








Women inspiring women in STEM professional careers: Journeys from Latin America

Vianney Lara-Prieto, PhD^{1,2}, Patricia Vázquez-Villegas, PhD², Luis Alberto Mejía-Manzano, PhD², Patricia Caratozzolo, PhD^{1,2}, Rebeca M. García-García, PhD¹, Jorge Membrillo-Hernández, PhD^{1,2}, and M. Ileana Ruiz-Cantisani, PhD¹

¹*School of Engineering and Sciences, Tecnológico de Monterrey, Mexico, vianney.lara@tec.mx, rebeca.garcia.garcia@tec.mx, miruiz@tec.mx*

²*Institute for the Future of Education, Tecnológico de Monterrey, Mexico, paty.vazquez@tec.mx, alberto.mejia.m@tec.mx, pcaratozzolo@tec.mx, jmembrillo@tec.mx*

Abstract— *Achieving gender equality and empowering women and girls around the world is one of the Sustainable Development Goals (SDG) defined by the United Nations. Women are underrepresented in leadership roles at a professional level. Within the engineering and sciences sectors, the gender gap is notorious. There are several initiatives working towards promoting STEM vocations and inspiring women to pursue a professional career in STEM. The Matilda Latin American Open Chair is an academic space that brings people together to promote the participation of women in STEM careers, grow their skills, retain them, and help them to reach their full potential. The Matilda Chair is a collaboration of persons and institutions in Latin America. This work analyzes the fourth book titled “Matilda and Women in Engineering in Latin America 4” which integrates the journeys, stories, and experience from women in STEM to encourage other women to pursue careers in STEM, to further promote gender equality and diversity in these areas. The study analyzes the authors’ profile to understand their context and motivation to be part of the book and suggest strategies to hopefully engage more women in this effort. This work also analyzes the main messages given in each article of the book to understand what is relevant for women, the main challenges they have faced along the way and what advice and learning they share with the readers. Integrating these valuable experiences, their advice, and reflections, elevates the voice of women engineers to give them more visibility and inspire other women to follow their path.*

Keywords— *Educational Innovation, Higher Education, Women in STEM, STEM Education, Socially Oriented Education, Gender Equality, Women networks*

I. INTRODUCTION

The 2030 Agenda for Sustainable Development is an instrument the UN adopted in 2015 to transform the planet's social, environmental, and economic dimensions without leaving anyone behind [1]. It consists of 17 sustainable development goals (SDGs), each with its respective targets. Still, despite being international, they are voluntary and do not contemplate sanctions or have mechanisms to ensure compliance [2]. However, its use for the generation of chemicals has been negligible due to a lack of funds and commitment from governments, a situation that worsened during the COVID-19 pandemic [1]. A great effort must be made to make significant progress in meeting the objectives

towards 2030. This will only be achieved by changing organizational structures and leadership [3].

SDG 5, achieving gender equality and empowering all women and girls, is made up of several targets, including: “Ensuring women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic, and public life”, “Ensuring equal access to education and vocational training for women and girls” and “Enhancing the use of enabling technology to promote women's empowerment”, among others [4]. Gender equality reduces poverty and increases economic growth, social development, and environmental sustainability [4,5].

Gender equality means the behaviors, aspirations, and needs of men and women (socially constructed roles) are equally valued and favored [1]. However, inequalities are still present in society. Work and education are public spheres where women remain segregated [4]. Today, backlash and resistance (denial, inaction, repression), individual and collective, formal and informal, to gender equity are commonly observable [6]. Efforts that have been undertaken to achieve gender equality since the 1970s consist of instruments to reduce poverty and empower women [7] to promote individualism and values of autonomy and self-determination, as opposed to collectivist values that generate acceptance of gender inequalities [8].

A. Context of the gender gap in engineering and science

In sciences, mathematics, engineering, and technology (STEM), the gender gap refers to the disparity in the representation of men and women in these fields and the barriers that prevent them from pursuing and succeeding in STEM careers [9]. According to UNESCO, less than 30% of researchers worldwide are women, and women are more likely to be underrepresented in fields such as engineering, physics, and computer science [10]. Despite significant progress, women remain underrepresented in STEM fields globally. The reasons for the gender gap in STEM are complex and multifaceted. Some factors contributing to this gap include stereotypes and biases, lack of role models, cultural and societal norms, and structural barriers (discrimination and prejudice in hiring and promotion) [11]. Girls may also face gendered

messaging, social pressures that discourage them from pursuing STEM fields, and a lack of access to quality STEM education [12]. In addition, women in STEM often face discrimination, harassment, and a lack of support and recognition [13].

