CHAPTER 2

The "Learning School": A Foundation for Gender Equality and Green Growth in Colombia

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Introduction

Increasing women's representation in green jobs, especially those requiring skills to design and operate sustainable technologies, not only strengthens women's economic independence but also creates a more diverse workforce. Bringing diverse perspectives to businesses and regions through gender-balanced teams strengthens their innovation and decision-making capabilities, creating more resilient societies in the face of environmental challenges. The Autonomous University of the West, in partnership with Colombia's National Apprenticeship Service's (SENA) Industrial Biotechnology Centre (CBI), sought to support a greater participation of women in the green economy labour market in Colombia.

SENA, created in 1957 under Colombia's Ministry of Labour and Social Security, has the mandate to provide Colombians with free, comprehensive technical and vocational training (TVET). This institution primarily serves vulnerable groups, including single mothers, displaced individuals, victims of armed conflict, rural populations, ethnic communities and low-income youth. In 2023, SENA supported approximately six million apprentices. SENA is the largest public educational institution in Colombia and in the words of Colombians, it is "the most beloved institution in the country". Through 118 centres, covering one or more municipalities, SENA is present in 1 102 of

the 1 103 municipalities in Colombia. The project introduced in this chapter was conducted in collaboration with the SENA CBI, a training centre in the south-western part of the country, which acted as the unit of analysis of the case study.

Background and context

Climate crisis and environmental degradation have accelerated a worldwide transition from a linear economy to a green and circular economy (Vidican Auktor, 2020). The latter incentivises taking innovative actions towards sustainable production and consumption that apply the 3Rs: *reduce, reuse* and *recycle* waste and by-products (Manickam & Duraisamy, 2019). The transformation towards more environmentally friendly processes and technologies generates a positive effect on employment generation (Vidican Auktor, 2020). In Latin America and the Caribbean (LAC) alone, between 15 and 22 million green jobs are expected to be created by 2030 (Saget et al., 2020). In LAC, countries face the challenge of achieving a green transition while producing green jobs that offer strong social protection and foster gender equality. A transition that helps to shape the labour market towards inclusion of Latina women, enhancing their employment opportunities in the green economy, is necessary (Bustelo et al., 2023; Organización Internacional del Trabajo y Comisión Europea, Dirección General de Asociaciones Internacionales, 2023).

However, according to the International Labour Organization, more than 80% of the new jobs created for environmental protection and decarbonisation in LAC are concentrated in traditionally male-dominated sectors such as agriculture, energy, manufacturing, transportation and construction (Bustelo et al., 2023). Their environmental transformation requires individuals with skills in Green and Science, Technology, Engineering and Maths (STEM) fields where women are underrepresented (Lathifa, 2023; Steinke et al., 2024). As defined by OECD and Cedefop (2014, p. 16), green skills are "the skills needed by the workforce, in all sectors and at all levels, in order to help the adaptation of products, services and processes to the transformations due to climate change and to environmental requirements and regulations". These include technical knowledge, values, attitudes and abilities to develop cleaner services and production processes and operate green technologies that protect ecosystems and biodiversity, preserve environmental quality and support a sustainable and resource-efficient society (Ibrahim et al., 2020; LinkedIn Economic Graph, 2022).

Minority women, including Latinas, African descendants and indigenous women, face greater barriers to enrol, persevere and advance in Green-STEM

careers (Armstrong & Jovanovic, 2015; Miles et al., 2022). One of the most common barriers is gender stereotypes that influence individual, family and cultural perceptions about which STEM green jobs are acceptable for women (UN Women, 2021). These barriers widen the green skills gender gap (LinkedIn Economic Graph, 2022).

Currently, women constitute less than 25% of graduates in fields of study required for the green economy and are underrepresented in sectors with green job potential (OECD, 2023). In LAC, women are almost absent in sectors such as gas, water and energy (Sevilla, 2021); in the energy sector specifically, women make up less than 20% of the workforce (Sacristán & Tatto, 2021). In Colombia, only 32% of students entering undergraduate STEM programmes in 2023 were women (Mineducación, 2023).

Against this backdrop, special attention must be paid to addressing gender inequalities in LAC contexts by equipping women with crucial STEM skills to advance in the sustainability sector (Islam & Jirattikorn, 2024). Any alternative risks rendering the green transition in the region gender-blind (Kolovich et al., 2024). Green skills acquisition can help prevent women's stagnation in low-productivity jobs, facilitate their advancement into high-productivity, eco-friendly roles and help them stay competitive in the sustainable economy (ILO, 2015; LinkedIn Economic Graph, 2022). Specifically, technical and vocational education and training (TVET), understood as "education and training given to the learners to acquire skills, knowledge and attitude needed in the world of work and necessary for employment in ones' chosen occupation" (Ejiofor & Ali, 2015, p. 2), is of great relevance to prepare women for the current and future needs of the labour market, economy and environment (UN Women, 2021).

