7 **Women in STEM in Chilean Higher Education**

Social Movements and Institutional Transformations

Jeongeun Kim and Sergio Celis

Overall, women have made significant progress in Chilean higher education. Among the 18- to 24-year-old population, or the traditional college-age population, the proportion of women attending higher education is 44.5%, compared to that of men being only 38% in 2019 (Servicio de Información de Educación Superior [SIES], 2020a). The gap in college attendance between the two groups has increased 4.3 percentage points between 2007 and 2019 (SIES, 2020a), and in 2019, women represented almost 53% of the first-year enrollment (SIES, 2020a). Moreover, women surpass their men counterparts in academic achievement, first-year retention, time-to-degree, and bachelor's degree completion (SIES, 2020a). However, despite this progress and positive indicators in educational attainment, women still face rooted social discrimination and stereotypes across ages and in various aspects of Chilean society (Rebolledo González & Valdés Subercaseaux, 2018). In higher education, women are underrepresented in the highest academic hierarchies such as top-level administration, as well as in some of the prestigious and high-paying fields in Chile (Andrade Lara, 2013). One of the areas where women are significantly underrepresented is in Science, Technology, Engineering, and Mathematics (STEM) fields (Bordon et al., 2020).

In May 2018, multiple student protests across university campuses sparked a large-scale feminist movement across the country (Palma Manríquez, 2018), which had ripple effects on gender structures in Chile. The feminist movement stood against sexual harassment on campuses and demanded victim protection and proper and faster investigations from university administrators (Palma Manríquez, 2018). The movement quickly escalated to a national phenomenon targeting a wide range of issues, such as domestic violence, family roles, and income inequality (Rebolledo González & Valdés Subercaseaux, 2018). The feminist movement also criticized multiple dimensions where women were either excluded or discriminated against. STEM fields are one of the domains where these issues occur. For instance, in 2019, the number of first-year undergraduate men enrolled in engineering and other technology programs was 65.5% higher than that of women (SIES, 2020a). This disparity contributes to women's status in other social spheres, as participation of women in STEM is often linked to personal benefits, such as better

job opportunities and higher income (Kim et al., 2015), and public benefits, such as high quality innovation produced by greater diversity in the field (Allen-Ramidal & Campbell, 2014).

While the feminist movement boosted discussion of women's participation in STEM fields across higher education, STEM students, faculty members, and staff in Chile already had been very active in organizing multiple forms of movements to increase women's participation in and influence on STEM fields in the last decade (Villaseñor et al., 2020). For example, the feminist movement originating from engineering disciplines has been focusing on making relevant changes in Chilean STEM education.

In this chapter, we explore how grassroots movements influence women's participation in Chilean higher education and describe overall patterns in the evolution of women's participation in STEM undergraduate programs. The chapter consists of two parts. First, we begin by discussing a brief history of women's participation in STEM disciplines and other related areas in Chile. We then introduce the main characteristics of the Chilean feminist movement, focusing on the case of Faculty of Physical and Mathematical Science (FCFM) at the Universidad de Chile, where a scientific and intellectual movement (Frickel & Gross, 2005) took place. To describe the case of FCFM, we review archival sources from the college, such as websites, magazines, undergraduate and master's theses, and personal communications with faculty members who were part of the grassroots movement.¹ Second, we analyze the country's higher education enrollment data to describe the evolution of women's participation in STEM fields between 2007 and 2019. We use enrollment trends for exploring to what extent the grassroots initiatives influenced women's representation in STEM across different types of institutions. We conclude the chapter with a discussion of current and future challenges and opportunities for increasing women's participation in STEM in Chile.

An Individual and Collective Journey

About a century ago, Justicia Acuña enrolled in the, until then, all-men FCFM and in 1919 became the first woman engineer to graduate in South América (Dávalos, 2019b). Justicia Acuña then accomplished a distinguished professional career in the National Railway. In Chile, Justicia Acuña represents an important milestone and is an iconic figure for women's participation in STEM (Dávalos, 2019b). Although Justicia Acuña opened the path for women in STEM, the path remained narrow until the beginning of the 21st century. Up until 1960, only ten women had graduated from FCFM. Even in 2014, women represented less than 20% of the entering cohort for the science and engineering programs at FCFM.

Adelina Gutiérrez was another woman who made history in STEM when she became the first Chilean woman PhD in Astrophysics, a degree obtained at Indiana University in the U.S. in 1964. Back in Chile, Adelina Gutiérrez became a faculty member at FCFM and was a leading figure in creating the

first bachelor's degree program in astronomy in the country, which became a key field for the nation. Adelina Gutiérrez's pioneering research and teaching served as a role model for women in the academic profession in STEM fields, as we will further describe in this chapter.