To address the gender gap in STEM, it is essential to promote policies and initiatives that encourage and support girls and women in STEM education and careers [14]. This includes providing access to quality STEM education, supporting female role models, promoting diversity and inclusivity in STEM fields, addressing gender-based discrimination and harassment, and fostering self-concept, self-efficacy, self-confidence, and self-perception [13]. Closing the gender gap in STEM is crucial since it can help address the skills gap and talent shortages in these industries, lead to more innovation and creativity, and lead to more inclusive and sustainable societies. By doing so, we can help build a more equitable and diverse STEM workforce and ensure that everyone can contribute to and benefit from advances in STEM.

B. Initiatives to promote the attraction and participation of women in STEM

A report in 2020 showed that the majority of countries in Latin America had implemented actions for promoting women’s participation in STEM; these have been ad hoc programs, scholarships for girls and young researchers, maternity and paternity licensees, scholarships extensions, competitions, creation of institutions and national gender commits, national gender surveys in science and technology, networks of scientific women, forums, workshops, and diverse activities (such as scientific coffees, round tables) [15]. In turn, these actions may be classified into six interventions: measures for awareness and eradication of gender stereotypes, activities for the attraction of girls and young women to the STEM ambit, potential development of STEM, support for women in STEM careers, specific programs and interinstitutional committees about gender and STEM, training and strengthening of women entrepreneurs in innovation and STEM [15]. In these same activities, international and regional organizations have been involved through critical programs. [15-21]. Table 1 displays some initiatives or programs, the participating organizations, and the benefited countries.

TABLE I
MAIN INITIATIVES AND PROGRAMS IN LATIN AMERICA FOR PROMOTING WOMEN’S INCURSION IN STEM

Initiative name	Organization	Countries
For the women in science	UNESCO, L’oreal	Argentina, Brazil, Chile, Colombia, Mexico, Panama, Peru, Uruguay, and French Guiana

SAGA project	UNESCO	Argentina, Chile, Haiti, Jamaica, and Uruguay
Gender gaps in Science, Technology, and Innovation in Latin	BID	Colombia, Chile, Mexico, and Panama
STEMpreneurs	BID	Colombia, Chile, Mexico, and Panama
Studies on Peruvian Women in the Science	OEI	Peru
Mulher e Ciência	ONU	Brazil
Financial support for indigenous women in STEM careers	IDRC, CIESAS	Mexico and Central America
Cátedra Regional UNESCO. Mujer, Ciencia y Tecnología en America Latina	UNESCO	Latin America
Women in Stem Entrepreneurship	IAE Business School of Austral University, BID, LAB	Argentina, Colombia, Ecuador, Peru, Chile, Republica Dominicana
Women for Science Working Group (WfS-WG)	OWSDW, IANAS	Latin America and the Caribbean
ACTOnGender	EC funding	Latin America
Building the Future of Latin America: Engaging Women in STEM	European Union. ERASMUS	Latin America
Women in INTEL	INTEL	Costa Rica
Female Leadership	Oracle	Colombia
They	Uber	Costa Rica, Mexico and Peru
Geek Girls LATAM	Support: IBM, Jergens, Visa and more	Latin America
Ingenia Women in Engineering and Sciences	Tecnologico de Monterrey	Mexico
OWSD	UNESCO	Global
Matilda Latin American Open Chair	ACOFI CONFEDI LACCEI	Latin America and the Caribbean

Digital Object Identifier: (only for full papers, inserted by LACCEI).
ISSN, ISBN: (to be inserted by LACCEI).
DO NOT REMOVE