Nevertheless, the TVET landscape in several countries remains anchored to gender and patriarchal structures (Wignall et al., 2023), especially in highly masculinised STEM programmes, leading to low female representation (Atsu & Lartey, 2018; Chauke, 2022). Although several projects and initiatives have made progress in promoting gender equity in TVET STEM-related education, few have done so in the framework of green growth and in LAC contexts. Further, these initiatives are limited in scope and tend to lack a systemic vision to address the educational institution as a whole. As a result, they focus on specific academic programmes or areas, prioritise the implementation of isolated actions (e.g. highlighting women scientists only on International Women's Day), propose strategies to achieve gender balance without addressing the root causes of inequity within the organisation and place greater emphasis on developing individual rather than organisational capacities. This approach fails to permeate the various levels of the organisational structure or foster

comprehensive transformations that lead to sustainable impact. It prioritises the transfer of new knowledge around gender equity in environmental STEM fields to trainees, without altering the organisational DNA.

Organisational learning provides an approach to advancing gender equity in a way that addresses the above constraints (Andersson & Johansson, 2022; Buzzanell, 2018; Posselt et al., 2018). Organisational learning processes are essential to fostering a culture that supports women's advancement into scientific and technical roles, including green jobs. However, very few initiatives for gender equality in green science and technology in LAC assume organisational learning approaches, focusing efforts on transferring knowledge and skills so that the organisation internalises gender equity in its values, behaviours, policies, processes and organisational routines (Crossan et al., 1999). When internalisation fails, that is, when it does not reach the heart of organisations, they easily revert to old practices and habits (Ørberg Jensen et al., 2013). In our case, this would imply returning to an organisational culture that favours inequity, accentuates sexist stereotypes and limits the personal and professional growth of women in vocational careers with an environmental STEM focus. Therefore, we sought to answer the following questions:

1. How, from an organisational learning approach, can educational institutions more effectively encourage female students' participation in Green-STEM fields?
2. How do educational institutions integrate and internalise gender equity in STEM to promote inclusive green growth from educational processes?

Theoretical tools of the study

The study adopted a gender-transformative approach, which seeks to constructively, and in a context-driven way, transform power relations and socially accepted norms that reinforce gendered inequalities (Hillenbrand et al., 2015; McDougall et al., 2021). Here, removing structural barriers is the starting point for changing habits, relations, norms, beliefs, stereotypes, laws, policies, practices and harmful behaviours that perpetuate gender gaps (Bilimoria et al., 2008).

In line with this, organisational learning is conceived as a means to achieve the desired change (Bianchi et al., 2022); in this case, the desired change was to reduce discrimination in STEM disciplines with an environmental focus in TVET education. Organisational learning studies show how an organisation

learns and adapts to change (Huber, 1991). It is a complex process of developing new knowledge that has the potential to generate behavioural and cognitive changes through action (Škerlavaj et al., 2007).

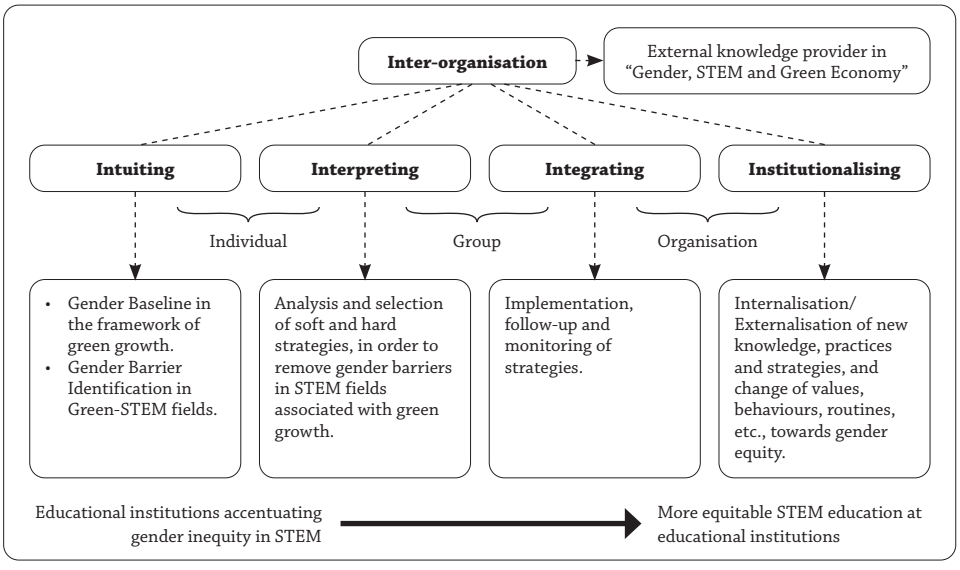
We used the 5i Learning Framework for Gender Equity in STEM proposed by Jones and Macpherson (2006) to guide organisational learning processes around gender equity in Green-STEM fields within SENA CBI (i.e. the TVET institution analysed in the research study).

