

Women in Science and Technology Bio-Bio Meeting: Empowering Young Women in Chile

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Abstract

College-age women often lack interest in STEM disciplines because of prejudices and stereotypes that have discouraged them. Chile is one of the countries that has made significant progress in reducing the gender gap. However, progress in training women in STEM disciplines has been low compared to other Latin American countries.

The Engineering Faculty of the Universidad Andres Bello has carried out the "Biobio Women in Science and Technology Meeting" for two consecutive years. The first was an in-person event, and the second in online mode. The sessions aimed to encourage young women in the last two years of high school (ages 16 to 17) to have greater interest and access to university STEM disciplines.

This study reflects on young Chilean women's needs and motivations to pursue a career in STEM areas in the event context. It focuses specifically on the various roles, such as external researchers (invited speakers), academicians (workshop instructors), and collaborating students (workshop assistants) who participate in the event. It aims to understand more profoundly the organization required to establish strategies that would allow continuity to this powerful initiative.

Data was collected from interviews with the participants (workshop instructors, workshop assistants, and invited speakers). The results showed that all those involved valued the initiative and would participate in it again. This type of event is necessary to empower girls and adolescents to choose STEM careers. Opinions ventured by students, academicians, and researchers made it possible to establish guidelines for future talks and workshops and new activities that may be interesting to implement in future versions of the meeting.

Keywords: gender perspective, STEM areas, students' attraction, women empowerment, higher education, educational innovation.

Background

The Organization for Economic Cooperation and Development states in the "ABC of Gender Equality in Education" report [1] that even though boys and girls are equally competent in mathematics and science, their attitudes towards learning, aspirations, and prospects are markedly different. This situation significantly impacts their decision to pursue higher education and career choice. This lack of confidence results in a low selection of university majors in science, technology, engineering, and mathematics (STEM). Thus, there is an under-representation of young women in secondary education courses in STEM fields and few female university role models and mentors in these disciplines to encourage them. Although the number of women participating in STEM disciplines has increased significantly in recent years, this participation remains low [1], [2]. According to the UNESCO Institute for Statistics [3], women constitute about 30% of scientific jobs worldwide. However, in Latin America, the proportion of

female researchers to men has attained 44%. Although not low, when disaggregated per country, the data reveals an alarming inequality among the Latin American countries in the region.

According to the World Economic Forum [4], Chile is one of the countries with significant progress in reducing the gender gap. However, progress made in training women in STEM disciplines is significantly less than in the Latin American region. The reason may be related to other variables not necessarily linked to education, such as prejudices, stereotypes, or cultural norms that influence the teaching of roles in the family and eventually impact the selection of a university career [5].

Currently, there are significant gaps in women's training for relevant scientific and technological careers in Chile. The low participation of women in science, technology, engineering, and mathematics curricula results in horizontal inequity. However, there is also vertical inequality, given the decrease in women's participation as their professional training progresses in the university, resulting in fewer women in high scientific or professional leadership [6].

Regarding horizontal inequality, the areas with wide gaps in female participation are engineering, industry, and construction (19%), followed by science (22%). On the other hand, the areas with the highest female participation are health and social services (76%) and education (74%) [6] - [7].

Vertical inequality displays in those areas where women's participation tends to decrease as they advance in their academic training, a phenomenon well-known as the "glass ceiling." External difficulties identified are socio-cultural barriers caused by stereotypes and the lack of visibility of women in science and technology and barriers within the institutions that hinder the access and advancement of women in professional careers [5], [8].

Many countries develop various programs in which the government, society, and academia have combined their efforts for gender inclusion in STEM skills [9], [10]. Universities in the United States have been pioneers for approximately 25 years [11] and mainly have directed their efforts to high school students about to choose a university career [12] - [15]. Literature reviews report similar experiences in different universities in the Latin American region [5], [16]. Chile has sought to strengthen STEM skills development among its young people through international programs such as *Girls in Tech* [17] and *Ingenious Science and Technology for All* (Ingeniosas) [18], educating and empowering girls and women interested in science and technology.

