Pathways to STEM: Classifying Initiatives for Encouraging Women to pursue Engineering and Science degrees

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Abstract

In this Work-In-Progress, the primary focus is on analyzing 40 initiatives designed to attract women to STEM degrees offered by eight Latin American universities. Data related to these initiatives was collected through an online survey answered by one representative per university and analyzed using inductive and deductive coding. By classifying these initiatives according to different categories, such as target population and location, findings reveal that most efforts take place at university campuses (30 out of 40 initiatives), and participation is not necessarily restricted to women students (only 4 out of 40). Concentrating on Latin American universities, this study offers region-specific insights for examining local challenges and creating new opportunities for young women to engage with STEM fields. Furthermore, the study contributes to the existing body of research by illustrating how to classify initiatives aimed at increasing women participation in STEM from an empirical perspective.

Introduction

The participation of women in Science, Technology, Engineering, and Mathematics (STEM) careers is essential to promote equity by fully leveraging the available talent in these critical fields. Given that these careers serve as catalysts for the development of new technologies, these fields can contribute to innovation and economic growth, quality of life, and environmental protection, in addition to creating high-demand and often lucrative career paths [5]. Specifically for women, pursuing STEM degrees offers both economic empowerment and opportunities for leadership, entrepreneurship, and self-efficacy, enabling them to challenge gender stereotypes and contribute to more diverse and inclusive solutions across industries. However, women remain significantly underrepresented in STEM fields worldwide, and this disparity is particularly pronounced in Latin America [7]. This issue arises from the early stages of primary and secondary education, being influenced by gender stereotypes and sociocultural factors that affect students' academic decisions [1].

Previous studies have shown that educational experiences during secondary school are key determinants in students' academic decisions of a university degree [1], where behavioral variables such as self-efficacy, interests, outcome expectations, and goals play a fundamental role in their decision [4]. Furthermore, research suggests that students' math achievement in their final years of high school, the exposure to math and science courses, and math self-efficacy, all play a crucial part in determining their intent to pursue a STEM major [8]. External factors, such as demographic shifts in countries undergoing epidemiological transitions, also influence the number of students with the potential to pursue studies in these fields or the preference for short-cycle programs [9]. This intention can translate into an actual STEM field choice at college. In addition, students' entry into STEM can also be affected by postsecondary support and barriers,

including academic guidance, financial aid, and expectations of pursuing graduate studies [8]. Therefore, it is proposed that implementing initiatives that provide information, spark interest, and foster practical development in STEM areas can significantly increase to enhance women representation.

In this Work-In-Progress (WIP), the primary focus is classifying and analyzing various initiatives designed to attract women to STEM degrees offered by a group of Latin American universities. By examining these initiatives, the study aims to provide a comprehensive overview of the strategies employed across multiple institutions, identifying common successful practices and areas needing improvement. The eventual classification of these initiatives into various categories may guide the analysis of their implementation and impact. Concentrating on Latin American universities offers region-specific insights, which are essential for contrasting local challenges and opportunities with those in other regions. Furthermore, the study contributes to the existing body of research by providing an empirical analysis of initiatives aimed at increasing women participation in STEM. The findings are intended to inform policymakers, educators, and university administrators about effective strategies to enhance women representation in STEM, leading to more targeted and impactful initiatives.

Methodology

This study is part of a broader collaborative project that aims to foster, promote and implement best practices that seek to attract women to STEM careers from the school environment —called ELA4ATTRACT [2]. Our research question is: what best practices can be identified from real-life university contexts to attract young women to STEM degrees? Although the overall goal is to encourage the effective implementation of attraction, admission, and retention initiatives for a larger number of women in STEM majors [2], the objective of this WIP is to classify a set number of initiatives implemented at Latin American universities that participate in this collaborative project, aiming to later evaluate the effectiveness of these practices according to different variables.

