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+*Ciencia*: a training program to increase evidence-based science communication and literacy for Hispanic high school and undergraduate students

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ABSTRACT Science misinformation represents a significant challenge for the scientific community. Hispanic communities are particularly vulnerable due to language barriers and the lack of accessible information in Spanish. We identified that a key step toward enhancing the accessibility of information for non-native English-speaking communities involves imparting science communication education and training to Hispanic youth. Our goal was to provide them with the skills to become science ambassadors who can effectively engage with their communities and bridge communication gaps. To address this, we developed the first science communication training program in Spanish for Hispanic high school and undergraduate students in Puerto Rico. The program called +*Ciencia* aims to provide training and education on science communication for Hispanic minorities through experiential and collaborative learning. In the short term, our multifaceted approach works to counter misinformation and promote science literacy within the broader community. Over the long term, our grassroots efforts with students will evolve into a generation of professionals equipped with strong engagement skills and comprehensive training in science communication with a specific focus on Hispanic audiences. Herein, we describe the components of this educational program and provide open access to educational materials and articles developed by three cohorts.

KEYWORDS science communication, science literacy, science communication training program, high school education, undergraduate education, Hispanic students

Given the quick and easy access to information for billions of people online, misinformation has become one of the biggest challenges faced by the scientific community in the 21st century. This was particularly evident during the coronavirus disease 2019 pandemic when misinformation hindered public trust in the scientific community and medical professionals, subsequently diminishing the public's compliance with health guidance and preventative measures (1–5). To counteract this issue, governmental institutions, non-profit organizations, and the scientific community have adapted to the rapid rise of social media to communicate science to the public and mitigate misinformation (6–8). Furthermore, many experts are investing efforts to decode the underlying "fundamental science" of science communication (9–12).

Despite ongoing efforts, the intricate complexity of scientific communication continues to fuel concerns about public misinformation (13–15). This is aggravated in non-English-speaking groups, such as Hispanic communities, where language barriers prevent easy access to information (16–19). Effective science communication is a vital component for informed decision-making, educating the public about the benefits and risks of their choices (18, 20). Nonetheless, it is essential that this communication is tailored to the audience and considers factors influencing message interpretation, such

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as language, culture, and values (21). For science communication to be truly effective, it must be rooted in a deep understanding of scientific concepts and processes, often referred to as "science literacy" (22), complemented by a solid knowledge of communication theories and best practices. In Puerto Rico, efforts to increase science communication and public engagement have been implemented by non-profit, private, and governmental organizations. However, to our knowledge, no training program centered on enhancing evidence-based science communication and literacy has been developed for high school and undergraduate students in Puerto Rico.

To address this, we developed the program *+Ciencia,* the first science communication program in Spanish for Hispanic students, particularly Puerto Ricans, pursuing their high school and undergraduate education. This program aims to provide accessible training on science communication, facilitate mentor-mentee relationships, and increase professional development and leadership opportunities for Puerto Rican students. The *+Ciencia* program was conceived as an auxiliary component of "*Ciencia en Tus Manos*" (CETM), a non-profit 501(c)(3) organization with more than 26,000 social media followers, dedicated to providing accessible scientific information to Hispanic communities. Through *+Ciencia*, students were exposed to educational workshops about science communication and writing practices and had the opportunity to apply their learning through the development of a scientific article for the *+Ciencia* magazine. To achieve this, they worked directly with CETM leaders and content creators. The *+Ciencia* magazine is the final project created by participants and published on the CETM website to increase students' experiences with literature review and writing while amplifying their visibility. Herein, we describe the components of this educational program and provide open access to educational materials and articles developed.

PROCEDURE

Student selection

An open call for applications was distributed through the CETM online platforms. The application consisted of two open-ended questions: (i) Why do you want to participate in the program? (ii) Describe your short-term and long-term professional goals. Applications were coded by the program directors and sent to the CETM board members for a double-blind evaluation. Each board member was asked to rate answers in ascending order (1 = deficient; 5 = excellent). Results were collected by program directors; students with the highest scores were chosen to participate. Students were notified of their acceptance via email. For minors, program directors met with guardians to secure parental permission to participate in the program. All students were required to complete a media release and participation agreement forms.