Taking the initiatives mentioned above as a reference point, a group of academicians from the engineering faculty of the Universidad Andres Bello organized the Biobio Women's first meeting in the spring of 2019 [19]. This first event featured a full day of in-person activities. The activities included:

- Four female guest speakers offered talks and round tables. The invited speakers, outstanding female researchers in the country, shared experiences, challenges, and main achievements of their professional careers. The objective of this activity was to motivate young women who would soon decide their career choices to enter science and engineering careers and STEM areas.

- The educational workshops were targeted at high school students in the Biobio region. Academicians from the engineering faculty and collaborating students facilitated these workshops. The workshops included topics about chemistry, physics, paleontology, 3D printing, robotics, geology, mining, metallurgy, civil engineering, and others. This activity aimed to provide authentic experiences allowing girls and young people to understand science, engineering, and technology phenomena. The workshops demonstrated the attractive, fun, curious, and relevant sides of STEM areas.
- Workshop assistants also prepared a poster session about outstanding women in science and engineering throughout history at the regional, national, Latin American, and world levels. This activity aimed to raise awareness of the contribution of prominent women in STEM areas throughout history.

Around 300 high school students attended the event as a target audience. These students commuted from their schools to the university facilities. They listened to the talks and participated in the workshops. All the event organizers (speakers, workshop instructors, and workshop assistants) worked voluntarily and without financial compensation.

Given the success and wide acceptance of the first event, the second meeting took place in 2020 [20]. However, due to the COVID-19 pandemic, the event was postponed to the fall in an online format. The virtual activities were carried out on two consecutive days and included four talks by outstanding female researchers and four educational workshops in different areas of science and engineering. Because the eight workshops offered in the previous event had been successful, workshops were given on the same topics in the second convocation. Some adjustments were made to the online format.

The objective of this study is to reflect on the perception of the event organizing roles and the needs and motivations of young Chilean women to increase their interest in STEM areas. Specifically, this study focuses on the perspective of workshop instructors, assistants and invited speakers to define synergistic strategies to ensure continuity of this initiative and increase its impact. The endgame is to improve the delivery and impact of the Biobio Women in Science and Technology Meeting to promote greater female interest in STEM university programs.

Method

To find out the opinions of those concerned about the needs and motivations of Chilean girls and women in STEM areas, we applied various interview techniques to collect data for this study. The roles of the three main event participants and data collection information follow:

- **Speakers:** Outstanding female researchers from the region and the country shared their experiences, principal achievements, and challenges throughout their professional careers. Six of the eight speakers were interviewed. Two did not accept the interview due to lack of time (75% participation).
- **Workshop assistant:** Engineering students who organized poster sessions on outstanding women in science and engineering throughout history. They also supported the instructors in developing the educational materials for the workshops. Eight of the ten students were interviewed (80% participation).

- Workshop instructor. Faculty from the School of Engineering organized and facilitated educational workshops in different areas of science and engineering. These eight academicians participated voluntarily. All participating instructors responded to the interview.