Jones and Macpherson outline five sub-processes (the 5is) for developing and internalising new knowledge: intuiting, interpreting, integrating, institutionalising and inter-organisation. *Intuiting* involves recognising new ideas for organisational change, often inspired by external actors (Huber, 1991). *Interpreting* analyses these ideas individually or in groups, with communication key to achieving collective understanding. *Integrating* implements the analysed ideas. And *Institutionalising* embeds the new knowledge into the organisation's routines, which include the procedures, strategies, technologies, beliefs, cultural norms and behavioural codes developed by organisations (Levit & March, 1988). *Inter-organisational learning* occurs when organisations collaborate on shared interests with external providers such as universities, consultants and researchers. These actors help develop and institutionalise knowledge, driving strategic renewal towards a culture of equity in STEM (Andersson & Johansson, 2022; Jones & Macpherson, 2006).

In this light, the study developed a new framework based on the 5is to guide education institutions towards more inclusive Green-STEM education processes (Figure 1). Integrating organisational learning and gender-transformative principles, the framework defines key actions for internal and external actors leading this transition. It frames the shift to a more equitable STEM pedagogy as a dynamic learning process, structured around five sub-processes (5is) and outlines specific actions for each phase.

It is not clear from existing research and practice how to integrate gender mainstreaming and organisational learning to achieve equity (Andersson & Johansson, 2022; see Chapter 3 for a discussion of the importance of gender mainstreaming and gender transformation in institutions and organisations). Therefore, our proposed model closes this gap by addressing gender balance in science and technology through the integration of organisational learning and gender transformative approaches. This approach can be used to plan, implement and evaluate initiatives that seek to increase the representation of women in STEM in higher education.

Figure 1: The 5i Learning Framework for Gender Equity in STEM



Adapted from Jones and Macpherson (2006)

Methodology

The research adopted the 5i Learning Framework for Gender Equity in STEM to guide the development of a single case study, with SENA CBI as the unit of analysis. The case study method, incorporating both descriptive and explanatory approaches, enables a deeper understanding of specific phenomena (Pereira et al., 2023). Widely used in social sciences and education (Schoch, 2020), the case study method has proven effective in various contexts, such as evaluating higher education institutions' information systems (Pereira et al., 2023), analysing student and teacher perceptions of active learning methodologies (Carvalho et al., 2021) and assessing the impact of problem-based learning on the practical skills and clinical experience of future physicians (Korniichuk et al., 2021). Both qualitative and quantitative data were collected to ensure triangulation, providing a comprehensive understanding of the research phenomenon and enhancing the validity and reliability of the findings. This mixed-methods approach allowed for a more robust analysis by cross-verifying results from different data sources.

Seven STEM-focused TVET programmes with high environmental potential were selected for this study. These included Environmental Monitoring, Biotechnological Processes Applied to Industry, Environmental Management

and Sustainable Use of Biodiversity. The invitation to participate in the survey was shared through institutional emails, SENA's digital platforms where a video encouraging participation was published and social media channels such as Facebook. The invitation message included the study's objectives, the eligibility criteria for participants and the survey link. Out of 1 002 apprentices, 121 responded to the online survey, ensuring a high degree of representativeness of the target population. In addition, 17 semi-structured interviews were conducted in person with instructors and academic coordinators who represented the entire group of educators involved in the seven prioritised programmes. To further explore specific topics, focus group discussions were also held with 134 apprentices, some of whom had already completed the survey. Participation in all data collection formats was voluntary. While only female apprentices were invited to participate, both male and female educators took part in the interviews.

