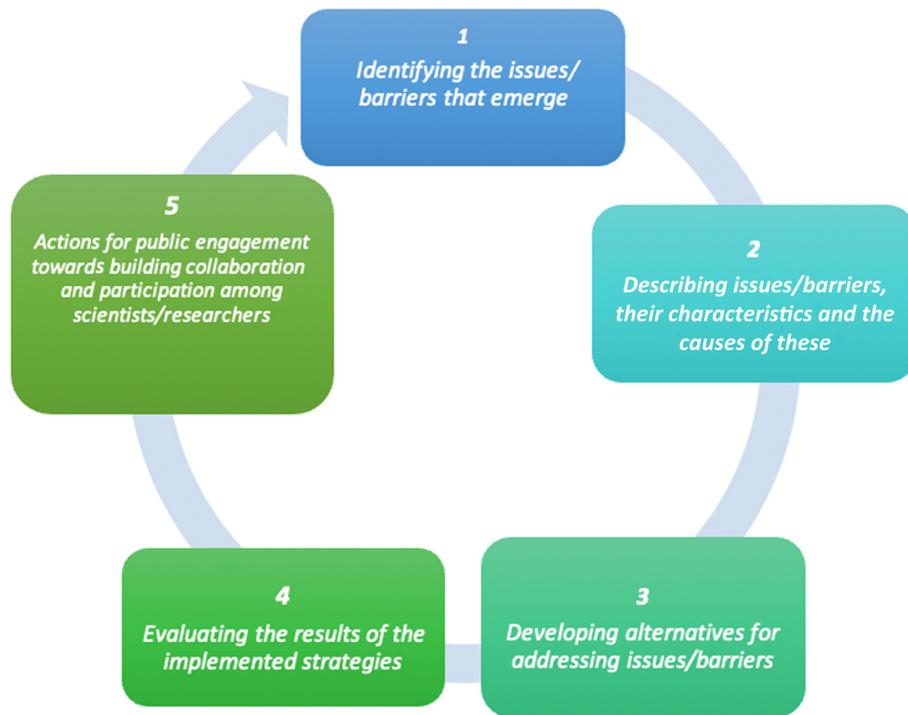
RQ1 addresses how to create and develop science communication for public engagement. In this study, we had two focuses related to audience engagement: to evaluate the current communication engagement of the programmes, and to improve teen audiences' engagement in science and health communication. We analysed collectively whether the suggested activities were effective in engaging young audiences, and how those activities could be improved or changed. RQ2 concerns how to create spaces and opportunities for collaboration among researchers and young people around healthy habits, and how researchers can develop strategies to motivate the audience's engagement.

Data collection tools

As decolonial epistemologies suggest incorporating participatory methodologies to overcome power imbalances, finding suitable data collection tools was crucial. As Western data collection tools are seen as extracting information from research participants (Tuck, 2009), instead we used participatory data collection tools that use iterative processes for co-constructing knowledge (see Table 1).

Table 1. Detail of data collection tools and co-design sessions (Source: Authors, 2022)

Research questions	Session	PAR data collection tools
RQ1 How can researchers/scientists of health behaviour studies develop better science communication strategies for public engagement, from the perspective of teenage/young-adult audiences?	1	PAR diagramming
	2	PAR diagramming Asset mapping
RQ2 How can teen audience engagement with science/health communication be improved?	3	Zines
	4	PAR diagramming

Figure 2. The action-reflection cycle process (Source: McNiff, 2014)

Participatory dialogue was an essential tool, focusing on the value of co-researchers' knowledge and 'real-life' problems (Coburn, 2005) to develop activities, resources and messages that would support healthy habits. We used action-reflection cycles (McNiff, 2014) to facilitate discussions and to organise collective participation, analysis and proposed actions, and thus we were able to more productively identify crucial factors that could influence the implementation of strategies to promote audience engagement (see Figure 2).

Among other PAR data collection tools, we applied participatory diagramming (see Table 1), which uses available materials (for example, paper, boards, colour-coded cards) to create charts that connect responses of participants with prompt questions that have the purpose to guide the discussion of co-design workshops guided by a facilitator (Kesby, 2000). PAR diagramming was used to organise the ideas to analyse the current programme's strategies to connect them to suggestions for improving engagement or to propose new strategies.

We also used asset mapping (Chapin and Threlkeld, 2001), a participatory tool that uses maps to locate specific places that provide resources, and which allows several people to work simultaneously by using online platforms such as Google Maps. To this end, we focused on identifying each city's information resources, as well as places we could use to organise events and activities to promote physical activity.