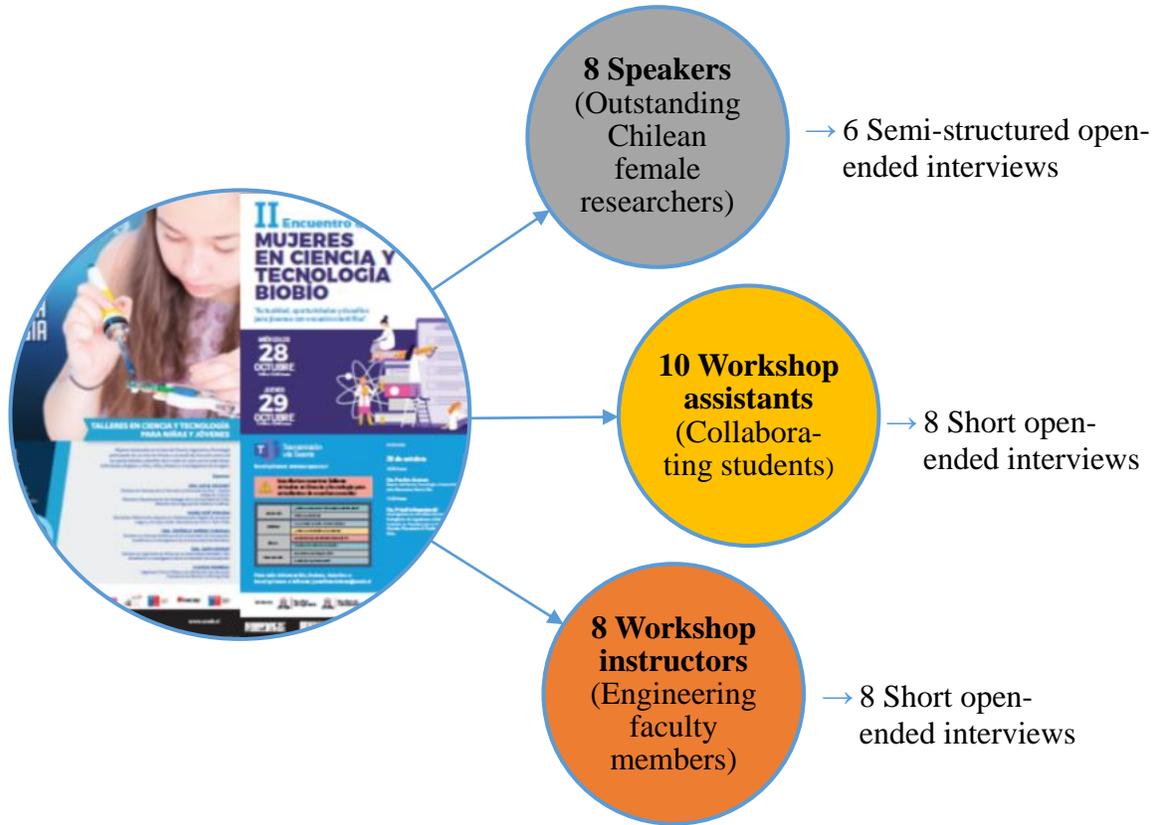


Figure 1. The number of participants and their roles and the data collection type and the number of interviews collected for each in this study.

The interview for workshop instructors and assistants focused on gathering information about their motivation to participate in the event (Table 1). Academicians were also asked their opinions on other activities that could be of interest in future events.

Table 1. Interview on motivation to participate with workshop instructors (engineering faculty members) and workshop assistants (engineering students).

Participant role	Interview questions
Workshop instructors	<ul style="list-style-type: none"> • What motivates you to participate and collaborate in this event? • What other types of activities do you think would be of interest when highlighting the event?
Workshop assistants	<ul style="list-style-type: none"> • What motivates you to participate and collaborate in this event?

Finally, six speakers responded to a semi-structured open-ended interview. By the time the speakers were invited to the interview about a week after the workshop, two could not participate. Thus, 75% of the speakers responded to the interview. The interview consisted of open-ended questions in four different areas: culture and family, training, professional-gender issues, and future perspectives. These questions sought insights into their experiences and challenges in their professional careers, any influences from family and role models, cultural factors, and most importantly, what the future holds and what is necessary to promote similar activities (Table 2).

Table 2. Questions from the semi-structured interview posed to speakers. The questions fall into four themes.

Theme	Interview question
Culture and family	<ul style="list-style-type: none"> • How do you think society, culture, and religion influence the development of a scientific or technological vocation? • How can we attract more young women and girls to scientific and technological activity and motivate them to continue the path?
Training	<ul style="list-style-type: none"> • Did you have a role model who inspired you to further a career in science and technology? Who?
Professional-gender issues	<ul style="list-style-type: none"> • What are the main limitations to women pursuing a science or technology career in your area of expertise?
Future perspectives	<ul style="list-style-type: none"> • What is being done in Chile to promote the participation of girls and women in science and technology? What do you think still needs to be done, and what is falling behind?

Data collection gathers information on possible future strategies and perspectives to open up the visualization of the event, strengthen the initiative and increase its impact.

Results

This section presents the participants' roles (workshop assistants, workshop instructors, and speakers). Each case includes a brief description of the analysis method, results, and discussion.