Specifically, we classified 40 attraction initiatives obtained from eight universities part of a collaborative project (refer to Table 1 and Appendix A), aiming to identify relevant variables to evaluate their effectiveness beyond women students admitted to STEM degrees. These initiatives were reported by university representatives through an online survey (refer to Appendix B) designed to gather information on institutional practices perceived as particularly noteworthy or impactful. Participants were invited to identify and describe initiatives they considered valuable to highlight. It is important to clarify that the initiatives collected through this process do not represent all existing practices at each institution, but rather those selected by the representatives to offer useful insights for the collaborative project. It is important to mention that these university representatives had a key role in the development and implementation of the initiative or had direct contact with the person in charge of that initiative.

One of the partner universities in the project created a Google Forms to collect data about the cultural context of all the participating universities (e.g., size of student enrolment, STEM

degrees offered by the institution, representation among some specific STEM degrees, etc.), and in that same survey, they asked university representatives to share different examples of practices/initiatives to attract and retain students to STEM degrees. A data set was created with the survey responses, most of the answers were attraction initiatives, each represented in a separate row, and each column contained information about the initiative, including the organizing university, the targeted audience, the purpose of the initiative, the delivery format, and a summary of each initiative.

Table 1. Description of universities involved in this study

University	Country	Year of foundation	Type of administration	Student enrolment (*n*)	Faculty (*n*)	Reported initiatives (*n*)
Pontificia Universidad Católica de Chile (PUC CHILE)	Chile	1888	Private non-profit	34.000	3.400	6
Universidad de Chile (UCHILE)	Chile	1842	Public	43.700	3.825	2
Universidad Nacional de Cuyo (UNCUYO)	Argentina	1939	Public	44.160	4.071	7
Universidad de Los Andes (UNIANDES)	Colombia	1948	Private non-profit	19.256	725	7
Pontificia Universidad Javeriana (PUJ)	Colombia	1930	Private	21.170	3.414	7
Pontificia Universidad Católica Madre y Maestra (PUMM)	Dominican Republic	1962	Private	17.000	1.430	3
Instituto Tecnológico de Santo Domingo (INTEC)	Dominican Republic	1972	Private	5.539	615	6
Instituto Tecnológico de Buenos Aires (ITBA)	Argentina	1959	Private	5.000	514	2

To identify relevant categories, we applied a classification methodology based on inductive and deductive coding [6]. First, each of the initiatives was classified according to categories proposed by the university representatives affiliated with the collaborative project (refer to Table 2). Then, researchers involved in this WIP defined a second set of categories that emerged inductively from reviewing the data collected from each one of the initiatives. Specifically, three categories were identified: purpose, venue, and target audience. Each of these categories has its own internal classifications, as shown in Table 3.

Table 2. Categories proposed by representatives participating in the collaborative project

Category	Description	Example of initiative
A.1 Activities at schools	Initiatives that take place at different schools, particularly at high school level.	STEM workshops
A.2 Activities at the university	Initiatives that take place at different universities.	Summer and winter schools, laboratories.
A.3 Competitions	Initiatives that motivate students to work individually or in teams to achieve a specific goal in STEM-related challenges.	Hackathon, Makeathon
A.4 Open Days, Education Fairs	Initiatives that inform and involve students in the academic context, answer their questions and offer the opportunity to talk to university students.	Open days, College fairs
A.5 Outreach (School agenda)	Initiatives that involve the students in academic backgrounds, motivated by each school's agenda.	College students talks and visitations

Table 3. Classification emerging from an inductive analysis

Classification criterion	Category	Description	Example of initiative
Purpose	Inform	Initiatives that provide key information about STEM degrees.	Open days, talks with college students and college tours.
	Involve	Initiatives that aim to give the opportunity to develop STEM-related skills and put them in practice.	Laboratories, workshops and hackathons.
	Support	Initiatives that guide the student in their application processes.	College fairs, talks on how to apply to college and seek funding.
Location	Schools	Initiatives that take place in schools.	Private and public high schools.
	Universities	Initiatives that take place at universities.	Private and public universities.
	Other	Initiatives that do not take place at schools or universities.	Public and private places such as book fairs, town councils and online platforms.
Target population	Women	Initiatives that are oriented to women.	Women-only hackathons.
	All students	Initiatives that are oriented to all the students.	Workshop for all 8th-grade students.
	Others	Initiatives that are oriented to professionals or parents.	Workshop for school counselors.