C. Books and publications by women in STEM who share their story

At the international level, “Rising to the Top” gathers in an electronic book the stories of women worldwide in the engineering field to inspire the new generation of engineering leaders and provide insights into the challenges facing women engineers worldwide. This initiative is a joint effort of GEDC (Global Engineering Deans Council) and IFEES (International Federation of Engineering Education Societies). This book has been published by various institutions, such as universities and companies [22]. The first two books include stories of engineering women leaders from around the world. The third book from Rising to the Top series focuses on journeys of women from India, and the fourth book brings stories of women from Africa. Among the books encouraging young girls to study STEM careers, according to the portal of MSNBC, are the following titles: Rocket says look up! The Girl who named Pluto, A royal ride: Catherine the Great's Great invention, Secret Engineer: how Emily Roebling built the Brooklyn bridge, Just right: searching for the Goldilocks planet, Frankie Sparks and the Class Pet, Parker Bell and the Science of the friendship, Reaching for the Moon: the autobiography of NASA Mathematician Katherine Johnson, Calling all minds: how to think and create like an inventor [23]. Other books with mentioned objectives dedicated to children at basic education levels are Rosie Revere, Engineer; Ada Twist, scientist; swimming with sharks: the daring discoveries of Eugenie Clark; The Fourteenth Goldfish; Women in Science: 50 Fearless Pioneers Who Changed the World; Radioactive! How Irène Curie and Lise Meitner Revolutionized Science and Changed the World; Wonder Women: 25 Innovators, Inventors, and Trailblazers Who Changed History; 3:59; Lab Girl; In the Land of Invisible Women: A Female Doctor's Journey in the Saudi Kingdom; Hidden Figures [24].

D. Matilda Latin American Open Chair

The Matilda Latin American Open Chair, commonly known as “Matilda”, is an academic space for the debate, reflection, collective knowledge creation, teaching, research, and organizing a variety of activities to promote equal rights, opportunities, and spaces for women in academic and professional contexts, as well as inspire girls and young women in Latin America and the Caribbean to study engineering and sciences (www.catedramatilda.org). The name of the Chair comes from the “Matilda Effect”, a bias against acknowledging the work and achievements of female researchers whose accomplishment is attributed to their male colleagues. The Matilda Chair was created as a collaboration of three institutions: 1) ACOFI (Asociación Colombiana de Facultades de Ingeniería - Colombian Association of Engineering Faculties), 2) CONFEDI (Consejo Federal de Decanos de Ingeniería - Federal Engineering Deans Council) in Argentina, and 3) LACCEI (Latin American and Caribbean Consortium of

Engineering Institutions). These three institutions are non-profit entities that connect engineering institutions in Latin America and the Caribbean to promote global collaboration to foster engineering, innovation, research, technology, and education in these areas.

The Matilda Chair executive board has representatives of the three institutions. Internally, the Chair is organized into six different committees: Communication, Education, Mentoring, Professional Practice, Vocations, and Research. The Matilda Chair members are persons and institutions that join freely and volunteer their work, time and will to implement different activities to promote the vocations, participation, retention, and development of women in engineering and sciences. Among the main activities organized by Matilda are: talks, seminars, panels, workshops, mentoring programs, a research conference, books and podcasts.

Matilda has published a series of books named “Matilda y las Mujeres en Ingeniería en América Latina” (Matilda and Women in Engineering in Latin America). The four books include the stories and journeys of Latin American women in engineering and sciences. The authors share their stories hoping to inspire other women to pursue professional careers in these fields. Their stories share insight about the challenges they have faced and the lessons they have learnt along the way, elevating their voice to create consciousness on the gender gap and the cultural bias experienced in this part of the world.

II. METHOD

This work analyzes the book “Matilda and Women in Engineering in Latin America 4” published in December 2022 by the Matilda Chair with the support of ACOFI, CONFEDI, and LACCEI [25]. The book includes 42 articles with the journey of women from different countries in Latin America, a variety of stories in terms of age, career stage, context, and perspective.

This study focuses on two main objectives:

- 1) Analyzing the authors’ profile
- 2) Analyzing the main messages shared in each article and overall, in the book.

Matilda books are an open call for authors, voluntary and free to participate. The authors’ profile is relevant to understand who the women that are writing are, and what can be done to motivate more women to share their story. Additionally, the authors’ profile provides more context about the person and it can be studied how it relates with the type of topics shared. In this work, the authors’ profile refers to: career stage, academic degree, engineering specialization area, and country. The article itself and professional social media (i.e. LinkedIn, ResearchGate, and OWSD profiles) were utilized to define the profile.