In Chile, in the late 20th century, women needed to open up spaces in STEM disciplines and society at large. During this time, women started to participate in social spheres that, traditionally, were exclusively for men, such as science, business, arts, and politics. For instance, just in 1949, Chilean women obtained the right to vote in the presidential election. In addition to the many individual women who became heroes, leaders, and examples for future generations, women's collective action across the socioeconomic spectrum shaped the nation's destiny at crucial moments (Baldez, 2002). A central episode was women's action on Salvador Allende's presidency and Augusto Pinochet's dictatorship. Regarding the former, groups of upper- and middle-class women organized protests against Allende in the early 1970s and called for military action (Baldez, 2002). One of their most significant actions was the March of the Empty Pots (Crummett, 1977). Regarding the latter, women organized in multiple underground organizations (e.g., student protest, human rights, economic survival, women's right) across the country to resist Pinochet's oppression in the 1980s and to fight back to restore democracy (Baldez, 2002). Among those women was Michelle Bachelet, who would become the first woman president in Chilean history in 2006, crystalizing women's social and political power in society. In the current century, women continue to organize to achieve greater justice in a society where men still hold privileges.

A Bottom-up Feminist Movement at FCFM

The most significant social movements in Latin American contemporary history (e.g., Bellei & Cabalin, 2013; Levy, 1991), such as the feminist movement of 2018, emerged from universities. In particular, Universidad de Chile played a significant role in these movements as the oldest and most prestigious public university in the country. Universidad de Chile was established in 1842, FCFM being among the university's first faculties, and very early on became a catalyst for national progress (Jaksic & Serrano, 1990). Even though the feminist and other historical movements were led by students at Universidad de Chile and other traditional universities, faculty members have substantially contributed to collective actions and political changes (Jaksic, 1989). Here, we explore one of the cases of faculty mobilization, describing how a group of women faculty members at FCFM began to challenge school and university authorities several years before 2018.

According to Snow et al. (2004), social movements are conceptualized as "collectivities acting with some degree of organization and continuity outside of institutional channels to challenge or defend extant authority" (p. 11). Collective action around STEM disciplines started to take form towards the end of the 2000s. In particular, a group of women faculty members at FCFM

started to organize informal channels of communication and share their rough experiences with maternity leaves, academic evaluations, and promotions.

There were two mechanisms that facilitated the gathering at the beginning. First, women faculty organized a small group to do physical activities in the FCFM's gym during lunchtime. They created a mailing list just for FCFM women engineers and scientists (N. Hitschfeld, personal communication, September 23, 2015). Communication among women faculty was crucial because the campus of FCFM was geographically located far away from the other four Universidad de Chile campuses. The physical isolation of FCFM from the rest of the university reinforced a men-dominated environment and women being a distinct minority (Bonilla, 2016). However, this isolation resulted in a positive outcome as women faculty created STEM disciplinary-based organizations on the FCFM campus.

Second, women faculty used the college's academic initiatives to raise attention about women's participation in STEM. Over the 2000s, FCFM went through significant curriculum reform of their undergraduate programs, seeking to add more hands-on experiences and move from teacher-oriented towards student-oriented engineering education. During this period of reform, FCFM received several guests from prestigious engineering schools in the U.S. Several women faculty members that were involved in the curriculum reform attended the guests' talks. In those visits, some of these guests brought up the topic of women's participation in STEM as one of the key issues in the U.S. What the guests shared presented a 'model' of engineering education to FCFM – women's participation as a legitimate engineering education problem and what practices to emulate to address the issue, as mimetic isomorphism explains (DiMaggio & Powell, 1983). This model reinforced the topic among the women faculty members (N. Hitschfeld, personal communication, September 23, 2015), which consisted of less than 15% of FCFM faculty at the time.

In 2011, the women faculty members' group started to call themselves *Adelinas* in honor of Adelina Gutiérrez. The group started discussions with FCFM authorities about issues such as the impact of maternity leaves on academic evaluations and promotions as well as the lack of opportunities for women faculty members to participate in key committees (Dávalos, 2019a), strategizing ways of ensuring women's participation in each of these committees and decision-making instances (Dávalos, 2019a). *Adelinas'* form of collective action resembles the concept of intellectual movements (Frickel & Gross, 2005). According to Frickel and Gross (2005), for scientific or intellectual programs, breaking with the past requires collective action that varies in scope, and it is inherently political and episodic phenomena. Moreover, intellectual movements are usually led by high-status senior scientists and tend to be smaller in size, less revolutionary, and less risky than social movements. Senior faculty members among *Adelinas* assumed leadership, supported and mentored new colleagues, and made their voices heard in critical instances, such as at FCFM's strategic retreats. In 2014, *Adelinas* achieved a national milestone, when FCFM implemented an affirmative action policy for

admitting more women into their undergraduate programs. This initiative was called *Programa de Ingreso Prioritario de Equidad de Género* (PEG), or gender equality admission program in English (Bastarrica et al., 2018).

