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Review Article

Integrating Colombian Pacific Traditional Knowledge and Gender-Inclusive to Enhance STEM Education: The BECAP Initiative

Carolina Orozco Donneys [1]*, Eduardo Arbelaez [1], Karen Londoño Isaza [1], Isabella Hernández Zúñiga [1], Isabella Alegría [1], Anna I. Castellanos [1], Camila Arevalo [1], Sebastián Victoria [1], Nazly Camila Majin [1], Laura España [1], Nicol Tatiana Guevara [1], Ana Isabella Trujillo [1], Norma Murillo [1], Jose Dario Perea [1]

[1] *Universidad Icesi, Facultad de Ingeniería, Departamento de Ciencias Biológicas, Bioprocesos y Biotecnología*, Cali, COLOMBIA

*__Corresponding Author:__ corozco@icesi.edu.co

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ABSTRACT

Background: Fostering students' interest in careers in Science, Technology, Engineering, and Mathematics (STEM) is one of the main objectives of current education. However, stereotypical beliefs about STEM careers and their difficulty often exist among elementary and high school students, especially in Latin American countries where access to higher education can be complicated or seem impossible in some areas. This study aims to develop effective strategies to combat stigmas by integrating Colombian ancestral pacific traditional knowledge and biochemistry engineering and promoting STEM education in populations with limited access to higher education in Colombia. The goal is to help participants understand the broader application of science in their daily lives and communities.

Results: By integrating pacific traditional knowledge with bioprocess experiments through our culturally relevant lab box, we have fostered greater interest in STEM careers among these diverse participants. This methodology effectively bridges the gap between traditional wisdom and modern science, creating a more engaging and relatable STEM learning experience.

Conclusions: In conclusion, we have observed a noticeable shift in participants' academic interests, and many have expressed a new enthusiasm for pursuing STEM-related careers. This project provides a highly viable and reproducible model that can be scaled to other cities or countries in Latin America, facilitating students' initial engagement with STEM careers. Additionally, it offers scholarship opportunities for participants, enabling access to quality higher education and promoting gender inclusion in STEM fields.

Keywords: STEM, bioprocesses, pacific traditional-knowledge, empathy, ethno-education, biotechnology, BoxLab, outer space

INTRODUCTION

STEM (Science, Technology, Engineering, and Mathematics) fields education, as an interdisciplinary approach, not only promotes education and research but also contributes to achieving sustainable development goals and advancing electronics, material science, and computer science. It also provides a valuable opportunity to enhance technological development at the national level by promoting the training of skilled professionals capable of addressing global marketplace challenges. Increased community engagement and understanding of the importance of STEM fields are considered critical factors in driving social change (Kendall-Taylor, 2020). As STEM education demonstrates its ability to strengthen a country's economy, educational programs emphasizing STEM fields have become a priority globally (Quigley and Herro, 2016; Kelley and Knowles, 2016). A prominent example of how STEM education can transform society into a technology-based society is the case of South Korea. The national STEM program implemented educational strategies covering STEM education at all school levels (Nationales MINT (STEM) Forum, 2014; Kang, 2019). This initiative demonstrates how STEM education can significantly impact a country's social and economic development. In this sense, it is essential to recognize the fundamental role of STEM education as a driver of change in society and as a key tool to drive technological and economic progress nationally and internationally.

Implementing comprehensive STEM educational strategies nationally in low-to-middle-income countries is a complex endeavor that necessitates substantial investments. However, integrating these strategies into existing educational systems poses significant challenges. Resource limitations, curriculum resistance, and social inequality are pervasive issues in countries grappling with high poverty rates and inadequate infrastructure. As a result, the democratization and widespread adoption of STEM education requires careful consideration and targeted interventions to overcome these obstacles (Savage, 2018). For a model, in Colombia, there is evidence of a low representation of women in STEM fields, with only 2% of women choosing STEM-related careers. According to the Colombian Ministry of Science and Technology, this is because their participation is affected by a series of socio-cultural barriers, which generate gaps with the male role due to factors such as the influence of parents and their family environment, discrimination, and biases of society and stereotypes of the cultural and academic sector (Morales Inga and Morales Tristán, 2020). Therefore, it is proposed to promote the inclusion and progress of women in Colombia by encouraging young women to study professions such as engineering, especially those whose access to higher education may be limited.

On the other hand, it is important to mention that the notion of STEM has evolved by adopting divergent thinking in scientific and humanistic disciplines, which allows children and young people to devise creative and innovative solutions to the challenges and activities presented (Wahyuningsih et al., 2020). This idea has resulted in multiple worldwide projects promoting pedagogical and interactive activities. An example of this is the STEM Boxed Kits Experience, a project aimed at children in Puerto Rico that seeks to improve their design and critical thinking skills by exploring the fundamental concepts of electricity and renewable energy management through an experimental kit (New Fortress Energy, n.d.), it is also worth mentioning some of our previous works with exploration in STEM and near outer space testing (Bustamante et al., 2021; Perea et al., 2021; Orozco et al., 2022; Orozco et al., 2024). In this line, ventures such as KiwiCo (American), StemBox (American), and STEM Education Works (Australian), not to mention National Geographic (American), have emerged, interested in working with lab boxes by developing branched activities about geography, robotics, art, and STEM subjects themselves. Several studies have also been published that evaluate STEM problems focusing on improving skills in students from 3rd grade onwards, especially by analyzing scientific literature, as is the case of the University of Indonesia (Erry et al., 2020), a high school in Hong Kong (Chung and Li, 2021) and a private school in Istanbul (Asigigan and Samur, 2021) in which an increase in critical thinking, in the development of problem-solving skills and motivation for the areas of study was obtained.