Once the classification was established, we quantified the total number of initiatives for each category for both sets, that is, the ones proposed by the project and those identified inductively. This was followed by a visualization of the data quantification through bar charts in BioRender, as well as a visual model to establish relationships between the project's categories and the newly introduced ones. It is important to note that a single initiative may have more than one classification, as these categories are not mutually exclusive.

Results

Figure 1 shows the number of initiatives that were classified according to the categories proposed by university representatives who are part of the collaborative project. Most of the initiatives were classified as outreach activities, followed by activities implemented at the universities, such as summer schools.

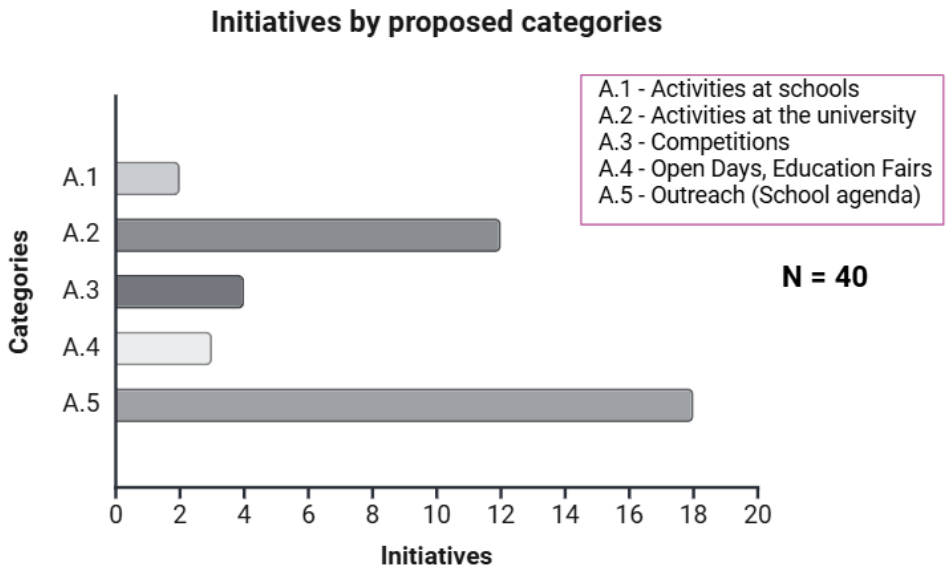

Figure 1. Classifications of initiatives according to categories proposed by the collaborative project (categories described in Table 2).

Although 18 initiatives aim to merely inform prospective students about STEM degrees, there is an important number of practices that aim to develop STEM related skills among these students (*n*=16). Related to the venue category, Figure 3 shows that 30 initiatives were classified as taking place at a university, 7at a school, and three in the other classification, referring to a university careers event held at that country's Book Fair. Concerning the target population category, Figure 4 revealed that 34 initiatives were aimed at all students, just 5 of them were targeted at women only and only one of them were targeted to others, in this case oriented to school counselors.