Workshop assistants

The answers given by the students who were workshop assistants about their primary motivation to participate in the event were analyzed. Since the interview had open-ended questions, the qualitative analysis consisted of reading the responses several times to become familiar with the main emergent themes. Then, a first categorization occurred with tally frequency. The data analysis consisted of determining the key elements mentioned by the workshop assistants. Thus, four primary reasons were identified in 90% of the responses for participating in the event:

1. **Contributing:** To promote interest in STEM activities among more girls and young people. A literature review indicated that in Chile, there is low participation of women in these areas due to cultural stereotypes or other limiting reasons, something all students agreed on [4], [5]. The aim is to achieve gender parity and integration of

- women in the different areas of science and technology soon, areas that the male gender has historically dominated.
2. **Participating:** In a scientific event in which salient STEM researchers present themselves and participate in designing and delivering workshops for young high-school students.
 3. **Disseminating:** The historic contribution of women in general and to the STEM disciplines, particularly, which they deemed exciting and motivating. The idea was to spread the importance of women participating in STEM to the community.
 4. **Sharing:** With their peers organizing the event as workshop collaborators. Also, sharing knowledge and experience acquired in each of their training areas to a younger community.

Concerning the above, Danny, a university collaborating student, commented, "Thanks to the poster session of the meeting, I learned about a paleontology pioneer, Mary Anning, which made me connect and extrapolate the biological sciences with the study of creatures that have been on earth for millions of years. It aroused in me a tremendous interest in paleontology and, after the event, I investigated what I could do to study fossils. I contacted a paleontologist and biologist from the Austral University of Chile. She motivated and guided me in all my concerns and questions, opening the doors to the world of paleontology. So I can say that thanks to this meeting, I managed to connect with something that I love and plan to study after finishing my first university degree."

Students agreed that all the event activities, such as talks by outstanding researchers, science and technology workshops, and poster sessions on salient women in STEM in history, were exciting and tremendously motivating, considering it necessary to have these in future event versions.

Workshop instructors

After the event, we asked workshop instructors to respond to the structured open-ended interview. The qualitative analysis was the same as with the workshop assistants. We read the responses several times, determined the emergent themes, tallied frequencies, re-grouped when necessary, and verified that ideas were categorized correctly. This study reports the most mentioned themes, with at least 80% frequency. Table 3 shows the principal responses given by the workshop instructors. It is noteworthy that this group was comprised of academicians from different areas (chemistry, physics, geology, civil engineering, metallurgical engineering), and there was gender parity (50% men and 50% women)

As in the case of workshop assistant, it is also essential for workshop instructors to break the myth that STEM careers are only for men and encourage more young people in the region to venture into careers in these areas. Similarly, they also mentioned the relevance of disseminating the achievements of women in different areas of science and technology, the tools they used in each of the STEM areas, and their experiences in their academic and professional development.

As a comment example, Jenny, an academician in the Civil Engineering program, mentioned that "*there is an opportunity to motivate girls from their own experience in science and engineering, generating a conscious vision that every girl can do it.*" Similarly, in Metallurgical Civil

Engineering, Mary commented that *"it is important to introduce girls to the world of engineering in the different fields, share work and teaching experiences with them, and encourage them in an area that men largely dominate."*

Table 3. Main findings on workshop instructors (engineering faculty members) participating in the Women in Science and Technology Meeting.

Question asked	Findings
What motivates you to participate and collaborate in this event?	<ul style="list-style-type: none"> • To introduce to the region's high school students the different science and engineering areas. • To break the myth that science and technology careers are for men only. • To motivate girls to enter into STEM careers, based on their experiences, both academic and professional. • To promote female interest in STEM fields early, from primary and secondary education.
What other types of activities do you think would be interesting to carry out to enhance the event?	<ul style="list-style-type: none"> • Scientific and technological fairs at regional levels, framed within the event. • University internships in STEM areas. • Testimonials from young university students in STEM disciplines. • Increase the number of workshops and face-to-face activities in different STEM disciplines, allowing experimentation and "learning by doing." • Increase the number of talks and workshops that can be delivered via streaming.

Many exciting and creative ideas arose regarding types of activities to consider for future implementations of the meeting. Some of the most mentioned were science fairs, research internships, new workshops (both face-to-face and virtual), and open discussions with female university students in STEM disciplines. Peer mentoring was also mentioned as a proven strategy to improve the professional outcomes of women studying STEM disciplines [21], and it could be tested to incentivize young girls to study STEM.