The literature review highlights a critical gap in STEM education: the need for projects tailored to historically vulnerable communities, particularly those with limited access to higher education, and a focus on engaging the female population. While current STEM initiatives predominantly emphasize robotics, there is a pressing need to diversify these efforts, especially toward bioprocess-oriented laboratory boxes. This gap presents an opportunity to integrate culturally relevant knowledge systems, as exemplified in the Colombian Pacific region of Valle del Cauca. In this context, "ancestral Pacific traditional knowledge" is a powerful conceptual framework. Rodríguez et al. (2021) define it as a set of endogenous practices deeply embedded in the cultural fabric and ecological relationships of Afro-descendant and indigenous communities. This knowledge base, encompassing sustainable crop management, ethnomedicine, and community organization systems, offers a rich resource for developing culturally responsive STEM education (Gómez-Baggethun and Reyes-García, 2013). Moreover, these practices serve a dual purpose: not only are they an integral part of the daily life of communities, but they also act as part of cultural resistance and preservation of identity in the face of the homogenizing forces of modernization and globalization (Escobar, 2020). This approach aligns with recent research on multidisciplinary and intersectional

educational approaches for motivating adolescent girls in STEM. For instance, a study by de Almeida et al. (2022) in Brazil demonstrated the effectiveness of a project, that addressed gender inequality in STEM fields by promoting STEM learning and psychosocial development among adolescent girls from underprivileged backgrounds. Such initiatives highlight the importance of tailoring STEM education to specific cultural and socioeconomic contexts while addressing gender disparities.

Thus, the BECAP project (Biochemical Engineering Community Assistance Project) was conceived and designed to connect the ancestral pacific tradition of Colombia and the well-known Western STEM. This is mainly because the indigenous and Afro-descendant communities have methodologies for producing knowledge that has allowed the development of their communities and even the Colombian population. In addition to encouraging the young participants of the BECAP workshops, we plan to create opportunities at a national and international level so that they can realize their dream of studying a career with a STEM focus or have an approach that broadens their perspective on the possibilities offered by STEM industries. This process is mediated by the project's interactions with national and international foundations and organizations, facilitating dynamics with the beneficiaries and generating educational scholarship donations for them. In addition to encouraging the young participants of the BECAP workshops, we plan to create opportunities at a national and international level so that they can realize their dream of studying a career with a STEM focus or have an approach that broadens their perspective on the possibilities offered by STEM industries. This process is mediated by the project's interactions with national and international foundations and organizations, facilitating dynamics with the beneficiaries and generating educational scholarship donations for them. As a consequence of this interaction, there is a need to establish an adequate dialogue of knowledge, also known as intercultural dialogue, which promotes exchange between communities of different characteristics or origins through these communicative processes (OPS/OMS | Organización Panamericana de la Salud [PAHO/WHO| Pan American Health Organization], n.d.). Notably, for developing this approach in Colombia, such intercultural dialogue seeks to bring historically vulnerable communities closer to STEM-related knowledge and thus generate a clear and powerful connection between science, technology, and Colombian Pacific Traditional knowledge acquired by these social groups through practical experience and tradition. From BECAP, this process is given through a series of practices and workshops taught by Biochemical Engineering students from the Universidad Icesi, who will serve as tutors and design activities that elucidate this connection between knowledge. In addition, there is a laboratory box that aims to generate a sense of belonging that helps young women to understand that science and technology are within their reach and can permeate other areas of both everyday life and industry so that they see scientific careers as a feasible and promising path in their life project.

METHODOLOGY

At BECAP (Biochemical Engineering Community Assistance Project) we have developed a series of innovative and engaging face-to-face activities that merge diverse fields of knowledge. We employ a mixed-methods (In person contact, Lectures, Workshop and Science fair) approaches to assess the impact of the BECAP initiative: Our methodology combines quantitative and qualitative data collection techniques, including pre- and post-participation surveys via structured interviews, focus groups, and participant observations:

- In-person contact: Assignment of mentors who provide personalized guidance and support. Ensure that students feel supported and motivated, and facilitate the resolution of any problems that may arise.
- Lectures: We illustrate the objectives and goals to be achieved. In another lectures, we give an interactive motivation of the role of biochemical engineering and natural sciences.
- Workshop and science-fair: We organize an interactive workshop and science fair to providing hands-on training and learning opportunities for students.

Our integrated approach ranges from an authentic dialogue of Colombian Pacific ancestral knowledge to the exploration of biochemical processes, and a brief introduction to near outer space testing, all condensed as an orientation in a custom-designed lab box. Our lab box serves as a practical and versatile tool, allowing participants to conduct illustrative and fun experiments that connect traditional wisdom with modern science. With these activities, we aim to inspire curiosity, encourage hands-on learning, and bridge the gap between ancient knowledge and contemporary technologies, offering an enriching and multi-faceted educational experience.

Our goal is to create an inclusive environment in which young women from diverse backgrounds can perceive science and technology as accessible and relevant to their lives and experiences. Through these methods, we examine how empathy-based approaches and knowledge dialogues influence STEM knowledge sharing among these young women. We aim to create a more integral and culturally resonant learning experience. This initiative not only enhances scientific understanding, but also validates participants' cultural backgrounds, potentially increasing their engagement and sense of belonging in STEM fields.

The students from the Colombian Pacific coast performed practical experiments that unite their ancient knowledge with scientific principles from biochemistry. Our analysis focuses on three key aspects of the BECAP initiative:

- The impact of integrating Colombian Pacific traditional knowledge with bioprocess experiments on participants' sense of belonging in science – Lab Box.
- The effect of empathy-based approaches and knowledge dialogues on STEM exchange among young women from diverse backgrounds.
- Promoting academic and professional opportunities: facilitating access to scholarships, internships, and establishing links with industries and universities for participants.

Across these aspects, we analyze survey data using descriptive statistics, while qualitative data from interviews, focus groups and observations are subjected to thematic analysis. To assess the long-term impact, we conduct follow-up surveys and interviews. In addition, we track indicators related to academic and professional opportunities facilitated by the program. This comprehensive approach allows us to examine the immediate and lasting effects of integrating pacific traditional knowledge, employing empathy-based approaches, and promoting STEM opportunities among our diverse participants. These results are in progress and will be presented in a subsequent article. Finally, we aim to foster a sense of belonging and empowerment, helping young women understand that science and technology are within their reach, regardless of their cultural background.