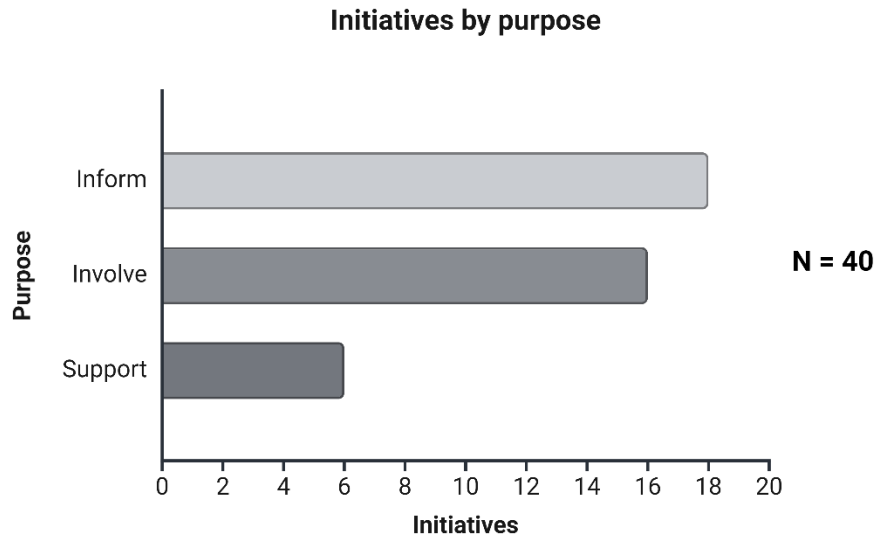

Figure 2. Classifications of initiatives according to their purpose (refer to details of this category in Table 3).

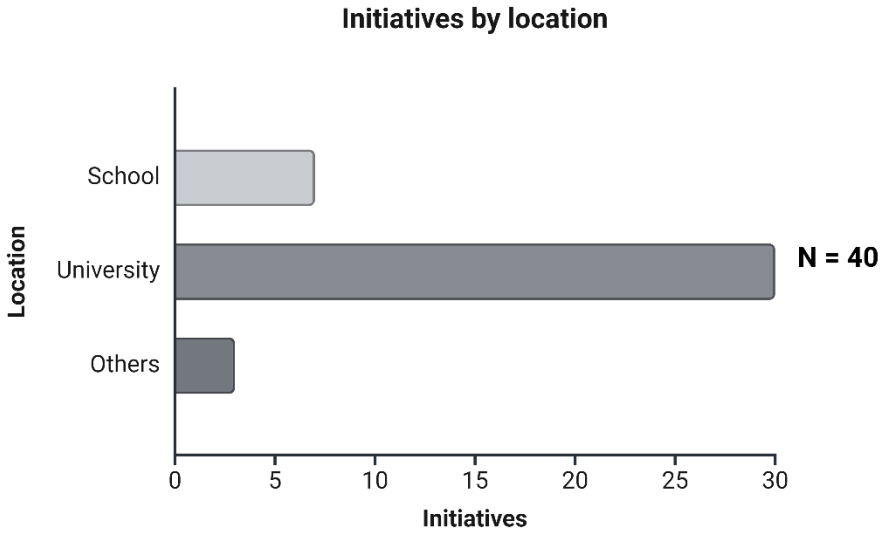

Figure 3. Chart showing classifications by initiative location.

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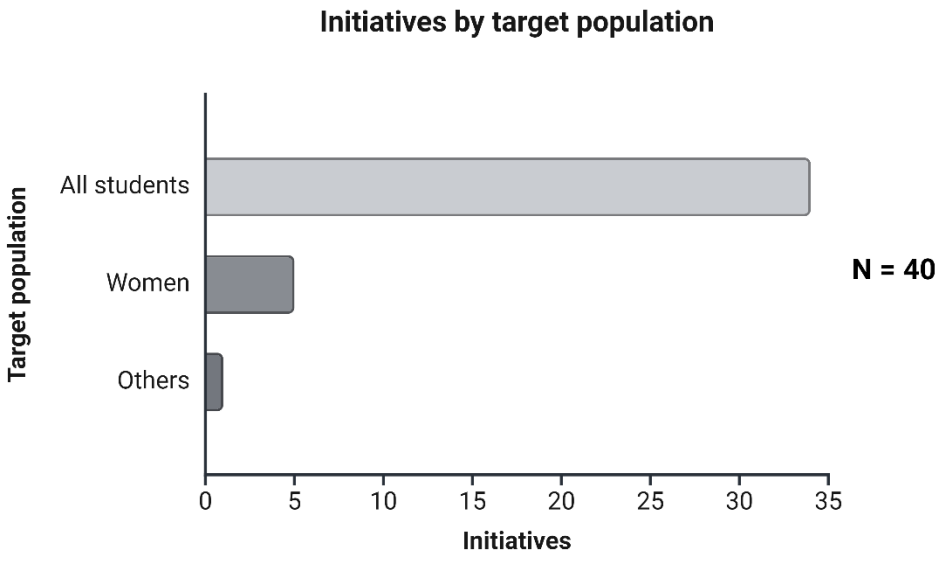

Figure 4. Chart showing classifications by initiative target population.