Finally, we used Zines (Chidgey, 2014), an arts-based tool that can combine drawings, collage and writing, and which uses simple materials such as paper and magazine cut-outs. Zines served to organise the overall strategies and their corresponding communication conduits and messages in order to motivate the creativity of the researchers and co-researchers.

Data analysis

Open coding was used to analyse the emerging data (Marshall and Rossman, 2014). As this study used PAR tools to co-design strategies, we put in place a system of colour coding to clearly identify and delineate issues, causes, consequences and proposed alternatives. This procedure enabled us to work simultaneously to develop new strategies for each programme.

We identified several themes and subthemes that then allowed us to create communication-practice guidelines for scientists who work on studies that promote healthy habits. Building on the insights of media theories such as two-step flow (Katz, 1957), medium theory (Collins et al., 2016; Meyrowitz, 2009) and framing (Entman, 1993; Listerman 2010) allowed us to develop recommendations to improve the strategies of each programme.

Results

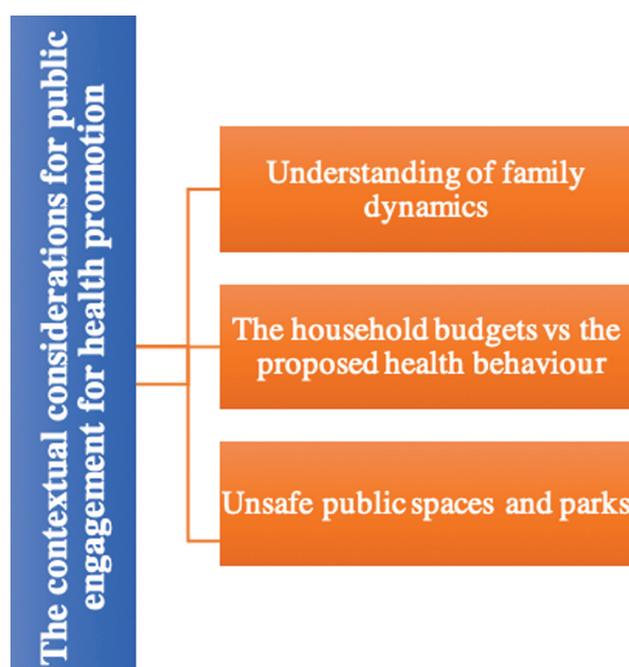
Regarding the demographics of the overall co-design teams, the three main researchers are a semi-diverse group. The first author is a Latinx female researcher with a PhD who is an assistant professor; the second author is a White male associate professor; and the third author is a White female associate professor. The ages of the researchers range from their 30s to their 70s.

Co-researchers of ESPH were the programme scientists and the children. Most individuals were Latin-Hispanic who were immigrants from Latin America (two programme scientists); there was also one White female scientist. The co-researchers were first-generation Latinos born in the US (three females and three males) ranging in age from 13 to 16; 4 of them were low-income DACA students. (Deferred Action for Childhood Arrivals is a programme of the US Citizenship and Immigration Service that provides youth with a work permit and protects them from deportation as they arrive and stay in the United States; Center for Diversity and Inclusion, Washington University in St. Louis [2018].)

The ACTIVITAL researchers were two Latinx female scientists who are professors and researchers. The co-researchers were all Latinx (three males and three females) ranging from 18 to 20 years old; they were first-year college students from middle- and low-income families who accessed higher education through government-funded merit scholarships.

Our study evidenced two important streams of findings in each programme: first, specific *contextual considerations* that influenced audience engagement and the development of co-designed strategies

Figure 3. Contextual considerations of Eat Smart to Play Hard (Source: Authors, 2022)



oriented towards improving such engagement; and, second, a set of useful guidelines for science communication for public engagement around health programmes.

In the case of ESPH (see Figure 3), we found that the current strategies and tactics were interesting and attractive to audiences. However, some of those tactics did not take into consideration certain limitations within some participants' households; for example, many New Mexican families lack access to safe public parks or playgrounds. Another chronic limitation is that certain foods, such as fresh vegetables and some protein sources, are prohibitively expensive for low-income families.

We found ACTIVITAL's programme strategy to be well thought out at the time of its implementation. However, to implement the programme during a time in which social media and other newer communication conduits are increasingly prevalent, it was crucial to create an interactive strategy approach, focused on developing learning for children, teenagers, their families and their teachers. Specifically, a hybrid online–offline approach was suggested which would combine activities and resources that are useful and interesting to ACTIVITAL's audiences (see Figure 4).