Women in professional practice, especially in areas where the gender gap is bigger, face bias and unequal opportunities that have an impact on their professional and personal lives. Frequently, women navigate unconscious bias from young ages, and even though these challenges build their character and

confidence when overcome, they also discourage many women along the way. The 42 articles in the Matilda 4 book were analyzed and categorized using the following topics by affinity: 1) work-life balance, 2) career decision making process, 3) unconscious bias, 4) women networks and support networks, and 5) career trajectory. A single article may cover one or more of these topics. The objective is to identify the frequency of these topics, analyze the main messages given by the authors, and understand what motivates them to share their thoughts.

III. RESULTS

A. Authors' Profile

Matilda books are an open call for authors, voluntary and free to participate. The authors' profile is relevant to understand who the persons that are writing are, and what can be done to motivate more women to share their story, or more men to tell the story of inspirational women. In the fourth book of the Matilda series, two men participated in writing about the inspirational women.

The variables considered to define the profile of the authors are: their current role, their academic degree, their engineering discipline, and their country of origin. In the variable related to their current professional function (role), more than half of the authors are faculty members in higher education, followed by professionals (see Fig. 1).

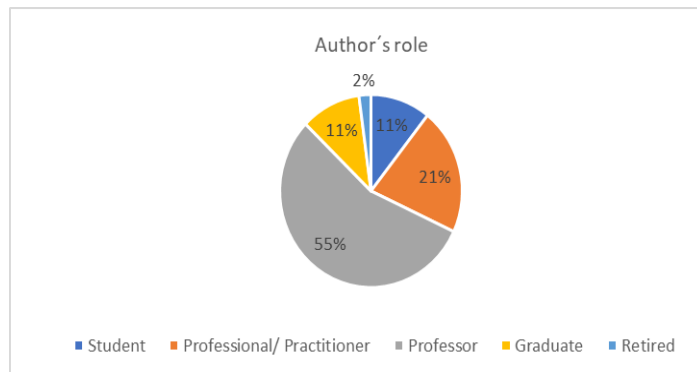


Fig. 1. Author's classification by role.

Authors were also classified regarding their highest academic degree. These results are shown in Fig. 2. It can be observed that 38% of the authors have a Bachelor degree, 27% a PhD, 25% a Master's degree, and 10% are still studying an engineering program.

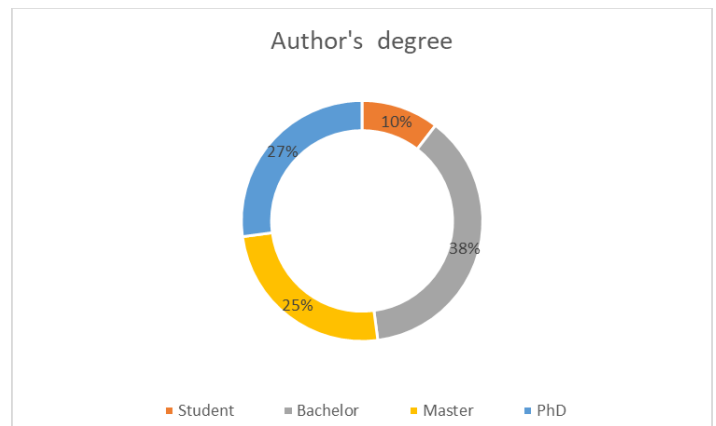


Fig. 2. Author's classification by academic degree.

In this edition, authors of 12 different Engineering Areas participated, being the most frequent Information Technology and Industrial Engineering, followed by Civil Engineering and Electronics/Electromechanical Engineering (Fig. 3). The least represented disciplines are Petroleum and Biomedical Engineering.