By cross analyzing the results of having classified the 40 initiatives according to both set of categories (i.e., categories established by project representatives and the categories that emerged from an inductive analysis), we can identify relationships tied to the initiative's purpose (refer to Figure 5). Specifically, the purpose of involving students in skill development (refer to Involve in Table 3) is related to classifications A.1, A.2, and A.3, which allude to activities at schools (A.1), at universities (A.2), and STEM related competitions (A.3).

In turn, the initiatives designed and implemented with the purpose of informing students about STEM degrees (refer to Inform in Table 3) are related to categories A.1 , A.2, A.4, and A.5, including activities at schools (A.1) and universities (A.2), along with open day events (A.4) and outreach efforts (A.5). Still, the latter types of events are also linked to initiatives that aim to support students in applying to STEM programs (refer to Support in Table 3), which are primarily associated with categories A.4 and A.5.

Table 4. Quantity of initiatives aimed to all students or only to women students

	All Students (35 out of 40 initiatives)	**Women students (4 out of 40 initiatives)**
Purpose		
Inform	17	1
Involve	12	4
Support	6	0
Location		
University	25	5
School	7	0
Others	3	0

Furthermore, most initiatives are directed at all students, rather than specifically at women, as shown in the comparison of target populations by purpose and location in table 4.

Discussion and limitations

To identify best practices for attracting young women to STEM degrees offered by real-life university contexts, this WIP study classifies and analyzes various initiatives implemented by eight Latin American universities. The analysis reveals a predominance of initiatives aimed at informing all students about STEM degrees, typically conducted on university campuses. For example, a three-day fair in which students from different regions visit the university to attend educational talks, tour laboratories, and interact with current students. While this initiative targets all majors, there are specific STEM-focused initiatives design to involve students, such as "STEM academy" by PUC Chile, "Women, Science and Technology Event" by UNIANDES Colombia and "Hands-On STEM Workshop" by INTEC, Dominic Republic. These initiatives offer knowledge and immersive experiences in STEM, along with exposure to the wide range of opportunities available in the field.

The classification framework used in this study, based on both project-proposed and inductively derived categories, confirms the feasibility of categorizing 40 initiatives and their corresponding purposes related to attracting women to STEM majors, despite not being exclusively targeted at women students. The findings highlight a strategic emphasis on disseminating information and generating broad interest among the entire student population, as mentioned in [4].

Initiatives that specifically target women students, although less common, may have a significant impact on their decisions by addressing factors such as self-efficacy, interests, and exposure to math and science courses [8]. Furthermore, assessing the impact of women students' decisions to pursue STEM careers presents a challenge, particularly when comparing those involved in general student initiatives with those participating in programs specifically aimed at women students. This requires examining their development through collaboration with peers and the confidence they gain in recognizing their own capabilities.

Although this WIP does not provide enough evidence to assess the impact of the initiatives that have been classified according to the two sets of categories, this study still contributes to addressing the underrepresentation of women in STEM by providing a novel classification methodology for current initiatives. By systematically categorizing and analyzing these initiatives, the methodology identifies existing gaps and offers guidance for developing more effective strategies to attract women to STEM fields.

As shown in the results, most initiatives target all students rather than specifically women, which may seem somewhat contradictory. However, it should be taken into account that many of these initiatives have internal admissions processes that may incorporate a gender equity approach in the selection of participants or reserve additional spots for women. In the future, it will be

important to understand the implications of these factors on the development of the initiatives and determine which approaches yield the best outcomes.