PEG: The Affirmative Action Program at FCFM

To better understand women undergraduates who are admitted to FCFM, it is necessary to learn more about admission policies of higher education in Chile. Selective public and private universities in Chile have a centralized system for admission. The system, under the authority of the Ministry of Education, operates admissions based on the national admissions tests, including tests in mathematics, language, sciences (i.e., Biology, Chemistry, and Physics), and history and social sciences. In addition to the tests, the system includes high school GPA and high school ranking in the admissions criteria. Each university's programs define the weights given to the tests and high school academic achievement indicators and may designate numbers of students for special admissions up to about 20% of their entering cohort. After the test results are delivered, each student applies to up to ten programs, indicating their preferences using the centralized system. Then, an algorithm assigns the students to the different programs and universities according to their scores (Ríos et al., 2014). Finally, each program receives a list of admitted students and a waiting list for the most sought-after programs.

Like other programs, the context and admission process for FCFM and its PEG program are unique (Villaseñor et al., 2020). Currently, FCFM offers 13 undergraduate programs: 9 engineering specialties, 3 sciences (Physics, Astronomy, and Geophysics), and Geology. All students at FCFM are admitted to a two-year common core program before choosing any of the 13 majors. FCFM admits about 800 students and is one of the most selective academic programs in the nation, recruiting students in the top 5% of the national test scores. PEG was implemented in 2014 in order to increase the number of women entering FCFM undergraduate programs. PEG is a quota program that consists of admitting a certain number of women immediately below the admissions requirement cutoff. In other words, PEG admits women according to their places in the waiting list for the FCFM common core program. The PEG quota has increased from 40 women in 2014 to 55 in 2020.

Part of the PEG rationale is that it helps mitigate the gap in test scores between women and men. In all the standardized tests that measure math academic achievement at the K-12 level, there is a significant gap where men outperform women (Bordon et al., 2020; Mizala, 2018). This gap is also present in the national math test for university admissions, which is the one that has the most weight for FCFM and other engineering and science programs in Chile. Mizala (2018) indicates that this gender gap is influenced by stereotyping of women in schools and families. In particular, Paredes (2014) focused on the role of teacher gender and gender segregated classrooms on women students' math scores. Having a woman math teacher increased the average scores of women

students in a national test, reducing one-fourth of the gender gap in math. The author explained the finding more as a role model impact than teachers' biases in the testing and grading, because the effect of teachers' gender was larger for gender segregated classrooms. Moreover, the study suggested the importance of family role models, such as mothers: the effect of teachers' gender had no effect for girls with mothers with higher levels of education. Bordon et al. (2020)'s analysis of applications to university majors in Chile supported this finding by showing that women are more likely to apply to health majors and less likely to apply to civil engineering and technology. While mother's field of occupation has a higher effect on daughters in health, business, social sciences and humanities, and law, for sons, father's field of occupation has a strong effect on their choices in all areas. Gender segregated schools also reinforced the gendered pattern of major choices via higher interaction with students of a certain gender. Finally, the authors also argued that the choice of a selective program is influenced by social stereotypes, as women may feel more insecure about their own knowledge and less apt to apply for more selective options, being risk averse and shying away from competition. Despite this gap, and as presented at the beginning of the chapter, women in both STEM and non-STEM majors outperform men in almost all academic achievement indicators once they attend higher education institutions.

PEG represents an inflection point for the participation of women in FCFM undergraduate programs. The percentage of women in the first-year FCFM common core program went from 19% in 2013 to 28% in 2014. Moreover, an unexpected effect was that the number of women applying to FCFM also increased (Bastarrica et al., 2018). In 2018, women represented almost 33% of FCFM's first-year cohort. Increasing the number of women at FCFM is an essential step in changing a men-dominated culture that is still perceived as hostile to women (Bonilla, 2016; Villaseñor et al., 2020). For instance, over the first two years at FCFM, women students reported feeling ignored by teachers and teaching assistants, implicitly being excluded from peer study groups, and being victims of other microaggressions such as *machistas'* jokes by teachers and sexual harassment by peers (Bonilla, 2016; Villaseñor et al., 2020).

Adelinas' bottom-up actions influenced other key changes by promoting gender equity for women administrators, faculty, and graduate students. In 2014, FCFM launched the *Programa de Equidad de Género en la Académica* (PEGA), a program aimed to increase the number of women among FCFM faculty members. PEGA consists of scholarships for women to pursue doctoral studies abroad with the commitment to return to a tenure track position at FCFM. Currently, about 17% of the FCFM faculty are women. In 2018, the movement became institutionalized when a new position of Associate Dean of Diversity and Gender Issues was created. In 2019, FCFM's tallest building, which hosts faculty administration, including the Dean's office, was renamed the Justicia Acuña building. These milestones join more than 100 initiatives regarding gender issues, ranging from the promotion of engineering and science to girls in K-12 schools, training for teaching teams, and more women researchers in engineering.

Despite the contribution of the FCFM faculty, many challenges persist in the long-run. One of the challenges is the distribution of women within FCFM programs. Some programs attract a relatively large number of women, such as Geophysics (40%), Astronomy (38%), Biotechnology Engineering (36%), and Industrial Engineering (35%). Yet other programs struggle to attract women students, such as Physics (16%), Mathematical Engineering (15%), and Electrical Engineering (11%). To increase women students in these majors, FCFM has promoted several initiatives, from supporting research to understand the dynamics that influence students' major choice, organizing public talks with distinguished women in these fields, to inviting women students to become teaching assistants (e.g., Villaseñor et al., 2020).