Findings

Intuiting

The case study was developed progressively, following the phases of the 5i Learning Framework for Gender Equity in STEM. Throughout this process, researchers worked to enable members of the SENA CBI community (learners, instructors and academic coordinators) to gradually gain the knowledge and skills necessary to independently implement, replicate and refine each phase according to their roles within the institution.

The first phase focused on strengthening the capacity of SENA CBI to *intuit* (recognise) alternatives that promote gender balance in TVET careers with an environmental STEM focus. Recognising that effective solutions cannot be proposed without a deep understanding of the problem and its causes, a gender baseline was established, primarily aimed at identifying the root causes of inequity that may serve as barriers to the advancement of female learners in science and green technology fields.

Through an extensive literature review and the collection of primary data from the SENA CBI community, the gender baseline was constructed. The review mainly focused on scientific articles and studies on gender barriers in STEM in developing countries. However, limited information was available on this topic in Latin America, particularly within the context of vocational education.

Based on the barriers identified in the literature, qualitative and quantitative tools were developed to collect primary data. The participation of instructors and coordinators from SENA CBI in designing surveys and interviews provided them with the opportunity to engage in research processes. This involvement also allowed instructors and coordinators to understand the project's objectives from the outset, fostering a stronger connection and ownership from the very beginning. Their engagement enriched the analysis of the barriers. Instructors' close relationships with learners enabled them to understand the learners' realities first-hand, facilitating a deeper understanding of the identified barriers and their causes. These connections deepened researchers' understanding of the identified barriers and their underlying causes, facilitated the analysis of their interrelationships, validating them within the project's context and scope, and ultimately selecting the key barriers to address in the next phase (Table 1).

Table 1: Main gender barriers in environment-focused TVET-STEM careers

Barrier	Description
B1	There are insufficient and/or undisclosed female referents in STEM fields, at the academic and occupational levels, and in the green industry field.
B2	Sexist and gender stereotypes, which establish the skills, roles and careers suitable for women and men, limit the participation of women in STEM careers in academia and the workplace.
B3	Lack of self-confidence in girls in mathematics, induced by the social and school environment.
B4	Women may be fearful of entering male-dominated academic environments, considering these environments hostile to them.
B5	Stereotypes that exclude women from STEM careers are reinforced in families.
B6	Managers, instructors or the trainees themselves may limit women's participation in practical activities considered masculine, which are specific to the career or job position.
B7	Women's technical skills are underestimated throughout their academic training and in the workplace, with men being preferred for the performance of some activities.
B8	When the majority of partners are men, women may feel intimidated or harassed by inappropriate comments, attitudes or practices towards them.
B9	There is a lack of training for women in technical subjects associated with green industries to help them move into leadership positions.

In particular, the interviews and focus groups were essential for enriching our understanding of women apprentices' experiences. The one-on-one and small group interactions fostered trust, facilitating the exchange of sensitive information. The semi-structured formats allowed for real-time adaptation of questions to delve deeper into specific or emerging aspects. In these spaces, the apprentices highlighted the persistence of social and family prejudices that question their ability to study and work in male-dominated fields such as industry, construction and the sciences. Apprentices reported hearing comments from

peers that underestimated their mental and physical capabilities to perform in these fields.

These stereotypes perpetuate the misconception that certain areas of the green industry, such as sustainable construction and renewable energy, are incompatible with the characteristics associated with femininity or societal expectations of women. This may be due to the persistent collective mindset that men should handle physically demanding labour (e.g. installing and maintaining solar panels, working at heights).

In this regard, an academic coordinator commented that companies often prefer male apprentices for internships in logistics, arguing that men have the technical skills and physical strength to carry boxes. For one coordinator, this is a misguided perception, as

> *[o]ur logistics programme is not based on physical strength. Our apprentices are capable of efficiently organising storage systems and inventory management, preventing product expiration and loss, which reduces waste and its negative environmental impact while improving the company's productivity. However, these green skills of our female apprentices are not recognised by those employers with outdated views on TVET careers and the role of women in them*.

Similar situations were observed with some companies that reported a preference for hiring men in production plants or manufacturing areas related to STEM competencies, arguing that "*They prefer not to hire women in agro-industrial production farms because these spaces are considered unsafe for women,*" as an instructor stated. Thus, gender biases end up excluding women or limiting their access to green jobs that require technical and/or physical skills, by deeming them supposedly incapable. However, the apprentices stated that women have the capacity to work in the sustainability field, often proposing innovative environmental solutions that their male counterparts have not identified. Additionally, some trainees who are already engaged in internships at companies shared: "*Women have to fight to keep our jobs, not let ourselves be sidelined, and never lower our heads*." This reveals that they perceive the workplace as a constant struggle to earn both technical and personal respect, simply because they are women.