Our project has been developed under the guidance of Biochemical Engineering students enrolled in the Biochemical Engineering Project Management course at Icesi University. We have created committees with their respective representatives to organize and distribute the tasks effectively. The following are the committees and their registered responsibilities:

- *Academic Committee:* Engineering students in this committee are in charge of selecting and designing the practices corresponding to the day of the event. They recruit people with a high affinity for teaching and the aptitude to transmit their ideas.
- *Marketing Committee:* They manage the management of networks and document the day of the event. They also take care of the box's design and ensure that its dimensions are sufficient for each item to be used by the participants on the day of the event.
- *Logistics Committee:* Students responsible for designing and ensuring compliance with the schedule on the day of the event and regulating the other committees' deliveries during the semester to ensure an efficient work scheme among students. They are also responsible for obtaining supplies and reserving the necessary spaces to develop the activities on the event day.
- *Financial Committee:* corresponds to students with financial qualities or who seek to emphasize their growth in this area. They must creatively propose efficient and innovative financing strategies to finance the event.
- *Relationship Committee:* responsible for securing sponsors or recruiting interested parties to support the BECAP project. Together with the finance committee, they are responsible for proposing fundraising strategies by consulting with potential companies interested in supporting the event.

It should be noted that each committee must maintain constant communication with each other in order to develop the event adequately. The descriptions of the practices and the expected impact on the participants are indexed, followed by vital parameters considered for the development of the project, such as empathy and the exchange of knowledge based on the dialogue of knowledge and the reproducibility and impact of the project on the media, ending with its actual viability. Within our comprehensive methodology, we are pleased to present the four meticulously crafted phases of the innovative BECAP project, as depicted in **Figure 1**. Through our unwavering commitment to excellence, we have meticulously designed a transformative approach that promises to revolutionize the way we train and inspire young minds. Each phase represents a strategic progression toward fostering a deep sense of belonging and unlocking potential. We have planned and structured the project to ensure its execution and generate maximum impact. The four phases outlined in **Figure 1**.

In this manuscript we will focus on phases I and II. Since the following phases (III and IV) are more of a consequence of the first two phases (I and II), it is a life project that would take a number of years to complete.

Phase I: Empowering Girls: Unleashing Motivation for STEM Careers

In the exciting world of STEM careers, it is essential to encourage the participation and motivation of girls, providing them with tools and opportunities to explore their potential. In this sense, an innovative proposal emerges: combining pacific traditional knowledge with the power of biochemical engineering. Integrating pacific traditional knowledge, enriched by the wisdom accumulated over generations, with biochemistry's scientific and technological advances bridges the past and the future. This synergy promotes a sense of belonging and connection to cultural heritage and opens doors to exciting and creative possibilities in the STEM field. Through this powerful combination, it seeks to inspire girls, empower them and awaken their innate curiosity, encouraging them to explore

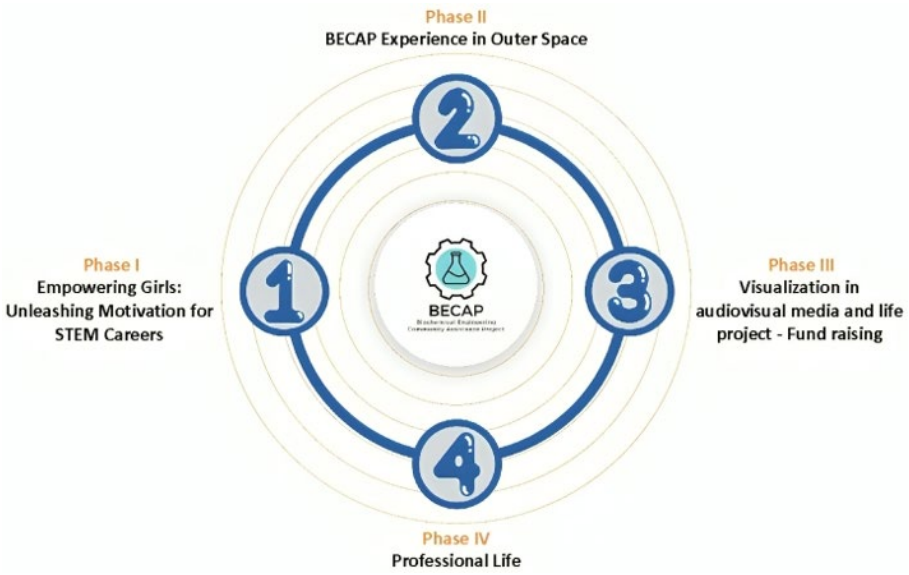

Figure 1. Diagram of the social scientific initiative BECAP

Figure 2. Schematic representation of the Lab Box and the whole experiments that have been carried out by the BECAP initiative

science and technology careers with a unique and valuable perspective. The result is a new generation of women leaders in STEM with a solid scientific foundation, a deep respect for ancient wisdom, and the ability to apply it innovatively in the modern world. The following is a brief description of the experiments (also illustrated in **Figure 2**):

A. *Chocolate making:* Cacao is an ancient fruit native to Central and South America. Exploring the history and traditions of chocolate production from ancient times provides girls and adolescents with an understanding of their cultural heritage. The chocolate workshop provides scientific knowledge and diverse processes related to the biochemical engineering involved in the transformation of cocoa into chocolate, such as the fermentation of cocoa pulp, the chemical reaction during roasting, and the manipulation of the components to obtain a desirable texture and flavor. In this practice, chocolate production is done on a small scale: Initially, the cocoa pulps are fermented, then a drying process of the cocoa is carried out to later crush and roast them at temperatures between 120 to 150°C, with what is obtained is then ground. Milk and sugar are mixed in a container, and finally the cocoa is added, kneaded, and cooled.

B. *Coffee Tasting Workshop:* Colombian coffee is recognized globally for its high quality and distinctive flavor; it is a product that is part of the identity and traditional culture of our country, having a significant social and economic impact. At the level of coffee production, there are scientific principles behind the cultivation, processing, and roasting of coffee. In addition, from the bioprocesses, such as fermentation, the extraction

of bioactive compounds, and the Maillard reaction during roasting, different flavor profiles can be changed or obtained, and high quality can be sought. Similarly, sensory analysis involves the development of skills by identifying aromas, flavors, and acidity, promoting the importance of perception and the application of the different STEM fields.