Program overview

The program was designed for high school students, grades 10 to 12, interested in pursuing a science degree after graduation. It was also tailored for undergraduate students currently enrolled in a bachelor's program in science interested in developing mentorship and leadership skills. The program centered on six learning objectives and was designed to be completed synchronously with three 1 hour workshops and a mentorship section (Supplementary Material Appendix 1; Fig. 1). The workshops focused on three main topics: (i) science communication, (ii) understanding of scientific literature, and (iii) scientific content creation. Workshops were led by *+Ciencia* staff and CETM board members with advanced degrees (Ph.D. or M.D.) in diverse STEM fields. Table 1 depicts the focus and timeline for each workshop, mentorship, and final project. A description of evidence-based practices aligned with the workshops can be found in Supplementary Material Appendix 2 (23–41). After completing the workshops, participants were grouped and given specific topics to work on the development of a scientific article, which served as their final project for the *+Ciencia* magazine.

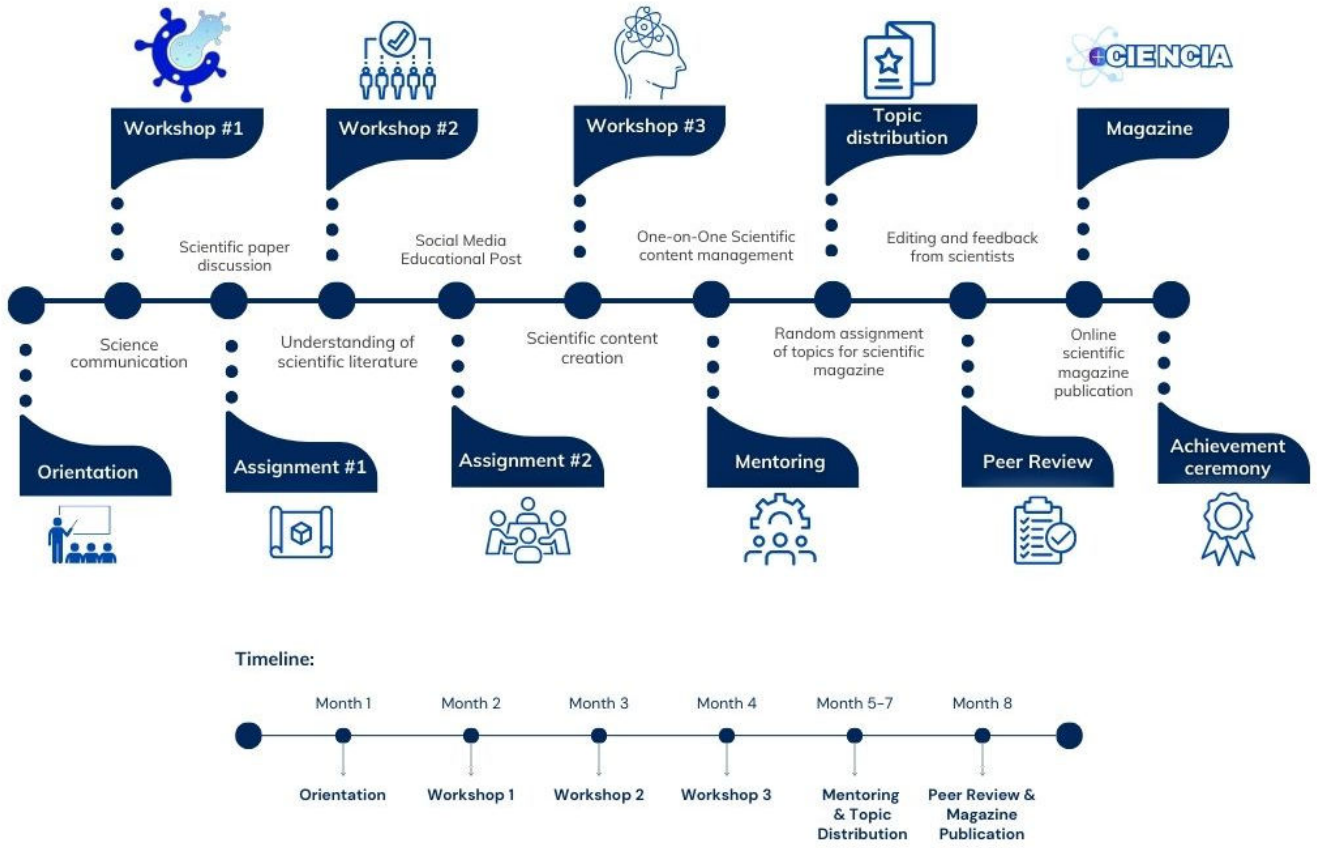

FIG 1 Schematic representation of the *+Ciencia* program. The program consisted of an orientation and three 1 hour workshops, with associated assignments, that occurred on a monthly basis. Following the workshop session, a mentoring session and the development of the *+Ciencia* magazine articles were held. Time spent in mentorship was determined by each mentor-mentee group with an estimate of 1 hour per week. Students had approximately 2–3 months to develop their articles and obtain feedback from their mentors; until the peer-review session with the *+Ciencia* staff. Timeline can be modified by instructors to fit the needs of their cohorts.

Program implementation and outcomes

Faculty instructions for program implementation along with recommendations for assessing student learning are available in Supplementary Material Appendices 3 and 4, respectively. Program outcome and description, and access to the *+Ciencia* magazine (final project) are available in Supplementary Material Appendix 5.

CONCLUSION

Given the lack of informed peer review, accuracy, and credibility of the information published online, misinformation has emerged as one of the biggest challenges in the 21st century. Non-English-speaking communities are particularly vulnerable, given that English has been adopted as the primary language to communicate science (42). Language barriers lead to public mistrust toward the scientific community and detachment from scientific research and guidance (18). To address this issue, scientists and researchers must rethink science communication and align the information to the audience's language, beliefs, values, and interests (12). Developing materials to target each one of those unique needs can be time-consuming and labor intensive. A promising strategy to address this challenge is to include training on science communication and literacy in the K-12 and higher educational curricula. The *+Ciencia* program seeks to increase training and education in science communication for Hispanic students, specifically in Spanish. In doing so, it not only battles misinformation but also

TABLE 1 *+Ciencia* workshop description and associated evidence-based teaching practices implemented[a]