Findings show that women apprentices face gender bias before, during and after their STEM training, compounded by factors such as age, ethnic background, educational level and geographic origin. At SENA, this is particularly prevalent due to the large heterogeneity of apprentices entering TVET

education, which includes individuals with continuous schooling, others who have been out of education for 10 to 15 years, members of minority groups such as Indigenous or Afro-descendant people, women from conflict-affected areas and older individuals, among other profiles. While universities primarily attract young graduates, TVET education attracts individuals of all ages, mostly with economic limitations, interested in learning a trade quickly to meet personal and family needs.

Interviews highlight that Afro-descendant apprentices at SENA CBI are particularly vulnerable, facing not only socio-economic difficulties but also racial and cultural discrimination. An academic coordinator shared how an instructor expressed biases based on both the skin colour and gender of an apprentice, attributing her low academic performance to these factors with comments such as:

> *Well, since that girl is from XXX city and is Afro-descendant, I have to help her because she can't keep up with the rest of the apprentices; I'm sure the education in her town isn't good, and here she's overwhelmed with so much information, especially with math.*

Another instructor remarked: "*Some apprentices criticise the hairstyles of their Afro-descendant peers and discriminate against them.*" On the other hand, older apprentices expressed feeling intimidated by their younger peers, questioning their ability to finish the programme: "*I'm so old, will I be able to finish this career? Who will hire me?*" In these cases, female instructors have been crucial, offering support and motivation to help them continue. Additionally, apprentices value the high presence of female instructors in some programmes, as it builds their confidence and facilitates interaction during their training.

Apprentices highlighted sexual harassment as a challenge that can occur in all spaces, from educational environments to the streets and workplaces. Apprentices shared experiences such as: "*In the company, since there are more men, when you ask for a favour as an apprentice, they make inappropriate insinuations.*" Unfortunately, many companies still lack guidelines, policies or mechanisms to implement a gender perspective or prevent gender-based violence, which hinders women's progress in STEM careers. As one instructor mentioned, in one company, the solution to prevent harassment of a SENA apprentice was to place a sign saying, "*No flirting with the SENA apprentice – Prohibited*", which is insufficient in addressing the harassment issue.

The ongoing involvement of SENA instructors and coordinators in designing, collecting and analysing field data strengthened and developed their

knowledge and skills to identify weaknesses and opportunities for promoting women apprentices in the green economy. Their participation in training sessions, reflection spaces and informal dialogues about gender equality in green jobs strengthened their knowledge to drive a green, just and equitable transition from the TVET institution. These reflections focused on how to promote environmentally sustainable economies without leaving anyone behind, ensuring inclusion through STEM environmental education processes that equip both men and women with the tools needed to access decent green jobs. Particular attention was given to actions taken by researchers, academic actors and governments in other countries, highlighting the resulting benefits in strengthening the role of women in STEM. This dialogue aimed to broaden the perspective on effective solutions that are sometimes overlooked or unfamiliar in the local context.

In addition, through the various activities, instructors reaffirmed their roles as professionals contributing to science and technology beyond their teaching duties, gained recognition as STEM experts from trainees and validated their impact as female role models inspiring young women. At the same time, trainees deepened their understanding of concepts such as STEM, gender equity and gender transformation, recognising that women scientists can thrive in Latin America. Thus, during the *Intuition* stage, the topic of inclusiveness in STEM careers started to be approached in a much more open way within SENA CBI. This stage was also key for introducing concepts and tools like the Gender Equality Continuum, which guides strategies and programmes to transition from gender-blind to gender-transformative approaches, advancing gender equity in STEM.

Interpreting

Once the SENA CBI community strengthened its ability to *intuit* (recognise) the causes and potential alternatives to reduce the gender gap in TVET-STEM careers with an environmental focus, the next phase began. This stage focused on enhancing their capacity to *interpret* (understand) these alternatives or solutions aimed at achieving gender parity. *Interpretation*, as a group exercise, allows for the collective analysis of alternatives in depth and the selection of the most suitable ones for later implementation, considering the project's objectives, context and scope. Thus, between external researchers and the SENA CBI team, it was concluded that two types of strategies were necessary: (1) soft strategies focused on raising awareness and highlighting female leadership in the fields of science and green technology, aiming to inspire and motivate women to take a

more active role in the green economy; and (2) hard strategies focused on transferring and/or strengthening new knowledge (mainly of a technical nature) and developing Green-STEM skills through practice. To this end, the use of active learning environments was proposed, in which environmental actions would be implemented under a practical learning approach. Table 2 consolidates the main strategies, which were built so that each one contributed to the removal of multiple barriers to maximise their impact.