The case of FCFM at Universidad de Chile is an example of the national feminist movement and the social changes of the first two decades of the century. Similar bottom-up changes have been reported in other STEM fields at Universidad de Chile and other science and engineering schools across the country (Paredes-Walker, 2020). Following the example of PEG, two other universities (Universidad Austral de Chile and Universidad Técnica Federico Santa María) located out of Santiago, the capital city, implemented similar affirmative action programs. Other programs have implemented initiatives to attract women without implementing quota systems. For instance, the engineering school at Pontificia Universidad Católica de Chile, another highly selective school, launched the *Mujeres Ingeniería* program in 2013, which promotes women's participation through focal initiatives in high schools and intensive networking among the current students, faculty members, and women alumni. Women's participation in STEM at this institution in terms of the first-year enrollment went from 19% in 2012 to 24% in 2015 (Fariás, 2016).

The case of FCFM at Universidad de Chile is a case of a STEM school at a top-tier university, so it may not represent the trends in all higher education institutions in Chile. On the one hand, Bordon et al. (2020) found that there is a more considerable gap between men and women choosing STEM fields in most Chilean selective institutions. Similar trends have been reported in other countries such as the U.S. and U.K. Despite women students being increasingly represented in selective and very selective institutions in more recent years, they were consistently underrepresented in highly or most selective institutions (Kim et al., 2020), net of background and academic factors (Hearn, 1991; Davies & Guppy, 1997; Ro et al., 2018). This might be in part the result of the most selective institutions tending not to offer traditionally women-dominated programs (Bobbitt-Zeher, 2007) and offering more degrees in fields where women are underrepresented, such as STEM (Bielby et al., 2014). On the other hand, literature on the social movement suggests that movements might have more significant influences on selective higher education institutions as selective institutions are often where the movement starts (Soule, 1997), and, those institutions might have resources to enact required changes in related practices. Thus, in the next section, we examine national-level data on women's enrollment in STEM undergraduate majors in Chile.

Analyzing the higher education enrollment data between 2007 and 2019, we describe how women's enrollment in different STEM majors has changed over time at different types of higher education institutions.

Evolution of the Participation of Women in STEM Undergraduate Education: 2007–2019

This section presents descriptive analyses based on the publicly available historical enrollment data provided by SIES (2020b), a governmental agency at the Chilean Ministry of Education. The database includes enrollment counts and characteristics of enrolled students for all higher education programs aggregated at the program level between 2007 and 2019. For this study, we focused on undergraduate programs only.

It is important to introduce the Chilean higher education context in order to present the results. The Chilean higher education system consists of 150 institutions divided into three major types. *Centros de formación técnica* (vocational-technical centers) (N=52) offer (1) two-year programs (equivalent to ISCED level 5 programs; UNESCO, 2012), and (2) professional institutes (N=39) offer four-year programs (equivalent to programs at ISCED levels 5 and 6); (3) Universities (N=59) are the only type of institutions allowed to grant bachelor, master's, and doctoral degrees (equivalent to programs at ISCED levels 6 and higher) (SIES, 2020c). In 2020, 1,151,727 students are enrolled across the three types of higher education institutions, with 11% at vocational-technical centers, 31% at professional institutes, and 58% enrolled at universities (SIES, 2020d). Vocational-technical centers and professional institutes (technical and professional institutes, TPI hereafter) are considered open access teaching institutions and the majority of their students come from low-income families (Espejo, 2016). Across the higher education system, women represent about 53% of the undergraduate enrollment (SIES, 2020d).

To study the evolution of women's participation in STEM, we addressed three groups of institutions in this section: TPIs, universities, and top-tier universities in science and engineering. We employed the U.S. World and News Report's Best Global Universities for Engineering in Chile (2020) to define the top-tier institutions. Four Chilean universities appear in this ranking: Pontificia Universidad Católica de Chile, Universidad de Chile, Universidad de Concepción, and Universidad Técnica Federico Santa María. We classified programs into STEM and non-STEM programs, according to the 24 Organization for Economic Cooperation and Development (OECD) sub-areas of specialization. We included fields related to agriculture, forestry and fishing, architecture and construction, life sciences, physical sciences, industry and production, computing, engineering, mathematics and statistics, and environmental protection in STEM programs. Non-STEM programs included were those related to arts, education, humanities, social and behavioral sciences, law, business, medicine, journalism, veterinary, and services.