Ethan, a student in the Geology program, expressed the importance of direct contact, experimentation, and "learning by doing" to demolish the myth that STEM careers are only for men, encouraging more girls to participate. Colden, an academician from the School of Physical Sciences, had a similar opinion, stating that face-to-face activities such as science fairs, where high school students can carry out experiments and projects, are crucial to increasing interest in STEM.

Speakers

To construct the interview protocol, the researchers of this study built a list of possible questions through brainstorming. Then, considering the length of the interview, we categorized the questions into themes and rephrased them to focus on the objective of the interview. Four main

themes turned out to be the most important 1) culture and family, 2) professional training, 3) gender issues in a STEM professional setting, and 4) future perspectives on increasing women participation in STEM areas. Table 4 presents the main questions for each of these themes and findings from the interview's analysis.

Table 4. Main findings from the speakers on empowering girls and young people in STEM disciplines by theme.

Theme	Interview question	Main findings
Culture and family	How do you think society, culture, and religion influence the development of a scientific or technological vocation?	Most agreed that these factors have a significant influence, especially in Chilean society. Most of the speakers empathized fostering a scientific or technological vocation.
Culture and family	How can we contribute so that more young women and girls are attracted to scientific and technological activity, eager to follow this path and stay on it?	Most comments indicate that the contribution should come from home, fostering self-confidence and critical thinking in girls, promoting a cultural change for all, presenting inspirational women involved in STEM, and eliminating early age biases at home and school.
Training	Did you have a role model who inspired you to further a career in science and technology? Who?	All speakers indicated the lack of role models to inspire them to further pursue their STEM careers. They mentioned their close relatives (parents, siblings) as sources of inspiration and pillars in their professional development. In addition, they had the support of women close to them who were linked historically to masculine careers and, also, outstanding women in STEM areas whom they saw in a talk, seminar, or conference.
Professional-gender issues	What are the main limitations seen in women when pursuing a science or technology career in your area of expertise?	Most speakers agreed that a significant limitation is a myth that women cannot pursue careers that have historically been considered for men because of their physical or intellectual abilities. In addition, highly trained women commented about their difficulties in accessing senior management positions.
Future perspectives	What is being done in Chile to promote the participation of girls and women in science and technology? What do you think we still have to do, and where are we falling behind?	In Chile, they all agreed that numerous initiatives are being developed by schools, universities, ministries, and government. These initiatives include programs, projects, talks, seminars, conferences. However, concerning what remains to be done, they emphasize the need for a regulatory framework with laws that guarantee gender equality, especially at work, such as equal opportunities and salary regulations.

Concerning culture and family, in Chile, society, culture, support, and education at home are primary factors influencing young women's choice to pursue a STEM career.

Vanessa, an associate professor and leading researcher in the chemistry department, made the following comments: *"I believe that, for better or for worse, the factors mentioned above influence how we behave and the decisions that we make in life. In this sense, a scientific vocation is no different from any other vocation."* Vanessa pointed out that *"pursuing this*

vocation will depend on the opportunities each person has in addition to personal work and making their own decisions." She elaborated on the culture and the inequalities that women face (in Chile as well as the rest of the world: "Unfortunately, opportunities offered within the home are decisive for future life and establish social-class biases that are very difficult to overcome. Although we like to say that science is for everyone, unfortunately, it is still very elitist." *Nature* (a weekly international journal of science) [23] dedicated a special issue to *Science and Inequality* to deepen understanding of inequality and the socioeconomic divisions affecting the scientific workforce.

Aisha, the first woman who graduated from mining engineering in Iran, is an academician at the University of Concepcion, Chile. She pointed out, "I believe that society, culture and religion affect people's education as much as 80%. Where I grew up, women are considered inferior. In my religion, it is not easy for a woman to develop in her area of interest." Then she added, "when I attended college, I wanted to be the best. I wanted other people to know that being the only woman did not mean that I was less." Women are not allowed to enter mines in her country, but that did not stop her: "Even though I could not enter the mine because I was a woman, I never let that make me give up my dreams of being a great engineer." In Chile, she has been able to practice her passion, teach at a university, and be a strong voice for equity: "Women have never been less. We must demonstrate our skills and knowledge with respect but never limit ourselves."