Table 2: Consolidated strategies and related barriers

Strategy	Soft	Barrier to remove
S.1	Recognising women's leadership in STEM fields.	B1, B2, B4, B5, B8
S.2	Inspiring women in STEM.	
	Hard	
S.3	Green pilots for experiential environmental training with a gender perspective (on-campus).	B1, B2, B3, B4, B6, B7, B9
S.4	Green pilots for experiential environmental training with a gender perspective and in real environments, including natural and business settings (off-campus).	

The combination of soft and hard strategies is essential, as they complement and reinforce one another, facilitating the development of a wide range of skills and promoting comprehensive learning. While soft strategies create the emotional and theoretical foundation that inspires and prepares apprentices, hands-on learning spaces strengthen that knowledge and transform it into applicable green technical skills for solving real environmental problems.

Integrating

Actively involving the SENA CBI instructors during this stage allowed them to *interpret* (understand) each of the strategies, including their scope and objectives, expected benefits and novel elements, among other aspects. Additionally, as part of the *Interpretation* phase, the researchers and the SENA CBI team collaboratively reflected on the activities necessary to implement the strategies, that is, to *integrate* them into the TVET educational institution. In order to facilitate their integration and long-term sustainability, activities were prioritised based on the following criteria: easy to implement at low or moderate cost; adaptable or replicable across multiple training programmes; promote learning-by-doing methods, teamwork, innovation and inclusion; involve low-complexity technologies, processes and practices that align with the academic or theoretical foundations guiding the selected training programmes;

and focus on Green-STEM topics of increasing relevance in both national and global labour markets. Internal and external stakeholders from various social and STEM disciplines played a key role in the *integration* of the strategies at SENA CBI. Their contributions are reflected in the activities carried out to put these strategies into action, as outlined below.

Recognising and inspiring female leadership in Green-STEM fields (S1 & S2)

Through a workshop called "My Favourite Scientist", trainees and instructors (both female and male) recognised the experiences and leadership of Latin American women in science and technology fields. The workshop began by presenting data about gender inequality in STEM in the world and Colombia. Then groups of trainees analysed the biographies of Latin American women scientists recognised for their contribution to science and the socio-environmental impact of their work. On a billboard, using comics and magazine clippings, trainees captured information such as the place and date of birth of the scientists, characteristics of their work, field of knowledge and curiosities of their biography. Finally, each group presented their work and reflections to their peers.

The workshop helped to break down false beliefs among the trainees. When students recognise women scientists living in the same region, who have overcome similar barriers, they understand that pursuing and excelling in the field of science is a real possibility for them.

> *When we asked the trainees to name their favourite scientist, the answer alluded to the 'dead men's fair', as they only named Einstein and Newton, but now they recognise that Colombian and Latin women are also doing science nowadays.* (SENA CBI Instructor)

> *It has been very inspiring for me to learn about the lives of these women and the obstacles they have faced. It encourages me to keep going forward, regardless of my age, and to continue to better myself every day.* (SENA CBI Apprentice)

Although the first workshops were led by an external practitioner from the gender area, SENA CBI instructors were always invited to co-lead this activity. This co-leadership approach eased the transfer of the necessary pedagogical and methodological elements for the development of the workshop; thus, instructors learned the details of the activity, were able to adjust or complement it

according to the particularities of each group of trainees and helped to guide and develop the activity on the ground. In other words, the instructors' abilities to integrate this strategy into the training cycle were strengthened, especially increasing their knowledge to promote gender balance in STEM with simple actions in the classroom.

The workshops were frequently accompanied by panels and live talks featuring successful local women in STEM fields, providing the apprentices with the opportunity to engage face-to-face with renowned scientists and engineers. These sessions allowed the trainees to explore both the personal and professional aspects of these women's journeys, learn about the strategies that led to their success and discover the technological advancements they are leading to protect the planet. The fact that these stories were local, referencing regions, customs and challenges familiar to the apprentices, facilitated a deeper connection.