Women in STEM by Institutional Type

We measured participation of women in STEM based on the first-year of enrollment, because it better hints at what has happened as social movements developed and universities, particularly the top institutions, have adopted admissions policies and practices to increase women in their STEM undergraduate programs. First, Figure 7.1, Panel (A) mirrors what was described in the previous section about the expansion of women's access to higher education in Chile. In 2007, the proportion of women among all first-year students in higher education institutions was 51.59%, which increased to 57.20% by 2017. Yet, women's representation in STEM was steadily low at 20%, except for a slight increase observed in 2008 (23.54%) and 2017 (23.11%). The increased representation of women in undergraduate education is mostly driven by the high proportion of women in non-STEM majors, which has been consistently above 61% and reached 65–66% starting in 2017.

Panels (B)–(D) show that women's first-year enrollment in STEM is stratified by institutional type. Specifically, women's representation in STEM programs was highest among the four top-ranked universities. As FCFM set an example that other institutions followed, implementing admissions policies and initiatives to attract women, this might be an expected outcome. Panel (D) shows that the proportion of women among the first-year STEM students was consistently higher by over 10% at these four top-ranked institutions, compared to the national average as well as other institutional types for the last two decades. Also, this group of institutions observed a significant increase in

Figure 7.1 First-year Enrollment: Women in STEM vs non-STEM.

women enrolled in STEM programs. On average, about 32% of the STEM first-year students were women between 2007 and 2009, followed by a slight decline between 2010 and 2013 (30–31%). Yet, in 2014, 2017, and 2018, women constituted 33%, 34%, and 36%, respectively, of the STEM first-year enrollment at top-ranked institutions. It is also important to note that only 42–46% and 53–57% of the students were women across all majors and non-STEM majors, respectively, which were lower than the national average for both measures.

These trends were the opposite for the other two institutional types. In particular, women remain strikingly underrepresented in the STEM programs at TPIs (See Panel (B)). On average, only 15% of the first-year students were women (lowest in 2011 with 11.33% and highest in 2008 with 20.52%). This is significant considering that 57% of all first-year students were women, which has increased by 5% since 2007, and that the proportion of women students in non-STEM majors has been between 62% to 67% during the analytic period.

Panel (C) reports the enrollment trends at universities other than the top four institutions. These institutions showed rather stable trends in the proportion of women first-years at around 26% (2007–2010) to 27–29% (2011–2017), which decreased by up to 3% point by 2019. Meanwhile, the representation of women in non-STEM majors increased steadily from 59% in 2007 to 66% in 2017, which remained at 64% in 2019. To sum, women's representation in STEM is higher at more selective institutions in Chile. This is different from trends reported in other countries such as the U.S. (Hearn, 1991; Davies & Guppy, 1997; Kim et al., 2020) or U.K. (Ro et al., 2018) as well as previous observations made in Chile (Bordon et al., 2020). This finding might be attributable to changes in the admissions policies, such as affirmative action or other initiatives for attracting more women to STEM that were induced by social movements (Villaseñor et al., 2020). Also, prestigious universities tend to offer more degree programs in STEM fields, including those areas (e.g., life sciences, physical sciences) that have relatively higher levels of participation among women in the Chilean context. We provide related analysis in the following section.

Women within STEM Fields

Often, underrepresentation of women is discussed in STEM as a whole. Yet, gender gaps might appear differently in specific STEM majors (e.g., Sassler et al., 2017). Here, we focus on universities and examine trends in enrollment across different majors within STEM. Table 7.1 compares the percentage of women among first-year students in the university system across four fields: Life sciences (e.g., biology, biochemistry, environmental chemistry), Engineering (e.g., mining, civil, electrical), Physical sciences (e.g., geology, astronomy, chemistry, physics) and Computing (e.g., computer programming, information systems) between 2007 and 2019.

Table 7.1 Percentage of Women by Major, First-year Students: All Universities

	<i>Life Sciences</i>	<i>Engineering</i>	<i>Physical Sciences</i>	<i>Computing</i>
2007	55.65% (16 institutions)	19.74% (35 institutions)	51.09% (18 institutions)	13.24% (40 institutions)
2009	52.83% (16 institutions)	23.12% (33 institutions)	46.35% (19 institutions)	13.99% (39 institutions)
2011	52.97% (17 institutions)	20.84% (35 institutions)	45.85% (23 institutions)	14.28% (39 institutions)
2013	52.46% (15 institutions)	25.91% (38 institutions)	41.18% (25 institutions)	11.68% (40 institutions)
2015	51.53% (15 institutions)	19.49% (37 institutions)	44.20% (26 institutions)	12.12% (38 institutions)
2017	46.52% (16 institutions)	21.80% (38 institutions)	50.44% (25 institutions)	10.61% (35 institutions)
2019	50.78% (17 institutions)	19.93% (39 institutions)	47.95% (25 institutions)	9.96% (35 institutions)

Notes: Analysis focuses on all universities, including the top-tier universities.