C. *Probiotic yogurts:* Packed with live beneficial bacteria cultures, these delicious dairy treats offer a tantalizing blend of flavor and health benefits, making them a favorite choice for those looking for a healthy addition to their diet. We teach the process of fermenting milk with specific probiotic bacterial cultures. The objective is to understand the principles of yogurt production and sterilization concepts, such as pasteurization, and the importance of ensuring quality in yogurt production and storage.
D. *DNA extraction:* Deoxyribonucleic acid is a biomolecule in all living organisms and is crucial for the functioning of life, storing genetic information. Through strawberries and tropical fruits, this component is extracted. For this, it is necessary to crush the strawberries carefully and make a mixture of half a cup of water, two tablespoons of liquid detergent, and two tablespoons of salt. Three tablespoons of crushed strawberries are added to the mixture without generating bubbles. Afterward, the solids of the mixture are filtered with a coffee filter, and alcohol is added to the liquid obtained. Once the steps have been carried out correctly, the corresponding DNA molecules of the strawberry should be visualized.
E. *Non-Newtonian fluids:* A classic example is slime, which can change viscosity and behavior under different conditions. For this, cornstarch (a typical corn-based product) is used as raw material, thus making it fun and educational, encouraging the learning of the properties of these fluids and their potential in the industry. In biochemical engineering, we analyze the interactions and biochemical processes at the molecular level to the scaling up to the industrial level, such as the control of non-Newtonian fluids, the development of new applications, and improvements in production.
F. *Microbial footprint:* Microorganisms are imperceptible to the naked eye, so microscopes are used to visualize them. However, they have a significant impact on life. In practice, the microorganisms that grow are observed by placing the fingertips of each participant in their respective Petri dish. Then, the morphology and characteristics of some microorganisms are observed under the microscope. The girls and adolescents are instructed on how to use the equipment and focus their samples properly, favoring the development of scientific skills.
G. *Agar art:* It consists of using an agar canvas in the Petri dish and simulating the painting with microorganisms to create an artistic piece through their cultivation. The agar used is YPD, and the microorganisms used are Saccharomyces and Rhodotorula of white and yellowish color, respectively. The idea is to detonate creativity, in this case, to connect with cultural and territorial roots to guide that creativity, requesting that the culture of its author must inspire the work. This activity shows how the arts can be integrated with STEM as STEAM (A to the Art contribution) to create something innovative with imagination. It is an excellent way to engage students in STEAM education in a didactic and engaging way by combining the skills of STEAM disciplines with the creativity and innovation of the arts. It also enhances learning and understanding of the STEAM disciplines by making them more accessible and appealing to girls.
H. *Green hydrogen:* Renewable energy is a global matter, as it can contribute to climate change mitigation, improve air quality, promote energy security, and pursue sustainability. One of its alternatives is green hydrogen which is produced from the separation by hydrolysis of hydrogen and oxygen. The energy product can be used as a source of clean energy and is emission-free; in this case, it is used for moving cars and boats on a small scale, also fans. Here the girls learn the basic concepts and the importance of seeking alternative energy sources. In this workshop, they perform hydrolysis; an experiment is done to move a car based on this renewable energy with the help of a simple and small solar module of monocrystalline silicon.
I. *Extraction of natural pigments:* Pigments reflect the color the human eye can perceive. However, most modern inks contain compounds that can be toxic and harmful to the environment. In addition, some dyes used in inks can be persistent and bioaccumulative, which prevents them from being easily degraded and can lead to their accumulation in the food chain. On the other hand, ancient techniques for extracting certain dyes are widespread in Latin American culture and used in coloring textiles to implement art. The organic inks used by indigenous communities to dye food, clothing, and other everyday objects fulfill this purpose splendidly. Therefore, this practice seeks the extraction of pigments from plants using organic solvents, a process that begins with the maceration of the sample. Then the solvent is added to obtain the liquid pigment.
J. *Production of edible fungi:* The aim is to establish a link with ancestry through the extensive history of the use of the organism by the communities. Also, through questions such as: Where do the fungi come from? How does it grow? How is it cultivated? In this way, learning about the growth of fungi from industrial wastes such as rice chaff, sugarcane bagasse, and coffee husks is encouraged to exemplify the sustainable use of

these industrial wastes. The case of edible mushroom Orellana (Pleurotus ostreatus), a saprophytic fungus that grows on wood, is used for this purpose.

K. *Production of soap from recycled oil:* Using used cooking oil to manufacture a value-added product such as soap. The Production of soap from this waste can help mitigate the impact on the environment since used oil is a waste that is difficult to recycle and, if not disposed of properly, contaminates wastewater. Soap is generated from a saponification reaction of the fatty acids of oils in the presence of a base such as sodium hydroxide (NaOH), taking on a more rigid or viscous texture and acquiring the ability to trap other different fats or particles suspended on surfaces.

L. *Scape room:* It is a challenge where girls and adolescents try to solve through clues, analysis of information and patterns, and applying logical, mathematical, and scientific thinking. The participants are evaluated through direct observation by a tutor in the Scape Room, where he/she will take into account the capabilities and the way of developing the activity. In addition, time will be an evaluation variable. Finally, self-evaluations, questionnaires, and feedback provide consistent data on the infants' performance. Keep in mind that a connection to STEM is created by fostering problem-solving skills, interaction with technology, application of scientific concepts, collaboration, and teamwork.

M. *Emerging Photovoltaics:* As another complement to renewable energies, another of its alternatives is photovoltaics. In our case, we wanted to explore the emerging non-conventional photovoltaics. Let us call these organic and synthesized inks. For this training, we had the collaboration of the group of Professor Christoph Brabec of the Friedrich Alexander Universitat, where Dr. Perea did his Ph.D. This energy product can be used as a clean energy source and produces very low emissions compared to its silicon analog. Here the girls learn the basic concepts and the importance of looking for alternative energy sources and why countries like Colombia would play a significant role in synthesizing these materials and their creation. In this workshop, synthesis inks are extracted and deposited on a super thin glass with an existing layer of the materials so that there is a charge transfer. These cells are tested for fading in near outer space through the 'Cubes in Space' project with launches at NASA.