By hearing stories they could relate to, as they had experienced similar situations, the apprentices found inspiration, feeling empowered to overcome obstacles in their own paths. Female engineers shared anecdotes that reflected the reality of many Colombian families and demonstrated that achieving great things is possible, motivating apprentices to excel:

> *In my family, we were four siblings. We walked to school under the scorching sun in Cali, and sometimes the only thing we ate all day was water with panela [a block of brown sugar] and royal bread [the cheapest bread in Colombian bakeries]. Now, I manage the circular economy department at a government agency, and … I have my own car.*

These workshops were effective; opportunities to hear from women role models are rarely provided in formal education contexts, where technical training often takes precedence. No matter how proficient apprentices become in technical skills or advanced technologies, if we do not inspire them, help them see themselves as STEM leaders and ignite their confidence and passion for science, our impact will remain limited.

Green pilots for experiential environmental training with a gender perspective (S3)

To guide active learning towards developing apprentices' problem-solving skills in their local environment, the project team decided to select a theme that would resonate with them: sustainable urban agriculture.

Active learning began with theoretical sessions to introduce the concepts and principles of agroecology, preparing apprentices before transitioning to practical activities. SENA instructors and external experts in resource efficiency and sustainable agriculture supported the pedagogical cycle, covering the design, construction and management of the experimental garden, built on approximately 170 m^2, as well as the harvesting and post-harvesting processes.

Apprentice groups were assigned specific responsibilities (i.e. watering, measuring plant growth, identifying pests, etc.) that enabled them to develop key skills, such as teamwork, critical analysis and decision-making. Additionally, the project team ensured that both male and female apprentices actively participated, making sure everyone had direct contact with the land and engaged in tasks that required numerical calculations or technical analysis. This approach allowed them to develop better agricultural skills and prevented women from being relegated to passive roles, such as taking notes, as has occurred in other cases.

The experience helped male apprentices break gender stereotypes, with many expressing pride in seeing their female peers working side by side, recognising their ability to perform tasks that require both physical and cognitive effort. On one occasion, an attempt to exclude women arose, despite the gender training prior to the activity. An external agroecology expert suggested that only men should till the land and measure environmental parameters due to their greater physical strength, prompting corrective action by the project team. This highlights the need, at times, to re-educate team members to question and reshape deeply ingrained gender beliefs within STEM disciplines.

Overall, the active participation of SENA CBI instructors was crucial in guiding the pedagogical sessions and identifying key areas for improvement in each selected training programme using the pilot garden. This involvement also highlighted the technical skills of the female instructors, who worked alongside external experts, showcasing to the apprentices the value of female leadership within their own institution. This engagement allowed the SENA CBI community to become more familiar with the garden, fostering a deeper connection with the environmental pilot, enhancing their ability to manage it and expanding its potential as a learning platform on a larger scale within the TVET institution.

Green pilots for experiential environmental training with a gender perspective and in real environments, including natural and business settings (S4)

The implementation of environmental pilots in community contexts brought the trainees closer to real environmental challenges, involving them in a

practical and reflective way in the search for innovative and sustainable solutions in collaboration with the local community. The apprentices, together with experts and instructors in STEM fields, took part in the installation of vermicomposting systems in 13 rural small businesses led by women, who make up a legally constituted Association of Rural Women Producers (Corpobarranco). The association is made up of women in agriculture, who are mainly involved in growing grapes, corn, bananas, fruit trees and raising small livestock (e.g. chickens and fish).

By working with a women-led organisation, apprentices gained appreciation for the role of women in the green economy, and the opportunity benefited the female farmers and their work.

Through the activity, female apprentices and female farmers interacted with each other and women from various STEM backgrounds to learn about the vermicomposting systems. The experiential learning process was supported by theoretical sessions to introduce key concepts before field activities. Participants then conducted exercises to validate parameters of the vermicomposting system. They also learned to monitor key variables like temperature and pH and apply corrective measures when necessary.

Vermicomposting systems were successfully implemented and operated by female farmers, producing high-quality bio-compost. All participants demonstrated the knowledge and skills needed for running the types of processes that promote rural circularity, tackling environmental challenges collaboratively. Notably, the apprentices recognised the effort and learning capacity of these women, viewing them as role models in technological and environmental transformations. The rural women's diverse ages, from very young to elderly, and their generally low educational levels, motivated the apprentices to excel in Green-STEM fields, following their example. This experience allowed trainees to explore intersectionality in the green economy and understand how to transfer knowledge to rural communities, witnessing that science can be successfully applied by rural women. Finally, on-site observation helped to constantly identify weaknesses in the transfer of STEM knowledge, from which actions were taken to strengthen the learning process for both female farmers and apprentices.