Participatory co-design outcomes strategies for ESPH and ACTIVITAL

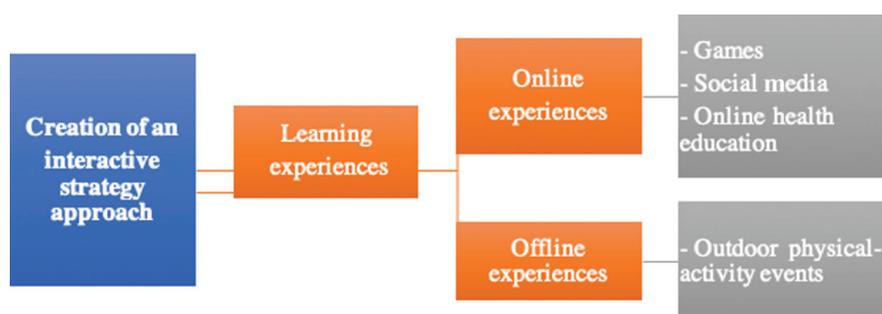
As a result of the participatory co-design workshop sessions, we developed several strategies to improve audience engagement. In both programmes, balancing power through egalitarian participation provided tangible positive results. Consequently, the study promoted a trust among researchers and co-researchers that facilitated the development of strategies that combined the ideas and creativity of co-researchers and the scientific expertise of researchers.

Spokespeople for health programmes

As noted above, the co-researchers suggested that scientists be the main spokespeople. In the case of ESPH, they created the ESPH Squad – two scientists (one female, one male) who would guide young audiences to learn about the science behind nutrition and physical activity, explaining how healthy foods and physical activity benefit the human body by encouraging growth and managing stress. The co-researchers also recommended including teenagers who resembled the older siblings of the children. Target-age children would also be included as the followers and main characters in the communication materials, shown interacting in the company of their pets.

Both co-design teams of both programmes felt that former programme participants would serve best. To motivate former participants' engagement, an 'ambassadors' programme was proposed: target audience members could sign up by uploading to their personal Facebook profile a video in which they would explain why they wanted to be an ambassador of the programme; participants with the most 'likes' would be selected. The winners of the contests would work with the scientists on the new co-designed programme activities.

Figure 4. Creation of an interactive strategy for ACTIVITAL (Source: Authors, 2022)



Engagement activities for audiences

A specific activity co-designed by the ESPH participants was to create a cooking contest promoted with the hashtag #ESPHcooking (see Figure 5). In this activity, participants would be invited to upload to social media a picture of themselves cooking a healthy meal with their families and featuring the hashtag on their photographs. The winners would be those who generated the most 'likes', and they would win a gift card from grocery stores or sports venues.

Additionally, considering the ESPH participatory co-design team's confirmation that some low-income families cannot afford healthy food (vegetables, grains and proteins), the team agreed to involve food gardens and food pantries at local schools. To do so, they developed activities soliciting donations of seeds and canned foods, and recruited teachers and parents as volunteers. The team's main goal was to provide free vegetables and other healthy foods often excluded from families' grocery shopping due to limited budgets.

In the case of ACTIVITAL, the participatory co-design research team recommended developing a strategy that would combine online resources and outdoor activities. Through asset mapping, the co-design teams located public parks and recreation areas in which free monthly events could be offered. A crucial factor was to bring together children, teenagers, their families and researchers to participate in these fun physical activities, as well as in healthy habits discussion groups.

Figure 5. Co-designed strategy artwork for the #ESPHcooking contest (Source: Artwork developed by ESPH participants)



Communication conduits for audience engagement

The co-design teams suggested that social media profiles – Facebook and Instagram – be created to provide informational resources for parents/caregivers, teachers and children. However, in both programmes, the co-design teams agreed to recommend using Facebook as the primary communication conduit through which underage children would be invited to interact in activities through their parents' or older siblings' accounts. The teams also recommended that social media be used by physicians as information tools for parents/caregivers of children and teenagers about healthy habits. The recommended content was healthy recipes for snacks and meals, as well as workout routines. Social media would also engender interactions with scientists and health experts, which could take place in real time and could be monitored and measured for evaluation.