N. *Building a rocket:* Rockets work thanks to the reaction principle since the gases from the engines push the rocket in the opposite direction. A water rocket is made of at least one PET plastic bottle, to which specific devices must be added to improve its aerodynamic characteristics so that it can fly at a certain pressure, with a certain speed, and be more stable. This workshop seeks the motivation for true democratization of outer space as focused in phase II. One of the ideas is to build in groups and give the girls certain parts of the rocket already built, where they will have to add accessories such as the wings and the head of the rocket. They will have to design these accessories so that the rocket can fly efficiently, and they will be able to give it a name and a distinctive logo that represents the connection with their culture and opens empathy with the rest of the group. While this is not an absolute rocket that can reach space, it does allow students to experiment with the fundamentals of rocketry and become familiar with the process of building spacecraft. In addition, by designing their props and naming them with a name and logo, girls can feel more involved and connected to exploring outer space and its science.

O. *Playing with the voice:* For the voice to work, our vocal cords are responsible for vibrating and emitting waves in a medium that can travel, in this case, the air that passes through the larynx. This is how they generate the sounds that form words. Nevertheless, when the waves travel in a less dense gas such as helium, the sounds are more acute, while when they travel in sulfur hexafluoride (denser gas), the sounds are serious. This practice proposes to fill a balloon with helium and another with sulfur hexafluoride, inhale a small amount of the helium and talk to observe the effect. The same is done for sulfur hexafluoride. It is a very amusing practice and allows us to transmit thermodynamic principles of daily life.

Phase II: BECAP Experience in Outer Space

The democratization of STEM and access to outer space has become an exciting and urgent goal in our modern era. Historically, space has been reserved for a privileged few, limiting access and participation to those with resources and institutional backing. However, we have witnessed a radical shift in this paradigm in recent years. Advanced technology, increasing international collaboration, and decreasing costs have opened space doors to various actors, from start-ups to educational communities to enthusiastic citizens. This democratization not only means more equitable access to space exploration but also provides unprecedented opportunities for developing innovative solutions and generating collective knowledge. The convergence of STEM and outer space promises to transform our societies, inspiring young minds, promoting global collaboration, and opening up a vast horizon of scientific discovery and breakthroughs. As we move toward an era in which space becomes a common ground for humanity, the democratization of STEM and access to outer space stand as fundamental pillars for an inclusive, inspiring, and possibility-filled future.

Figure 3. Photograph of our BECAP initiative bacteria at the NASA Wallops in Virginia

Although a prominent academic and industrial spectrum of interest in STEM careers exists, access to higher education in Colombia is still a challenge. Although higher education is one of the main drivers of a country's economic and social development, more opportunities in this area are needed for the current population. For this reason, Colombia encourages women to study STEM careers and reduce gender inequality in education. To this end, several programs have been created that offer scholarships to encourage women's extraordinary potential in science. Today there are several opportunities to study, such as the Women in STEM Scholarships, which is a program led by the Ministry of National Education and the Colombian Institute for the Promotion of Higher Education, which seeks to provide scholarships for women in undergraduate programs in STEM in public and private universities. The scholarship covers up to 100% of tuition and is awarded per semester. BECAP plans to connect with the industry to obtain undergraduate scholarships for young women to motivate them to study STEM-focused careers and achieve their dreams. An example of what has been achieved is to generate two scholarships for these girls with the Mayagüez Sugarcane company, which financed the girls' college tuition, food, and transportation.

In our initiative, BECAP has allied with 'Cubes in Space' and partnered with NASA to encourage student participation in space exploration and innovation. Democratization of outer space refers to making space more accessible and available to a broader range of people and nations rather than being restricted to a select few countries or organizations. Only a handful of countries can launch rockets and send missions into space, and space exploration has been primarily dominated by government agencies and private companies with significant resources. However, as technology advances and the cost of space exploration decreases, there is the potential for more countries and individuals to become involved in space activities. In this regard, BECAP aims to teach its students about the possibilities of bioprocessing and STEM. The collaboration with 'Cubes in Space' associated with NASA has enabled students to participate in space exploration and contribute to technological innovation to make space research more affordable and accessible (How new technology democratizes access to space Spectra - https://www.cubesinspace.com/). **Figure 3** shows a picture of one of our cubes employed for near outer space testing. This democratization of outer space has the potential to promote innovation, scientific discovery, and economic growth while fostering international cooperation and collaboration. Under this category, we will test, as a continuation, a group of edible fungi, but this time in an astronaut analog project under the auspices of the European Space Agency in Poland in July 2023. The Analog Astronauts group is called Tachi Ûmada.

Phase III: Visualization in Audiovisual Media and Life Project – Fundraising

A. Project Reproducibility

The BECAP project has proven to be highly replicable due to the increasing desire of participants to access STEM careers. This is because it is based on structured methodologies focused on motivating girls to choose a STEM-focused career by implementing activities that promote STEM. Part of the project is given by the laboratory

practices that involve the approach to different branches of STEM. These practices are easily reproducible due to the use of affordable materials. The interest in accessing STEM knowledge has reached different parts of Colombia, such as Risaralda, Barranquilla, Popayán, and others (Territorios STEM+ | Colombia Aprende, n. d.). The project could take advantage of these focal points of interest to be carried out in these cities or regions. In addition, the fact that it encourages empowerment and gender equality means that the model can be adapted and applied in different geographical contexts. Therefore, this project can be extrapolated to different parts of the world due to its structured and easy-to-scale form.