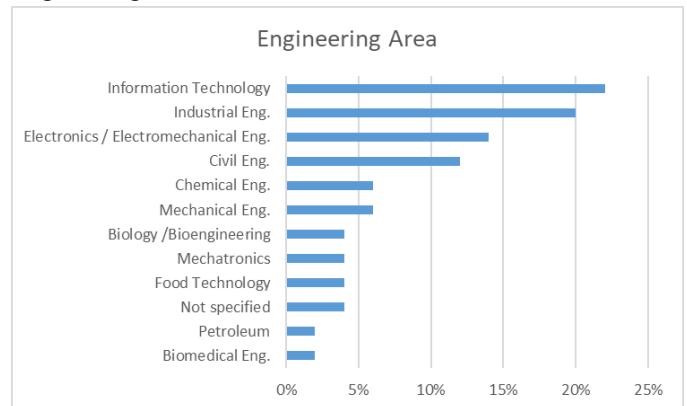


Fig. 3. Author's classification by engineering discipline.

In the fourth book of Matilda, the perspective of 9 different Latin American countries was represented. Argentina and Colombia are the countries with more authors' participation in this book (Fig. 4).



Fig. 4. Author's classification by country.

B. Articles Topics

The articles in the fourth book of Matilda were analyzed and categorized using the following topics by affinity: 1) work-life balance, 2) career decision making process, 3) unconscious bias, 4) women networks and support networks, and 5) career trajectory. It was considered that a single article may cover one or more of these categories. The frequency of these categories was identified to understand what is the main message that the author wants to share (Table II).

The most frequent topics are: career decision making process, followed by career trajectory and unconscious bias. Interestingly enough, most of the authors whose article focuses on the career decision making process, talk about their childhood and memorable experiences that influenced their point of view regarding engineering and sciences. In the same way, the difficulties and challenges they faced are shared in their stories. 8 articles talk about the career decision making process and unconscious bias; this shows how every single comment matters (intentional or unintentional). Being conscious about this should make people think twice before saying something that would discourage girls into studying a STEM related field, or opportunely identify biased comments or situations to avoid or correct them.

TABLE II
ARTICLES CLASSIFICATION BY TOPIC CATEGORY

Topic Category	Frequency
Work-life balance	9
Career decision making process	25
Unconscious bias	16
Women networks / support networks	4
Career trajectory	17

Finally, the narrative type is analyzed (Fig. 5). Most of the articles (93%) talk about personal experience, written in first person. Only 7% (3 articles), tell the story of someone else's life, sharing their career trajectory as role model or talking about unconscious bias. In fact, these 3 articles show examples of unconscious bias and how the protagonist of the story overcame them. Another interesting fact is that 2 of these 3 articles were written by men.

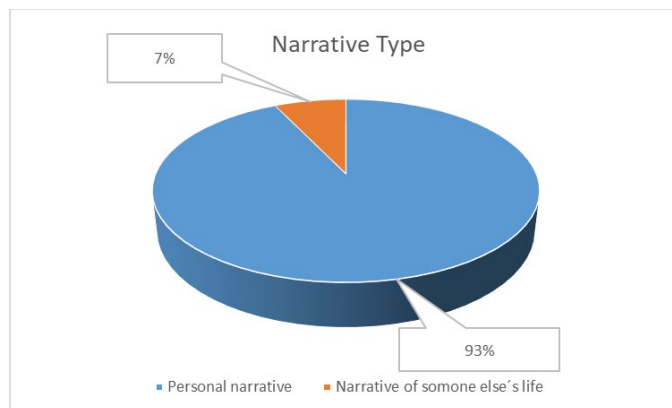


Fig. 5. Narrative Type

IV. DISCUSSION

The fourth book of the Matilda series tells the journey of inspiring women across Latin America, from different backgrounds, at different career stages, but with the same goal in mind: inspire more women to pursue a STEM professional career and empower them to reach their full potential.

The most common topic shared along the book is the career decision making process, in some cases going all the way to describe the career trajectory. It is very relevant to point out that regarding the career choice, several factors were observed to have an impact: socio-economic factors, limited access to quality education [12], the need of having a strong educational background to understand physics, mathematics and basic sciences, lack of female role models [11], unconscious bias, and the support given by parents and family members.