Teenagers on the co-design team also suggested creating an app for registering their physical activity and food intake, allowing participants to keep track of their habits and receive tailored recommendations for avoiding unhealthy behaviours. The app would give participants the option of creating avatars of themselves that would change and adapt according to the habits of the user. Further, the app would be linked with social media resources.

Decolonial and PAR methodological approach outcomes

Incorporating decolonial principles as guidelines for the study procedures enabled the researchers to manage the power relations and possible imbalances. More specifically, decolonial principles through the self-reflexivity guidelines of this study guided the process of working collaboratively with co-researchers and not overstepping their needs or interests.

Discussion

Science communication for public engagement suggests two avenues for research. One would create spaces for interaction among scientists and the public as a first step towards establishing sustainable relationships that can lead to science–society partnerships (Bowater and Yeoman, 2013). The other suggests a new methodological design for future studies that prioritises dialogue. To this suggestion, several scholars agree that PAR methods are well suited for facilitating an egalitarian framework among scientists and members of the public for mutual collaboration (Stilgoe et al., 2014). The research design of the present study addresses these suggested avenues. Also, in each case study, the findings respond directly to each of the research questions and its units of analysis regarding how to create strategies that promote audience interest and engagement with scientific research about children's and teenagers' healthy habits.

At the same time, we found some significant differences and some similarities related to the cultures and contextual factors of the countries. These led us to various implications for the future planning and execution of science communication for healthy habits promotion with young audiences. These are discussed in the following sections.

Understanding the lifestyle dynamics and context of audiences

The two case studies evidenced quite a few differences in cultural and other issues, as well as a few similarities regarding food and nutrition, family dynamics and the use of public spaces. By understanding the data that emerged from the participatory co-design, such as household dynamics, participants' relationships with their parents, and the available knowledge about and resources for healthy habits available to children and teenagers, the process of creating tailored strategies that addressed their interests and concerns was enriched. The tasks of co-designing messages, choosing incentives and finding useful communication conduits were shared among the researchers and co-researchers.

It was also useful to reflect on the complementarity of the health behaviour change frameworks used for each study, such as social marketing (Shamsi et al., 2014) in the case of ESPH and socio-cognitive theory (Bandura, 2004) for ACTIVITAL. For example, the social marketing framework worked well for creating attractive activities and compensations for children, but it required more attention to providing resources for parents, given the needs of low-income households. In contrast, the socio-cognitive theory model was effective in creating learning activities, and it required us to enhance the motivation of children and teenagers through activities that were attractive to them.

Theoretical and methodological guidelines for science communication for public engagement

Media theories can be used as guidelines for science communication research and practice. In the present study, we used communication theories as a framework when analysing the co-designed outcomes of the participatory co-design workshops to organise the science communication strategies for each programme.

The two-step flow theory helped guide our decisions about who might be the most appropriate and successful spokespersons. Interestingly, co-researchers in both locations ultimately concluded that the scientists themselves should be the spokespeople, because they are credentialed researchers who can provide audiences with accurate information. This finding was in line with previous science communication studies, which found that leaders who are non-scientists, and either journalists or public figures, face a higher risk of misshaping the findings and possibly communicating inaccurate information to the public (Dunwoody, 2014).

Medium theory provided the foundations to reflect on which communication conduits were most suitable to impart specific scientific content. So informed, we found it crucial to assess the complexity of the scientific information and how to select the most effective media to make that information clear, understandable and attractive to young audiences. To that end, we explored the specific features that enhance audience engagement on platforms such as Facebook, Instagram and YouTube (Collins et al., 2016), and we found that children and teenagers expressed interest in interacting directly with researchers through social media for learning about healthy habits. This finding corroborated prior studies showing that social media provide opportunities to open dialogue with society; for example, Twitter and Facebook have offered positive outcomes for researchers who seek to dialogue with non-experts about their research (Pearce et al., 2015). At the same time, each social media platform offers different tools for combining video, graphics, animations and live streaming that can be helpful to researchers in attracting audiences and engaging them in discussions about scientific topics of their interest (Liang et al., 2014; Nisbet and Kotcher, 2009).

Framing theory, too, provided a useful approach for designing messages with scientific content by understanding that audiences have different interpretative schemas – frames – that allow them to interpret and make sense of an issue (Entman, 1993). In the case of science communication and scientific journalism, frames help audiences put topics or issues into shared contexts (daily life situations or habits) that are understandable for people (White, 2013). The present study reveals, specifically, that to create content and a messaging strategy for science communication for public engagement, formative research and PAR can be used effectively to identify communication insights, to craft messages, and to determine the language (and tone) that is most suitable to the audiences.