B. Impact on the Latino American Community

STEM programs are critical to the growth of Latin America because they provide students with the skills and information they need to succeed in a globalized society. In addition, incorporating pacific traditional knowledge into STEM education helps foster cultural diversity, social inclusion, and long-term growth while honoring the vital contributions of indigenous communities to science and technology. In addition, the link between STEM and pacific traditional knowledge is increasingly recognized (Gonzalez, 2017). Based on centuries of observation and experimentation, many indigenous societies in Latin America have a deep understanding of science and technology. Students can learn to value ancient information and its potential for innovation by incorporating this knowledge into STEM instruction. This approach can also foster cultural diversity, social inclusion, and sustainable development by recognizing the vital contributions of indigenous groups to the scientific world. That is why BECAP aims to enable tutor-to-tutor knowledge sharing. Where the learner knows their community and ancestors and can relate it to the scientific background and concepts hidden in their inherited wisdom. In addition, by combining old behaviors and beliefs with modern technologies and systems, we can foster innovation. Working closely with indigenous tribes and learning from their traditional knowledge, for example, can mean the sustainable exploitation of natural resources or the development of new therapeutic remedies (UNESCO Office Santiago and Regional Bureau for Education in Latin America and the Caribbean, 2017). Latin American civilizations can produce new solutions that include traditional and modern forms by recognizing and valuing our ancestral knowledge. This can also help preserve and revitalize indigenous cultures, which have faced significant obstacles in preserving their traditional knowledge in the face of globalization and technology. Overall, the innovation of Colombian Pacific Traditional knowledge has the potential to generate more sustainable and culturally rich civilizations throughout Latin America.

Phase VI: Professional Life

The professional life of a project dedicated to STEM education for girls from ethnic communities that are just beginning is an exciting journey full of challenges and opportunities. From its conception, an unwavering passion for advancing equal opportunity and empowering these young minds is displayed. The BECAP team is tirelessly dedicated to developing and adapting educational programs that foster curiosity, critical thinking, and creativity in science, technology, engineering, and mathematics. Meaningful connections are woven with ethnic communities, working with leaders and parents to ensure active participation and a deep understanding of these girls' specific needs and challenges. Despite the obstacles and setbacks that may arise, the project is strengthened by every small achievement and every spark of inspiration in the eyes of these young women, who find new confidence and passion for exploring the fascinating world of STEM. As the professional life of this project unfolds, it is hoped that its impact will endure for generations to come, creating a solid path toward gender equality and diversity in science and technology. The ultimate idea is that some participants will contribute to the project's continuity in a few years. Also, through this initiative, we can apply for government and corporate grants.

RESULTS AND DISCUSSION

In this section, we will show the results of the BECAP initiative and how it has impacted motivation, learning, the pursuit of opportunities, and funding for girls from ethnic communities. Professor Carolina Orozco Donneys and scientific leader Dr. Jose Dario Perea lead the BECAP project. Additionally, its approach transcends academic boundaries, as it is taught under an independent model, thus marking a milestone in promoting equity and inclusion.

Number of Girls Directly Impacted

The BECAP project has shown remarkable progress since its inception in 2021, successfully engaging 400+ girls and young women from indigenous and Afro-descendant communities in the Colombian Pacific region. Our preliminary data reveals a significant impact, with 70% of participants expressing a determination to pursue careers in science or engineering after engaging with the program. Building on these promising results, we are currently compiling data from more than 10 BECAP initiatives, which will form the basis of a forthcoming manuscript. This

comprehensive analysis will present detailed statistical insights into the project's effectiveness in inspiring STEM engagement among diverse young women. The upcoming paper aims to provide a more extensive evaluation of BECAP's impact, offering robust evidence of its success in fostering interest in STEM fields among participants from varied backgrounds, and potentially serving as a model for similar initiatives elsewhere.

The current article serves as an introduction to the BECAP methodology and preliminary findings, while the future publication will offer a more comprehensive and data-driven analysis of the project's outcomes and broader implications. It is important to note that, in its beginnings, BECAP had a valuable collaboration with a regional project known as EtnoCiencias, which focused on teaching Colombian Pacific Traditional knowledge and providing an introduction to robotics to 360 girls from ethnic communities. These EtnoCiencias girls were integrated into the BECAP project until the EtnoCiencias program reached completion. We intend for this impact to expand geometrically and be continuously encouraged, following the guidelines shown in **Figure 1**, which guide our steps toward a promising future full of achievements.

Knowledge Sharing, STEM + Knowledge Dialogue

The dialogue of knowledge is a practice that seeks the integration and exchange of knowledge between different communities and cultures. In this sense, pacific traditional knowledge plays a fundamental role since it represents the accumulation and transmission of knowledge between generations, involving the incorporation of pacific traditional knowledge in STEM education and contributing significantly to the development of innovative and sustainable solutions to current and future problems; because it allows the construction of scientific and technological knowledge from traditional practices or empirical learning of a community. In addition, it provides learning from the resolution of real problems; these communities are characterized by great respect for the environment. This is why promoting the dialogue of knowledge, recognizing and valuing the fundamental role of pacific traditional knowledge in this communicative exercise facilitates the achievement of a more inclusive education (ethno-education), which gives girls and young people from historically vulnerable communities the opportunity to contribute to the development of sustainable solutions to problems in their environment.

To Knowledge Dialogue to the Empowerment of Girls

For the project, the management of learning during the workshops must have as a pillar that the young girls appropriate the concepts presented from pedagogical tools such as ethno-education, this being a notion of intercultural dialogue that is based on experiences, projects, and knowledge in which various ethnic groups that have historically been involved in social problems converge (Castillo Guzmán, 2016). Attending to the influence that the young women's environment has on their personal and professional projection during the internships and workshops, it is intended to maintain a constant link between Colombian roots and scientific advances that potentiate that pacific traditional knowledge wealth. This can be evidenced in the proposed practices such as chocolate production, coffee tasting, pigment extraction, and non-Newtonian fluids, to name a few. Each stage is explained from the harvesting of the raw material to the distribution of the product of interest, assuming an exercise of exchange of cultural and disciplinary knowledge mediated by an environment of closeness, in which the members of the project have the opportunity to learn more about their roots and the young women can connect the tradition with the scientific development of the country. All of the above aim to encourage BECAP participants to get involved in careers or industries with a STEM approach from the outstanding contributions of tradition and ancestry.