Regarding the socio-economic factors, some authors described the challenges they faced to have access to quality education, to buy their books and study material, the need to move from their home-town with the hope of better opportunities, and the challenge it involves to live away from home. A reflection from this is that it is not only about choosing what to study, but ensuring equal opportunities from early ages with quality education and building the foundations to be prepared to study whatever you like. Some articles concur that, as students, they lacked strong foundations for physics, mathematics and basic sciences. It was mentioned that during the first year at university, some lecturers would mention some concepts as a review for everyone to remember. However, for some of the students, it was the first time they heard about them,

so they had to study hard and prepare themselves outside class to be able to follow the class.

Several articles also relate the career decision making process with childhood experiences, role models within family members, and the support they received from their parents when leaning in for a career in engineering and sciences. Nowadays, there are many initiatives and efforts to increase the participation of women in STEM careers [4]. With these narratives, it is clear that these efforts have an impact on girls of young ages, and that simple memorable experiences can wake up their curiosity and ingenuity. Another common factor was having inspiring engineering role models (male or female) within their family. However, at the same time, it was mentioned the lack of female engineering role models in society, which was also found in literature [11]. The support received by their parents when deciding to study engineering was also considered a relevant factor among the authors. Even though in many cases the support was positive, in others the cultural factors, stereotypes and bias played an obstacle on their journey.

Stereotypes, mental models and unconscious bias were mentioned in different articles, both at the time of the career decision making process and at the professional level in the workplace. Throughout their lives, women receive comments, based on these biases, that sometimes discourage them from pursuing a career in STEM or continuing with their professional growth and development. Some of these type of discouraging comments that women shared in the book are:

- “Go somewhere else to look for a boyfriend.”
- “Shouldn't you be at home washing dishes and cooking?”
- “Engineering is not for girls.”
- “Study something else that would be useful to get married and be a housewife.”

Work-life balance is a common worry when talking about women in the workplace. However, in Matilda 4, it was not a topic frequently mentioned in the articles.

From the total of articles included in the book, 3 out of 42 talk about someone else's journey. In the case of 2 of these 3 articles, men are the ones sharing the story of successful women. One of the male authors talks about the story of the only woman in a class of 200 students that studied a technical profession in electronics in the 1970's in Argentina. Everyone ignored her and looked at her as a weird creature. It took them a while to accept her as a colleague and as one more of the group. The girl was firm with her decision and told the rest of the students that she was planning to graduate, and no one will prevent her from achieving her goal. She was not necessarily looking for acceptance, but at least not being ignored. The efforts and initiatives towards gender equality should involve everyone, not only women, since it requires a conscious cultural change. We celebrate the participation of male authors in Matilda 4 and encourage more men to get involved in this kind of initiative.

Finally, among the messages shared, several authors agree on the relevance of having a purpose. Engineering allows you to understand how things work, to create new knowledge and transform the world into a better place for all. The journey might have challenges and difficulties. However, resilience is a characteristic that defines engineers: hard work, keep up studying and trying, and never giving up. It is ok to ask for help and find or create support networks. Fostering self-confidence and self-perception would help to avoid losing valuable female talent along the way [13]. We must be clear, efforts like the book "Matilda and women in engineering in Latin America 4" are a place where successful women can be role models for other young women who have doubts whether the path of science is the path for professional and personal development. It is actually an effort that promotes diversity, inclusion and gender equality in STEM professional fields and gives more visibility to the voice of women to strengthen their presence around the world. They integrate the journeys of different women around the globe, inspiring stories and experiences that have shaped their lives and careers and that they are now successful women in engineering. Initiatives like this inspire more women to follow their dreams, pursue STEM careers, and empower them to reach their full potential. Let us not forget that the statistics have not changed much in recent years, even the disparity in the number of women is still massive compared to the number of men in STEM careers. If anything, the statistics are modified to have a greater number of women in the STEM careers path, we will have fulfilled our goal.

ACKNOWLEDGMENT

The authors would like to acknowledge the financial support of Writing Lab, Institute for the Future of Education, Tecnológico de Monterrey, Mexico, in the production of this work.