Institutionalising

To ensure the long-term sustainability of the strategies developed in the project, a programme was created as part of the *Institutionalising* (internalisation) phase. The programme consolidates the different strategies and defines

the application route for them within SENA CBI, to guide their ongoing implementation, even after the project team leaves. Protocols, guidelines, booklets and pedagogical material were provided to guide the use of the technological prototypes and the development of the soft strategies, with a view to sustaining them over time. Instructors and coordinators were involved in creating these materials and received training in key aspects to maintain the progress made. This approach modified pedagogical processes and practices, bringing the SENA CBI community closer to real-world environmental business transformation in enterprises and rural associations led by women, while promoting female leadership in STEM fields across various contexts.

An observation process supported by evaluation criteria showed that SENA CBI developed internalisation capabilities by effectively replicating the strategies internally with other groups of trainees from different training programmes. SENA CBI initiated the scaling up of strategies to other SENA centres not covered during the project in other cities in Colombia. Critically, sharing and externalising the knowledge acquired demonstrates a high level of internalisation. SENA CBI staff are also analysing the possibility of converting some of the soft strategies into pedagogical courses on gender equity to be included in the training programmes led by the SENA School of Instructors. In turn, SENA CBI has begun to lead gender equity initiatives in Green-STEM fields in schools that are affiliated with this institution, which also demonstrates its capacity to transfer the knowledge acquired to other types of educational entities.

Inter-organisationalising

Finally, as demonstrated in the case description, the *Inter-organisational* approach brought together various stakeholders who supported the learning process. (1) The UAO University, with its researchers and experts, contributed specialised technical and scientific knowledge; (2) Corpobarranco, a rural women's association, shared valuable empirical knowledge on small-scale food production; and (3) rural small businesses led by women served as STEM laboratories, where different areas of expertise were integrated to foster environmental improvements. These collaborations connected the SENA CBI community with the dynamics and challenges of the local context, providing a platform for developing both green-technical and life skills.

Conclusions

To address climate change and ensure environmental sustainability, we need to move from unsustainable industries to ones that promote green and inclusive growth. Yet, because of the inequities in STEM programmes and careers in Colombia, there are not as many women prepared to enter this sustainable labour market as their male counterparts. This case study demonstrated how the most important and recognised TVET institution in the country could address issues of gender inequity in training programmes with an environmental STEM focus by using an organisational learning approach. The organisational learning approach was crucial to modifying behaviours, attitudes and pedagogical practices that may have been reinforcing the gender gap in STEM.

Change towards a more equitable TVET institution was possible via a gradual learning process, through the stages of Intuition, Interpretation, Integration, Institutionalisation and Inter-organisation. In our case, it was essential that the project team actively involved the TVET institution and dedicated sufficient time to ensure that it acquires the knowledge and skills necessary to develop and continue to improve each stage of the learning cycle on its own. Efforts were directed towards achieving integration and internalisation levels, as this allows progress to be made in modifying the organisational processes, routines and policies in favour of greater participation of women in the green science and technology sectors.

Equally important was the combination of soft and hard strategies and their gradual implementation, as they enable the development of a wide range of skills, from motivation to the application of technical concepts across various productive sectors. Starting with soft strategies facilitated a smoother and more natural transition to hard strategies. This combination proved to be key to breaking down barriers such as the lack of female referents in the green industry, bringing female instructors and trainees closer to environmental practices and technologies in real scenarios, facilitating the processes of interpretation and integration of new STEM knowledge through innovative educational strategies outside the classroom. The selection of easy-to-apply strategies, which can be replicated and sustained over time with the technical, human and financial resources of the TVET institution, should be given priority.

Constant dialogue and communication between external knowledge providers and TVET institution staff allowed for the creation and application of innovative strategies to remove gender barriers in STEM. Spaces for joint reflection enabled the sharing of knowledge, and adjusting, redesigning or maturing strategies, based on a process of co-creation and feedback between

external and internal actors (see Chapter 7 for another example of stakeholder engagement and co-creation).

Finally, SENA CBI proved to be a 'learning organisation' that developed multiple capabilities to more effectively address gender equity issues in STEM through inclusive TVET training. Moving forward, it is crucial that companies of all sizes (micro, small, medium and large) also engage in these learning processes, strengthening their capacity to welcome and empower women, allowing them to take on leadership roles in the transition of productive sectors to green technologies. Until this happens, the efforts made by the TVET institution to empower its apprentices in environmental STEM careers will be in vain, as women shall continue to face barriers in the industrial sector that hinder their progress in Green-STEM fields. Although this chapter has focused on the TVET system in one country in Latin America, it will be important to explore if and how it can be used to facilitate gender equity in Green-STEM programmes of study in other educational contexts.

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