Workshop	Description	Evidence-based practices
Workshop 1: science communication	In this session, the basic concepts of science communication were taught. Instructors introduced the definition of science communication, its importance, and the techniques and steps needed to communicate science to different audiences. Following the presentation of these concepts, students were introduced to the structure of the *+Ciencia* magazine and their role in developing content for the magazine as their final assignment. For the last part of this session, the participants were introduced to the overall structure and anatomy of a scientific paper in preparation for workshop 2.	Teacher-focused learning
Workshop 2: understanding of scientific literature	In this session, the basic concepts of science literature were taught through interactive lectures and open discussion. Prior to the workshop, students were assigned a scientific article and asked to summarize the article in 10 bullet points. Selection of the article was done utilizing a strict guideline detailed in Supplementary Material Appendix 3. The summary needed to be centered on answering the following questions: (i) What is the article about? (ii) What did the scientists do or complete? (iii) What did the scientist find? and (iv) What does it mean to the community? Students were asked to participate in an open discussion by sharing with colleagues their answers. During the open discussion, instructors shared feedback with students and encouraged further analysis of the article when needed. Through this interactive lecture and open discussion forum, students were taught the main components of scientific articles, the proper ways to identify and simplify concepts, and the importance of transmitting its significance to the community.	Discussion-based learning; 5-e model
Workshop 3: scientific content creation	In the first part of this session, students were exposed to the best practices for scientific concept creation and social media usage as a communication tool. The topic of this workshop was selected by *+Ciencia* staff and CETM board members given the current demand of social media for science communication. *+Ciencia* staff and CETM board members chose to use Instagram and Facebook as science communication tools or platforms, and the use of Canva as a graphic designer tool. Prior to the workshop, students were asked to select an article and create a visual that they could use on social media to communicate the science behind the article to the public. Access to the CETM Canva Pro and Instagram/Facebook accounts was provided to students to complete this task. Students were also provided with the option of personalized guidance on the use of Canva with the *+Ciencia* staff. Following the presentation, students were asked to participate by sharing with colleagues their creations and explaining the following points: (i) Why did they select that type of content? (ii) What are the advantages and disadvantages of using that content? (iii) Where was the information obtained? and (iv) What are the main takeaways? After each student's presentation, the group engaged in an open discussion and feedback session. Through this lecture, students were taught the importance of understanding the audience, defining communication goals, crafting, and tailoring an appropriate message, and understanding the channels selected to share the information.	Discussion-based learning; experiential learning
Mentorship and completion of the final project	After the completion of the workshops, students were assigned a topic and a group. Each group would work on the creation of an article for the *+Ciencia* magazine. The groups were composed of one undergraduate student and no more than two high school students who served as a mentor and mentee(s), respectively. The role of the undergraduate student was to assist the high school student in the development of the article by completing a literature search around the topic and selecting appropriate references, designing diagrams, and editing the article when needed. The role of the high school student was to develop the article's draft and communicate with the undergraduate mentor for guidance and feedback. Time spent in mentorship was determined by each mentor-mentee group with an estimate of 1 hour per week until the editorial meeting with the *+Ciencia* program directors. Roles and responsibilities of *+Ciencia* students are detailed in Supplementary Material Appendix 6. After the mentorship period, groups submitted a progress report to the team of editors. *+Ciencia* directors and editors provided feedback to each group for students to implement before the submission of the final article. Once the final article was approved, students and *+Ciencia* editors developed the magazine layout and visuals using Canva Pro and included the students' articles and "Extra sessions" (see Supplementary Material Appendix 5). The magazine was released and available for free download by accessing the official "*Ciencia en tus Manos*" website https://www.cienciaentusmanos.com/revista-mas-ciencia (Supplementary Material Appendix 5).	Project-based learning

[a]Description of evidence-based practices can be found in Supplementary Material Appendix 2.

champions science literacy within the broader community by cultivating future science ambassadors.

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The corresponding author confirms, on behalf of all authors, no involvement that might raise the question of bias in the work reported or in the conclusions, implications, or opinions stated.

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Nicole Colón Carrión, Validation, Writing – original draft, Writing – review and editing | Nathalie Fuentes, Conceptualization, Project administration, Supervision, Writing – review and editing | Valeria A. Gerena González, Project administration, Writing – review and editing | Nicole Hsiao-Sánchez, Conceptualization, Project administration, Supervision, Writing – review and editing | Luis Colón-Cruz, Supervision, Writing – review and editing | Kevin de Jesús Morales, Supervision, Writing – review and editing | Kenneth J. De Jesús Morales, Supervision, Writing – review and editing | Maria González Morales, Writing – review and editing | Cayetana Lazcano Etchebarne, Project administration, Writing – review and editing | Marcos J. Ramos Benítez, Conceptualization, Project administration, Supervision, Writing – review and editing

ETHICS APPROVAL

Guardian or parental permission for high school students to participate in the program was obtained prior to the start of the program. Guardians or parents were informed of the program goals, activities, and implications. Consent from the students and guardians (for minors under 18 years of age) to share assignments and final projects across multiple channels was asked prior to the start of the program.

ADDITIONAL FILES

The following material is available online.

Supplemental Material

Supplemental Material (jmbe00040-24-s0001.docx). Appendices (learning objectives, evidence-based teaching practices, faculty instructions, suggestion for determining student learning, magazine description, student roles and responsibilities).

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