Regarding increasing young women and girls' attraction to scientific and technological activity, Perla, an IT engineer and Director of the "Girls in Tech International Foundation" for the Biobio and Ñuble regions, highlighted the importance of showing young women examples of successful women working in STEM areas. Her comment stressed the importance of events like the one presented in this study.

Along the same lines, Lena, a Ph.D. in Physics specializing in Astrophysics, points out, "We can contribute by showing how science and technology can improve people's quality of life." Like Aisha, Lena takes any opportunity to promote a cultural change to widen girls' view of their future: "(we women can) forge a country where young women have the opportunity to be what they want to have an ecosystem that serves that purpose."

On the other hand, none of the invited speakers claimed to have had a role model who inspired them to pursue a STEM career. However, these prominent researchers pointed out the importance of making visible the work and professional careers of outstanding women working in STEM areas in outreach activities (such as talks, conferences, and seminars) that may touch girls and young people.

In Chile, one of the main limitations is the so-called "glass ceiling." Regarding this, Vanessa commented, "There is a certain glass ceiling that invisibly limits the rise of highly skilled women in an essentially male-led world." Vanessa also stated that this situation goes beyond STEM areas. She said, "I believe that limitations in my area are no different from those faced by women in other areas and are inherent in the model of society that we have built." On this same point, Perla mentioned, "As the educational level of women increases, we reach a "glass ceiling" that hinders us from attaining senior management positions."

Finally, regarding what is being done in Chile to promote female participation in science and technology, all the interviewed speakers agreed that many things had transpired. Examples given included programs, projects, conferences, talks, and seminars implemented by colleges, universities, ministries, and government. The important thing is that all these initiatives continue over time.

As for what still needs to be done, Perla stated, "It is necessary to have a regulatory framework and laws that guarantee that women can perform in STEM disciplines under equal conditions." On this point, Lena indicated, "*We must guarantee that if a woman chooses to pursue a STEM career, she can practice her profession under equal conditions.*"

The Ministry is currently working on this point through its Gender Agenda, whose objective is to create the conditions and appropriate ecosystem to reduce the gender gap for women in STEM careers.

Conclusions

This subject area has many facets, and not all addressed in this work. The main objective was to reflect on the impressions and opinions of the actors involved in the organization, development, and dissemination of the "Biobio Meeting of Women in Science and Technology" event. From these opinions, new ideas, strategies, and initiatives may arise that provide continuity to the event, enhancing it year by year.

Also, the study offers significant reflections. First, students, academicians, and researchers who participated in the event (workshop assistants, workshop instructors, and invited speakers) valued and considered it necessary to reinforce the paradigm changes nationally for women's participation in STEM careers. Second, everyone in each role agrees that the event allows them to contribute, encourage, and motivate girls and young women to develop careers in STEM areas if they so wish.

Regarding the different event sessions, participants agreed that the talks by prominent female speakers and the poster creations should continue. This event increases women's visibility and disseminates women's contributions in science, engineering, and technology throughout history to the present day. They also considered the workshops very relevant for young people and looked to diversify them in future offerings of the event.

We note that implementing talks and workshops via streaming turned out to be a success in times of pandemic. So what seemed to be complicated now will allow reaching a larger target audience or have talks from leading professional women in STEM from different parts of the world.

Another aspect that must be considered is the influence that cultural and family factors might have in reducing the gender gap in STEM careers. The event should delve into that in future versions. Similarly, work should be done on new initiatives to reach the target audience in different ways, such as research internships, scientific fairs, talks with peers, among many other exciting implementations.

Although this study is based on the experience of the Universidad Andres Bello in the Biobio region of Chile, many of the activities carried out and proposed for the future could be replicated in other universities, especially in Latin American institutions that share similar contexts. Therefore, it is necessary to consider the various ideas of the interviewees, many relevant when organizing more initiatives of this type.

Finally, it is essential to highlight the initiatives being developed in Chile to contribute to gender equality, including incorporating more women in STEM careers. It is here where the "Biobio Meeting of Women in Science and Technology" aligns with the goals of government, universities, and society [23]-[24] to break paradigms, reduce the gender gap and motivate more girls and young women to pursue a STEM career. An accommodating environment and ecosystem favoring their development are necessary for the success of these goals.

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