REFERENCES

- [1] L. Eden and M.F. Wagstaff, “Evidence-based policymaking and the wicked problem of SDG 5 Gender Equality,” *JIBP*, vol. 4, pp. 28-57, 2021.
- [2] J. A. Van Zanten and R. van Tulder, “Multinational enterprises and the sustainable development goals: An institutional approach to corporate engagement,” *JIBP*, vol. 1, pp. 208–233, 2020.
- [3] R van Tulder, R. *Business & the sustainable development goals: A framework for effective corporate involvement*. Rotterdam: Rotterdam School of Management, Erasmus University, 2018, pp. 123.
- [4] Achieve gender equality and empower all women and girls, United Nations. <https://sdgs.un.org/goals/goal5>.
- [5] OECD. *The pursuit of gender equality: An uphill battle*. Paris: OECD, 2017.
- [6] M. Flood, M. Dragiewicz and B. Pease, “Resistance and backlash to gender equality,” *Aust. J. Soc. Issues*, vol. 56, no. 3, pp. 393-408, 2021.
- [7] L. Patel, “Gender: Toward gender equality and poverty reduction,” in *Handbook of social policy and development*, J. Midgley, R. Surender and L. Alfors, Eds. UK: Edward Elgar Publishing, 2019, pp. 71-88.
- [8] L.S. Davis, and C.R. Williamson, “Does individualism promote gender equality?” *World Dev*, vol. 123, no. 104627, 2019.
- [9] A. García-Holgado, J. Mena, F.J. García-Peñalvo, J. Pascual, M. Heikkinen, S. Harmoinen ... and L. Amores, “Gender equality in STEM programs: a proposal to analyse the situation of a university about the

- gender gap,” *IEEE Global Engineering Education Conference (EDUCON)*, pp. 1824-1830, April 2020. IEEE.
- [10] Women in science, UNESCO. <https://uis.unesco.org/en/topic/women-science>.
- [11] T. Breda, E. Jouini, C. Napp and G Thebault, “Gender stereotypes can explain the gender-equality paradox,” *Proc. Natl. Acad. Sci.*, vol. 117, no. 49, pp. 31063-31069, 2020.
- [12] I.J. Raabe, Z. Boda and C. Stadtfeld, “The social pipeline: How friend influence and peer exposure widen the STEM gender gap,” *Sociol. Educ.*, vol. 92, no. 2, pp. 105-123, 2019.
- [13] S. Verdugo-Castro, A. García-Holgado and M.C. Sánchez-Gómez, “The gender gap in higher STEM studies: A systematic literature review,” *Heliyon*, no. e10300, 2022.
- [14] T. Schmader, “Gender inclusion and fit in STEM,” *Annu. Rev. Psychol.*, vol. 74, pp. 219-243, 2023.
- [15] Las mujeres en ciencias, tecnología, ingeniería y matemáticas en América Latina y el Caribe, ONU Mujeres – América Latina y el Caribe. <https://lac.unwomen.org/es/digiteca/publicaciones/2020/09/mujeres-en-ciencia-tecnologia-ingenieria-y-matematicas-en-america-latina-y-el-caribe>
- [16] Women for Science Working Group, The I. Partnership (IAP). <https://www.interacademies.org/news/women-science-working-group>.
- [17] Women and STEM disciplines in Latin America: The W-STEM European Project. <https://repositorio.grial.eu/handle/grial/1706>
- [18] WISE: Women in Stem Entrepreneurship. <https://wiselatinamerica.com/>.
- [19] Geek Girls Latam, <https://geekgirlslatam.org/>.
- [20] W-STEM - Building the future of Latin America: engaging women into STEM, GRIAL Research Group. <https://grial.usal.es/wstemproject>.
- [21] #ACTonGender, ACT. <https://act-on-gender.eu/>.
- [22] Rising to the Top, GEDC. <http://www.gedcouncil.org/rising-to-the-top/>
- [23] 10 awesome books for young girls that encourage and celebrate STEM, MSNBC.com. <https://www.msnbc.com/know-your-value/10-awesome-books-young-girls-encourage-celebrate-stem-n1047826>.
- [24] 12 Inspiring STEM Books for Girls, Edutopia. <https://www.edutopia.org/article/12-inspiring-stem-books-girls-emelina-minero/>.
- [25] A. C. Páez Pino, M. T. Garibay, and L. Rathmann, *Matilda y las Mujeres en Ingeniería en América Latina 4*, Argentina, CONFEDI-ACOFI-LACCEI, 2022.