Not all majors in STEM have the same level of underrepresentation among women. Although the data do not allow us to analyze enrollment trends by specific disciplines, we observe the proportion of women among the first-year students enrolled across broader subject areas. In particular, life sciences programs filled over 50% of their first-year enrollment with women students, and even the lowest point for the proportion of women enrollment in the respective major was 47%; similarly, women were 45–50% of first-year enrollment in physical sciences between 2007 and 2019. In contrast, engineering and computing majors have a significantly lower proportion of women among their first-year students, even though the number of institutions offering these programs is nearly twice the number of those offering life sciences and physical sciences. On average, women usually made up about 20% of the first-year enrollment in engineering programs, which peaked at 26% during the analytic period before decreasing again to 19.93%, which is close to where the observation started in 2007. For computing majors, the proportion of women is even lower, showing mostly diminishing trends over time: in 2007, 13.24% of first-year enrollment was women, which increased slightly through 2011 (14.28%), then decreased to 9.96% as of 2019. This underrepresentation among women in engineering and computing majors is critical considering that higher education is the gateway for women for science and technology professions and diverse social roles. Also, this suggests the importance of understanding women's access to STEM in a more nuanced way as well as understanding sub-field level participation when it comes to designing policies and practices to attract and support women.

Discussion

While increasing women's representation and their voices in STEM is a keen interest in many countries, most approach it from a top-down perspective where public policy or related industry and organizations lead initiatives. In this chapter, we discussed how women's participation in undergraduate STEM programs might be improved via social movements using the Chilean case as an example. We first introduced the historical changes that happened at FCFM at Universidad de Chile to exemplify how women faculty members' grassroots movement produced relevant institutional changes to increase the participation of women in STEM, such as the PEG affirmative action for admission into engineering and physical science programs. The evidence suggests that women faculty members' collective action resembles a scientific and intellectual movement (Frickel & Gross, 2005). The movement at FCFM was effective in increasing the percentage of women in undergraduate programs and institutionalized gender and diversity issues at the top administration level. The case of FCFM served as an example for other institutions that subsequently adopted institutional policies to attract more women students to STEM undergraduate programs, and FCFM is continuing to share its success stories and advise other engineering and science campuses in the country to follow suit.

It is important to note that it is too early to forecast how far the movement will go in its efforts. The grassroots movement is continuing work on its agenda to make FCFM a welcoming place for women, promoting science and engineering among K-12 students, and conducting research on gender related topics in STEM fields. It is also attending to issues with recruiting and retaining women faculty, such as hiring and promotion practices. Therefore, more future research is needed to examine the impact of the grassroots movement on gender equality in STEM fields. Future research is warranted for a deeper understanding of women students' experiences at FCFM and their trajectories beyond graduation such as access to graduate education or working in STEM professions that fit their majors. We encourage researchers to examine how the feminist social movement is perceived by students, faculty, and university administrators. Additionally, researchers may consider how the grassroots movement results in changes and adoption of policies and practices to attract, retain, and support women in STEM, as well as how these efforts are legitimized and encouraged by the central and local governments and related industries in Chile.

In this chapter, the analysis of the national trends in undergraduate enrollment data suggested that the social movement-induced, institutional changes that were made at FCFM, along with the nation's other prestigious institutions (e.g., the School of Engineering at Pontificia Universidad Católica), to attract more women might have achieved some success. The country's top four institutions already had a better representation of women in their STEM programs in 2007 compared to other institutions in the country. Yet, in the periods after the

introduction of affirmative action (2014) or other engagement programs, the proportion of women among STEM first-year students increased by 2% in the first-year, and up to 5% approximately four-years after implementation. While this improvement shows the potential of making these academic units act as a spearhead that can influence the rest of the country's institutions in the long-run, the national-level statistics and data from institutions that provide more open access to higher education raise significant questions.

At the national level, women's participation in STEM is still and has been steadily low as women make up just above 20% of STEM enrollment, despite the drastic increase in women's access to higher education and academic achievements that surpass men. Yet, somehow, the mobilization of women on university campuses, and the greater public awareness about women's underrepresentation in STEM fields, is not yet reflected in the national data. This might be due to the stratification of higher education institutions and STEM programs where top schools with more resources have capacities to implement affirmative action policy, develop engagement programs and practices, and build faculty capacity (e.g., more women faculty in general and/or in STEM) thereby implementing a systematic approach. Also, the students who apply, receive admission, and matriculate to STEM programs at top institutions might have different attributes, such as higher socioeconomic status and better academic preparation than students enrolled in other types of institutions or non-STEM majors.

In fact, we found that women's enrollment in STEM is strikingly low for the last 12 years of analyzed data for TPI institutions. Since TPI enrolls students primarily coming from low-income families, their role in addressing the gender gap in STEM is important where the issues of gendered education and social class intersect. According to Sepúlveda (2019), Chile's vocational and technical education sector was firmly rooted in Chile's early industrialization process at the end of the 19th century. Women were from very early ages pushed towards service majors and clothing manufacturing. Since the 1980s, women have moved towards other TPI programs, such as education, health, and administration and accounting. Women remain underrepresented in vocational STEM programs, such as automotive mechanics or telecommunications, that provide the highest employability and income in the sector (Sepúlveda, 2019). These different major offerings at TPI institutions may place women in the lower paying jobs in the country. Usually, TPI is off student movements' radar and receives little attention from educational researchers in Chile. Public policy must pay greater attention to the participation of women in STEM programs at TPis. Joining efforts with the successful programs in top-tier universities in giving support to gender initiatives and programs TPis is an action worthy to explore. The TPI sector represents about 40% of Chilean higher education and is an effective route for social mobility, and there is potential to significantly increase women in STEM.