Empathy Between BECAP Monitors and the Students

Beyond the academic interaction between Biochemical Engineering Project Management monitors and the girls participating in BECAP, empathy is applied as a strategy of rapprochement. They are "the ability to understand the needs, feelings, and problems of others, putting oneself in their place and thus being able to respond correctly to their emotional reactions" (Balart Gritti, 2013). It is intended to establish a greater connection, higher learning of the girls, and promote the dialogue of knowledge mentioned above.

Thus, by having tutors in the workshops with ages between 18-23 years, the connection with the girls and adolescents participating in BECAP is maximized because being in a stage of life close to the young women, the trainers will be more understanding people, generating a greater closeness and a learning environment where the girls can ask questions without fear of being judged and without calls for attention. Consequently, when project members demonstrate greater flexibility and care for young people's well-being and needs, a greater understanding of concepts, participation, and learning can be evidenced.

Empathy is fundamental for everything described above to work and for there to be a positive impact on the motivation of the girls and adolescents participating in BECAP, given that they are in academic and personal development; this is demonstrated when they show interest and understanding of scientific topics or concerning

STEM, in addition to choosing related careers at the end of the days and presenting a more significant commitment to their educational process.

Future Prospects and Evaluations

According to the results of the previous BECAP initiative, there was a notable increase in interest in STEM-related careers chosen by the participating girls. The project has worked with girls supported by governmental entities or companies. These girls expressed an interest in pursuing their studies in higher education institutions in Colombia. However, they needed more means or sufficient resources to achieve this goal. BECAP proposed showing the girls a different reference to conventional STEM careers to verify if it could increase their interest in studying careers related to science, technology, engineering, or mathematics. Through a wide variety of didactic content, we sought to determine if this empathetic approach strategy could be significant for girls in their potential career selection, thus favoring the participation of women in STEM careers in Colombia.

Two questionnaires are actually conducted to determine the possible impact of the events on the girls' perception of STEM-related careers. The first questionnaire is administered upon the participants' arrival at the event and served as a diagnostic test where, in addition to recording the participants' initial interest in areas of higher education, it inquired about their perception of careers related to engineering or science. On the other hand, the second questionnaire would show information regarding the change in the participants' perception and reported their interests in higher education careers once the event was completed. These results are in progress and will be presented in a subsequent article.

The empathetic approach offered, in addition to the standardization of the project through the implementation of the our lab box (also called BECAP BOX), has allowed an adequate approach between the biochemical engineering students and the participants of the project, where the aim is to encourage leadership on both sides and timely exchange of knowledge through dialogues. In addition, offering a scientific approach to ancestral bioprocesses has not only allowed the participants to feel more knowledgeable about the topics that are taught throughout the events, thus encouraging their participation but also generated the emergence of a large number of interesting questions to the tutors (engineering students) from the participants who finally understand the science behind bioprocesses that have been passed down for generations.

We conducted also educational talks in different schools on the Colombian Pacific coast. These sessions focused on establishing connections between biochemical processes and space exploration, addressing the relationship between food, water treatment, energy generation, and health. During these activities, BECAP project leaders wore official astronaut analog suits to capture participants' attention and highlight the links between earth science and space advances. This innovative approach sought to inspire young female students and encourage their interest in STEM careers by highlighting the relevance of biochemistry. And how it connects this to advances on Earth.

The impact that BECAP has achieved in the national and international media shows the degree of approval that has permeated the project during its iterations, causing more and more companies to be interested in supporting the events. This is of great interest when considering the reproducibility of the project, either in other cities or other countries. Each iteration of BECAP has favored the standardization of the process to be carried out, in addition to having an increasing number of valuable contacts that facilitate the optimal development of the project—given the above, justifying the high reproducibility of BECAP and proposing to scale it a posteriori.

CONCLUSIONS

In conclusion, the BECAP initiative has proven to be a hope in promoting quality STEM education, catalyzing a genuine democratization of science, engineering, and, surprisingly, even outer space. Through a rigorous and respectful approach to knowledge dialogues, we have created an environment conducive to the development and empowerment of girls.

At BECAP, we recognize and value the importance of our Colombian Pacific Traditional knowledge, understanding that this traditional knowledge intertwines with advances in STEM to address the challenges and issues facing our world. We are proud to promote the idea that our cultural roots and traditions can enrich and strengthen scientific and technological knowledge, providing innovative solutions that positively impact society.

In addition, thanks to the BECAP initiative, we have generated scholarships and educational opportunities for those talented girls and young women who might otherwise have been denied access to quality STEM education. These scholarships allow them to pursue their dreams and realize their potential and generate an invaluable bond between students, teachers, and beneficiaries, which helps mitigate the lack of empathy and connection we experienced during the COVID-19 pandemic.

BECAP is much more than an educational project. It is a transformative force paving the way for an inclusive and empowering future in the STEM field. We are committed to continuing to promote the dialogue of knowledge, empowering girls, and making a lasting impact on our communities and the world at large. Together, we are building a more equitable society based on diversity and scientific excellence, where everyone has the opportunity to shine and make a difference.

REFERENCES

Asigigan, S. I. and Samur, Y. (2021). The effect of gamified STEM practices on students' intrinsic motivation, critical thinking disposition levels, and perception of problem-solving skills. *International Journal of Education in Mathematics, Science, and Technology*, 9(2), 332–352. https://doi.org/10.46328/ijemst.1157

Balart Gritti, M. J. (2013). La Empatía: La Clave Para Conectar Con Los Demás [Empathy: The Key to Connecting with Others], *Observatorio de Recursos Humanos*. Available at: https://clasica.gref.org/nuevo/articulos/art_250513.pdf.