Methodological recommendations

As noted above, the existing literature on science communication for public engagement suggests that dialogical frameworks are best suited for enhancing society's interest and participation. To plan engagement strategies, it is necessary to investigate and create a comprehensive understanding of a target audience's demographic and psychographic characteristics so as not to fall into the common traps

possible when applying the tenets of deficit, diffusion or transmission models (Davies et al., 2009). In other words, PAR allows scholars to productively tailor useful and engaging science communication strategies.

To this end, further formative research that is designed with an ethnographic-qualitative approach could also provide a greater understanding of audiences, and provide suggestions to be aware of, and sensitive to, participants' household dynamics and difficulties.

Creation of an interactive strategy approach

The researchers acknowledged the contribution of PAR in their respective programmes to their own education about how those programmes can benefit young people. Key here was the value the co-researchers perceived in having the opportunity to directly interact with scientists and to co-create strategies that would allow them to reach even wider audiences. These acknowledgements support the findings of Dierking et al. (2003) and Wood (2011) that science communication based on dialogic models – and particularly on the transactional model of communication, in which message senders and receivers share common contexts and experiences over time – can be especially effective in getting audiences to adopt healthy habits. Co-designed strategies that operated through communication conduits that promote direct dialogue with their audiences were built on a key finding of scholars of the transactional model: that communication needs to be a frequent and sustained activity. By contrast, communication strategies that are based on only one contact with the audience will not be useful (Bowater and Yeoman, 2013).

In the case of Ecuador, there is significant evidence that social media are increasingly effective tools for science communication. According to the National Institute of Statistics and Censuses of Ecuador (INEC, 2019), 98 per cent of people above the age of 12 have a Facebook account, making that platform an increasingly useful conduit for audience engagement. Nonetheless, low-income Ecuadorians have little access to the internet and to technological devices, meaning that digital communication cannot be seen as the sole solution. At the time of the completion of the present study (2019), only 28.8 per cent of the rural populations had access to a tablet or smartphone. Moreover, these households had only one computer, which was used primarily for educational purposes, and only 36.7 per cent had a Facebook account (INEC, 2019). Consequently, future studies could focus on how to develop science communication for engaging marginalised communities.

It is still necessary to simultaneously consider alternative in-person strategies, combining mass media with social media to amplify messages and boost audience coverage (Hsu et al., 2018), recognising that dialogue takes place not only digitally, but also in person.

Conclusions

Co-designing science communication strategies leads not only to creating resources that are useful for society, but also to new opportunities for strengthening the relationships between scientists and the general public.

Regarding RQ1, which focuses on how science communication can be improved from the perspective of young audiences, strategies to enhance engagement must combine online and offline tactics. While social media, as we have shown, can provide important platforms for achieving collaboration and public engagement, there is still a way to go. The present study shows that audiences want to dialogue with scientists and learn from them through in-person activities and by using digital conduits such as social media. Social media can also serve as strategic conduits for sharing interactive activities that can simultaneously motivate scientists and audiences to engage and enhance all parties' understanding. Regarding RQ2, we can suggest that PAR methodologies provide opportunities to develop partnerships that can lead to future collaborative research that attends to the needs of local communities with initiatives for social change.

Indeed, PAR research opens opportunities to explore in depth the issues that people face, such as to adopt healthy behaviours, and it can also help to create feasible solutions. This is possible when researchers and their target audiences share an egalitarian space for research. Moreover, the co-design participatory approach facilitates processes in which scientists and members of the public can experience mutual learning around topics of common interest. In order to achieve participation, scientists need to open their studies to public dialogue, and to explore – with the collaboration of audiences – how to create initiatives that provide useful information and resources.

Finally, the willingness of researchers to participate and share their research with the public is a key component for engaging science communication. As this study shows, researchers' involvement in dialoguing with their audiences and co-designing initiatives are the crucial factors motivating audience engagement.

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Declarations and conflicts of interest

Research ethics statement

The authors declare that research ethics approval for this article was provided by the UNM IRB ethics board, Approval # [1259243-1], and that it was waived for publication by protecting the identities of the participants in this study.

Consent for publication statement

The authors declare that research participants' informed consent to the publication of findings – including photos, videos and any personal or identifiable information – was secured prior to publication.

Conflicts of interest statement

The authors declare no conflicts of interest with this work. All efforts to sufficiently anonymise the authors during peer review of this article have been made. The authors declare no further conflicts with this article.

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