In addition to the institutional type, we found that there is great variability of women enrollment within STEM programs. Underrepresentation of

women is severe in engineering and computing fields across all universities, despite the number of institutions that offer engineering and computing is nearly twice more than the universities offering science majors. The FCFM case also shows that within engineering, there are significant differences between subfields, with low percentages of women in math and electrical engineering. While these are the key areas for Chile's economic sustainability and technological progress, not recognizing the nuanced placement of women across sub-STEM majors would have ramifications for women's career and life opportunities as well as for the diversity and innovation of Chilean society through science and technology. While different fields have unique norms and cultures, it is important to understand how women are attracted and retained across different types of institutions. It is also important to better understand how universities, departments, and faculty shape women students' experiences during college and influence their outcomes beyond undergraduate education.

Conclusion

The participation of women in STEM in Chilean higher education is unique and significant as their progress stems from social movements and scientific and intellectual movements internal to higher education. The achievement of these movements that resulted in institutional policies that increased women's representation in STEM suggests to other countries the pivotal role of letting faculty and students, particularly women groups' voices, be heard. While the systems' most prestigious institutions have led the changes and progress, we suggest that the Chilean and other educational systems consider how to encourage and support institutions that lack resources, capacities, or means to attract and support women undergraduates in STEM, considering the unique backgrounds of and challenges experienced by the students at these institutions.

Note

- 1 The corresponding author has been part of FCFM since 2015 and is currently part of the internal council of the Associate Dean's office for gender and diversity affairs, which helped the authors identify and understand these materials.

References

- Allen-Ramidal, S. A., & Campbell, A. G. (2014). Reimagining the pipeline: Advancing STEM diversity, persistence, and success. *BioScience*, 64(7), 612–618.
- Andrade Lara, C. (2013). *Del biombo à la cátedra: Igualdad de oportunidades de género en la Universidad de Chile*. <https://doi.org/10.34720/3vwj-m574>
- Baldez, L. (2002). *Why women protest: Women's movements in Chile*. Cambridge University Press.
- Bastarrica, M. C., Hitschfeld, N., Samary, M. M., & Simmonds, J. (2018). Affirmative action for attracting women to STEM in Chile. *Proceedings of the 1st International Workshop on Gender Equality in Software Engineering*, 45–48.

- Bellei, C., & Cabalin, C. (2013). Chilean student movements: Sustained struggle to transform a market-oriented educational system. *Current Issues in Comparative Education*, 15(2), 108–123.
- Bielby, R., Posselt, J. R., Jaquette, O., & Bastedo, M. N. (2014). Why are women underrepresented in elite colleges and universities? A non-linear decomposition analysis. *Research in Higher Education*, 55(8), 735–760.
- Bobbitt-Zeher, D. (2007). The gender income gap and the role of education. *Sociology of Education*, 80, 1–22.
- Bonilla, N. (2016). *Experiencia académica de estudiantes mujeres en primer año de ingeniería. propuestas de mejoramiento de los sistemas de apoyo a estudiantes con mirada de género* [Unpublished master's thesis]. Universidad de Chile.
- Bordon, P., Canals, C., & Mizala, A. (2020). The gender gap in college major choice in Chile. *Economics of Education Review*, 77, 102011. <https://doi.org/10.1016/j.econedurev.2020.102011>
- Crummett, M. A. (1977). El poder pfFeminino: The mobilization of women against socialism in Chile. *Latin American Perspectives*, 4(4), 103–113.
- Dávalos, A. (2019a). Red Adelina Gutiérrez: Académicas por la equidad de género. *Beauchef Magazine*, 12, 16–18.
- Dávalos, A. (2019b). La primera ingeniera de Sudamérica: Un logro con Justicia. *Beauchef Magazine*, 12, 26.
- Davies, S., & Guppy, N. (1997). Fields of study, college selectivity, and student inequalities in higher education. *Social Forces*, 75(4), 1417–1438.
- DiMaggio, P., & Powell, W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review*, 48(2), 147–160.
- Espejo, A. (2016). La educación técnico-profesional en el futuro. *Estudios Sociales*, 124(1), 161–178.
- Farias, J. (2016). *Mujeres ingeniería UC y más mujeres para la ingeniería y las ciencias de la U. de Chile: una mirada al impulso del acceso, experiencia y permanencia de las mujeres en las carreras ingenieriles y científicas en Chile* [Unpublished master's thesis]. Universidad de Chile.
- Frickel, S., & Gross, N. (2005). A general theory of scientific/intellectual movements. *American Sociological Review*, 70(2), 204–232.
- Hearn, J. C. (1991). Academic and nonacademic influences on college destinations of 1980 high school graduates. *Sociology of Education*, 64(3), 158–171.
- Jaksic, I. (1989). *Academic rebels in Chile: The role of philosophy in higher education and politics*. State University of New York Press.
- Jaksic, I., & Serrano, S. (1990). In the service of the nation: The establishment and consolidation of the Universidad de Chile, 1842–79. *The Hispanic American Historical Review*, 70(1), 139–171.
- Kim, C., Tamborini, C. R., & Sakamoto, A. (2015). Field of study in college and lifetime earnings in the United States. *Sociology of Education*, 88(4), 320–339.
- Kim, J., Jung, J., & Mlambo, Y. A. (2020). Institutional selectivity and occupational outcomes for STEM graduates: A generational comparison. *The Journal of Higher Education*. <https://doi.org/10.1080/00221546.2020.1819945>
- Levy, D. (1991). The decline of Latin America activism. *Higher Education*, 22(1), 145–155.
- Mizala, A. (2018). Género, cultura y desempeño en matemáticas. *Anales de La Universidad de Chile*, 14, 125–150.