Bustamante, D. G., Perez, A. M., Calderon Cerquera, K., Orozco-Donneys, C., Orozco, A. M., Giron-Sedas, J. A. and Perea, J. D. (2021). Tech Lunar Toilet: A STEM project with high school students. *European Journal of STEM Education*, 6(1), 08. https://doi.org/10.20897/ejsteme/11322

Castillo Guzmán, E. (2016). Etnoeducación afropacífica y pedagogías de la dignificación [Afro-Pacific ethnoeducation and pedagogies of dignification]. *Revista Colombiana de Educación*, (71), 343–360. https://doi.org/10.17227/01203916.71rce343.360

Chung, S. K. and Li, D. (2021). Issues-based STEAM education: A case study in a Hong Kong secondary school. *International Journal of Education & the Arts*, 22(3). https://doi.org/10.26209/ijea22n3

de Almeida, T. M. C., Brasil, K. T., Viana, D. M., Lisniowski, S. A., Shzu, M. A. M., Ganem, V., Ávila, S. M. and De Paula, A. S. (2022). A multidisciplinary and intersectional educational approach for motivating adolescent girls in STEM, in M. T. Segal and V. Demos (eds), Gender Visibility and Erasure (pp. 145–161). Leeds (UK): Emerald Publishing Limited. https://doi.org/10.1108/S1529-212620220000033016

Erry, A., Rahmawati, Y. and Marciah, A. (2020). STEAM-project-based learning integration to improve elementary school students' scientific literacy on alternative energy learning. *Universal Journal of Educational Research*, 8(5), 1863–1873. https://doi.org/10.13189/ujer.2020.080523

Escobar, A. (2020). *Pluriversal Politics: The Real and the Possible*. Duke University Press. https://doi.org/10.1515/9781478012108

Gómez-Baggethun, E. and Reyes-García, V. (2013). Reinterpreting change in traditional ecological knowledge. *Human Ecology*, 41, 643–647. https://doi.org/10.1007/s10745-013-9577-9

Gonzalez, G. (2017). Looking at Latin America's challenges in innovation and STEM education, *ACS Publications Chemistry Blog*. Available at: https://axial.acs.org/cross-disciplinary-concepts/latin-america-challenge

Kang, N.-H. (2019). A review of the effect of integrated STEM or STEAM (science, technology, engineering, arts, and mathematics) education in South Korea. *Asia-Pacific Science Education*, 5, 6. https://doi.org/10.1186/s41029-019-0034-y

Kelley, T. R. and Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education*, 3, Article 11. https://doi.org/10.1186/s40594-016-0046-z

Kendall-Taylor, N. (2020). Science of Science Communications: Want to Drive Social Change? Make A Stronger Case for Science, *Georgetown University Center for Social Impact Communication at the School of Continuing Studies*. Available at: https://csic.georgetown.edu/magazine/science-science-communications-want-drive-social-change-make-stronger-case-science/.

Morales Inga, S. and Morales Tristán, O. (2020). ¿Por qué hay pocas mujeres científicas? Una revisión de literatura sobre la brecha de género en carreras STEM [Why are there so few female scientists? A literature review on the gender gap in STEM careers]. *aDResearch ESIC*, 22(22), 118–133. https://doi.org/10.7263/adresic-022-06

Nationales MINT (STEM) Forum. (2014). *MINT-Bildung im Kontext Ganzheitlicher Bildung* [STEM-Education in the Context of Holistic Education]. Herbert Utz Verlag.

New Fortress Energy. (n.d.). Generando un Pensamiento Innovador "Dentro de la Caja" Sobre STEM [Generating Innovative Thinking "Inside the Box" About STEM], *New Fortress Energy*. Available at: https://www.newfortressenergy.com/mx/stories/generando-un-pensamiento-innovador-dentro-de-la-caja-sobre-stem. (Accessed: 1 May 2023).

OPS/OMS | Organización Panamericana de la Salud [PAHO/WHO| Pan American Health Organization]. (n.d.). Metodología de los Diálogos de Saberes [Methodology of Knowledge Dialogues], *PAHO*. Available at: https://www.paho.org/es/documentos/metodologia-dialogos-saberes. (Accessed: 11 March 2023).

Orozco Donneys, C. and Kołodziejczyk, A., (2024). A space camp's cultural exchange. *Science*, 384(6696), 631. https://doi.org/10.1126/science.adj8438

Orozco-Donneys, C. and Perea, J. D. (2022). Empowering Afro-Indigenous girls. *Science*, 375(6582), 730. https://doi.org/10.1126/science.abo4155

Perea, J. D., Gasca, D. C., Echeverry-Prieto, G., Quiroga-Fonseca, V., Orozco-Donneys, C., Díaz- Montealegre, L. C., Ortiz, A., Molina, G., Cruz, D., Persad, A., Redd-Kantareddy, S. N., Wachsmuth, J., Heumueller, T., Brabec, C., Rodriguez-Toro, V. A. and Salguero, C. (2021). Last Generation Solar Cells in Outer Space: A STEM Outreach Project with Middle and High School Students in Colombia. *European Journal of STEM Education*, 6(1), 12. https://doi.org/10.20897/ejsteme/11353

Quigley, C. F. and Herro, D. (2016). "Finding the joy in the unknown": Implementation of STEAM teaching practices in middle school science and math classrooms. *Journal of Science Education and Technology*, 25, 410–426. https://doi.org/10.1007/s10956-016-9602-z

Rodríguez, A., Martínez, C. and López, J. (2021). Traditional knowledge and its integration in STEM education: A case study in the Colombian Pacific. *Revista Latinoamericana de Etnomatemática*, 14(2), 45–67.

Savage, N. (2018). Expanding the reach of science. *Nature*, 562 (S11). https://doi.org/10.1038/d41586-018-06833-z

UNESCO Office Santiago and Regional Bureau for Education in Latin America and the Caribbean. (2017). Indigenous knowledge and practices in education in Latin America: Exploratory analysis of how indigenous cultural worldviews and concepts influence regional educational policy.

Wahyuningsih, S., Nurjanah, N., Endang, U., Hafidah, R., Pudyaningtyas, A. and Syamsuddin, M. (2020). STEAM learning in early childhood education: A literature review. *International Journal of Pedagogy and Teacher Education*, 4(1), 33–44. https://doi.org/10.20961/ijpte.v4i1.39855