It is also noteworthy that the predominance of initiatives aimed at involving all students (including women) in STEM careers is consistent with what was reported by [8], which is further evidenced by the increase in the number of women enrolled at one of the universities of the project, PUC Chile, before and after the implementation of a women-only program. Specifically, it was observed that before the implementation of the initiative, the percentage of women enrolled increased from 20.7% to 25.3% out of a total of 1,606 and 1,617 students, respectively [3].

The proposed approach enables a comprehensive understanding of all existing initiatives, revealing that most are implemented within the university campuses, and aim to inform or engage all students rather than mainly women. This may encourage further work to explore the impact of going to schools to conduct women-only activities, motivating school educators, university administrators, and policymakers to create targeted, impactful, gender-focused programs.

As with any study, there are limitations, including that the initiative dataset was based on self-reported information subject to the knowledge of university representatives, potentially overlooking other initiatives that might have been implemented by faculty, student associations, or other stakeholders that were not part of the shared knowledge. The dataset also lacks budgetary and financial information for each practice, which varies by university and country, making it difficult to determine the effectiveness or applicability of a given practice to other institutions.

The inductive classification of initiatives was limited to the data collected, which limited the emergence of other categories that could have been relevant to classify attraction strategies, such as content (e.g., coding or mathematics) and length (e.g., one-hour workshop or one-week bootcamp). Additionally, considering the demographics and social context of each country presents challenges in establishing a definitive manual of best practices. Future work involves developing such a manual, capturing lessons learned from the comparison of initiatives across the project.

Acknowledgements

This work was funded by ELA4ATTRACT (project 101128703— ELA4ATTRACT—ERASMUS-EDU-2023-CBHE). This project has been funded with support from the European Commission. This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use that may be made of the information contained herein. The authors would like to thank all project representatives for their contributions to this work in progress, as well as the anonymous reviewers for their valuable feedback.

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Appendix A - List of initiatives analyzed in this study

1. The Scientific Suitcase
2. Educational expo
3. Science fair / Argentine Junior Science Olympiad
4. Research Days
5. Open Science Fair
6. Talks-debates (International Day of Women and Girls in Science)
7. Entrepreneurship contest
8. Hands-On STEM Workshops
9. Informational Sessions and Career Guidance Talks (Virtual/In-person)
10. Visits to Educational Centers
11. Individual and Group Guided Tours
12. Intec Fest
13. Career Panel
14. ITBA Challenge
15. Workshop for High School Career Counselors
16. University Fairs at Schools
17. Internal Invitations to University Facilities for Schools
18. Summer School
19. Hackathons
20. Assistance at the Book Fair
21. ExpoJaveriana
22. Ada Byron Award Ceremony
23. Open House
24. Visit to schools
25. Panel on the Labor Market in Telecommunication Engineering
26. SaviaLab
27. Inter-school Decipher
28. STEM Academy
29. Coding
30. STEM Workshop for International Day of Women in Engineering
31. Technological Schools
32. Guided Tours and University Fairs
33. University Fairs
34. International Day of Women and Girls in Science
35. Program Yourself with Your Program and Walking at Uniandes
36. Relationship with School Counselors
37. Event: Women, Science, and Technology
38. Participation in School Fairs
39. Club of the Cool Kids
40. Uniandes Family Fest and Uniandes Fest

Appendix B - Online survey to collect information about iniatives

The online survey was structured with the following questions, to which each university had to provide open-ended responses:

1. Country
2. University
3. Name of initiative
4. School Level (High School | Bachelor's (Undergraduate) | Master's)
5. Target Audience (high school graduates, high school students, parents, women, students from low-income families, ethnic minorities, rural communities, other)
6. Type of activity (workshop, focus group, mentoring, talk, call, etc.)
7. Format (virtual, in-person, blended)
8. Attraction/Retention
9. Summary/Description
10. Duration/Frequency
11. Communication Strategies
12. Location of the event
13. Support information about the initiative