- Palma Manríquez, I. (2018). Debates abiertos en la coyuntura sobre las instituciones universitarias por las estudiantes del movimiento mayo feminista. *Anales de La Universidad de Chile*, 14, 89–107.
- Paredes, V. (2014). A teacher like me or a student like me? Role model versus teacher bias effect. *Economics of Education Review*, 39, 38–49. <https://doi.org/10.1016/j.econedurev.2013.12.001>
- Paredes-Walker, V. (2020). Mujeres que marcan precedentes en Ingeniería. Su experiencia en la carrera académica en una universidad de investigación en Chile. *Revista Iberoamericana de Educación Superior*, 30(11), 137–159.
- Rebolledo González, L., & Valdés Subercaseaux, X. (2018). Género y orden social: Dificultades para implementar relaciones de género igualitarias en la vida cotidiana. *Anales de La Universidad de Chile*, 14, 17–30.
- Ríos, I., Larroucau, T., Parra, G., & Cominetti, R. (2014). College admissions problem with ties and flexible quotas. Article no. 2478998. <http://dx.doi.org/10.2139/ssrn.2478998>
- Ro, H. K., Fernandez, F., & Alcott, B. (2018). Social class, human capital, and enrollment in stem subjects at prestigious universities: The case of England. *Educational Policy*. <https://doi.org/10.1177/0895904818813305>
- Sassler, S., Michelmor, K., & Smith, K. (2017). A tale of two majors: Explaining the gender gap in STEM employment among computer science and engineering degree holders. *Social Sciences*, 6(3), 69–96.
- Sepúlveda, L. (2019). Estudiantes mujeres en educación técnica profesional en Chile: Continuidad y ruptura en inclusión educativa. *Sinética*, 53(1), 1–19.
- Servicio de Información de Educación Superior (SIES). (2020a). *Informe de brechas de género en educación superior: Datos 2019*. Ministerio de Educación de Chile. https://www.mifuturo.cl/wp-content/uploads/2020/03/Brechas-de-genero-en-educacion-superior_SIES_2019.pdf
- Servicio de Información de Educación Superior (SIES). (2020b). *Base de datos de matriculados en educación superior: Histórica 2007–2020*. Ministerio de Educación de Chile. <https://www.mifuturo.cl/bases-de-datos-de-matriculados/>
- Servicio de Información de Educación Superior (SIES). (2020c). Instituciones de educación superior vigentes: 31 de diciembre de 2019. <https://www.mifuturo.cl/instituciones-de-educacion-superior-en-chile/>
- Servicio de Información de Educación Superior (SIES). (2020d). Informe 2020: Matrícula en educación superior. https://www.mifuturo.cl/wp-content/uploads/2020/07/Informe-matricula_2020_SIES.pdf
- Snow, D. A., Soule, S. A., & Kriesi, H. (2004). Mapping the terrain. In D. A. Snow, S. A. Soule, and H. Kriesi (Eds.), *The Blackwell companion to social movements* (pp. 3–16). Blackwell Publishing.
- Soule, S. A. (1997). The student divestment movement in the United States and tactical diffusion: The shantytown protest. *Social Forces: A Scientific Medium of Social Study and Interpretation*, 75(3), 855–882.
- UNESCO Institute for Statistics. (2012). International standard classification of education ISCED 2011. <http://uis.unesco.org/sites/default/files/documents/international-standard-classification-of-education-isced-2011-en.pdf>
- U.S. World and News Report. (2020). Best global universities for engineering in Chile. <https://www.usnews.com/education/best-global-universities/chile/engineering>
- Villaseñor, T., Celis, S., Queupil, J. P., Pinto, L., & Rojas, M. (2020). The influence of early experiences and university environment in female students choosing geoscience programs: A case study at Universidad de Chile. *Advances in Geosciences*, 53, 227–244.