Concept Paper

Belonging and Masculinities: Proposal of a Conceptual Framework to Study the Reasons behind the Gender Gap in Engineering

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Abstract: The low participation of women in STEM fields is well-known and has been well documented around the world. Closing this gap plays a central role in achieving a more equal society and thus sustainable development. The gender gap in STEM must be understood as a complex problem which can be explained through various factors (cultural, economic, and social) and therefore requires the efforts of different disciplines and actors. This article proposes that the hegemonic masculinity theory together with the concept of belonging, understood from the point of view of feminist studies and cultural studies, can contribute a necessary conceptual framework for understanding the causes behind the gender gap in engineering.

Keywords: gender gap; engineering; belonging; masculinities and technology; STEM

1. Introduction

Closing gender gaps in science and technology is a cornerstone for the development of society. In fact, gender equality is the fifth 2030 Sustainable Development Goal (SDG) established by the United Nations [1]. This objective includes six targets, three of which are related to the educational realm: end discrimination against women and girls; promote empowerment of women through technology; and adopt and strengthen policies and enforceable legislation for gender equality. Additionally, SDG4, concerning quality of education, is also linked to gender equality as it aims to eliminate gender disparities in education and ensure equal access to all levels of education and vocational training [1]. Moreover, according to the Organisation for Economic Cooperation and Development, "gender equality and environmental goals are mutually reinforcing" [2].

In addition to the above, in understanding sustainability as a multidimensional concept in which social, environmental, and psychological coordinates converge [3], it becomes imperative to remove barriers to access and obstacles to women's retention in STEM disciplines in order to achieve a more sustainable future as this gender gap has consequences that threaten the well-being of women, gender equity, and diversity and ultimately social sustainability.

1.1. Some Axes to Study the Gender Gap in STEM

When researching the gender gap in STEM (Science, Technology, Engineering, and Mathematics) it is necessary to consider—at least—three axes: To document the low proportion of women in these disciplines; to account for the consequences at different levels that this brings; and to investigate the reasons that could lead to the gender gap, taking into account the relational and performative dimension of gender [4]. This article aims to contribute to the development of the third axis.

As an example of the first one, we mention some numbers corresponding to Chile: According to the 2020 Analysis of Gender in Science, Technology, Knowledge, and Innovation [5], the percentage of women enrolled in undergraduate programs reached 55% in

2020, which is certainly great news. However, if this is disaggregated by discipline, we find that programs from the area of technology only account for 24% of female enrollment and basic sciences reach 47%. In contrast, social sciences and health degrees, many linked to the field of care, which has been historically related to what is considered 'feminine', reach 65% and 74%, respectively. Additionally, by 2018 degrees related to science, engineering, industry, and construction showed enrolment rates close to 25% [6]. This phenomenon is commonly known as horizontal segregation, caused by the sexual division of knowledge, activities, and spaces, which itself translates into the low participation of women in STEM degrees [7]. Similarly, gaps exist on a vertical level. In 2020, the enrolment rates of women in master and doctoral programs from the technology area in Chile were 24% and 33%, respectively [5]. This gender gap worsens as the academic path advances [8]. In fact, only 34% of researchers in Chile are women; 38% of people with publications indexed to the Web of Science (WoS) between 2010 and 2018 were women; and only 15% of the total number of patent requests are conducted by women [5]. Furthermore, the COVID-19 crisis has had vast negative impacts on the field of women in academia around the world, particularly those in the STEM areas [9–11].

Regarding the second axis, the scarce female participation in STEM degrees has consequences of a different nature: For women, for knowledge production, and for the economy. For instance, for women it can impact salary differences and occupational prestige as feminized disciplines are usually undervalued by the market and remunerations are lower. As an example, the University of Chile confirmed that the faculties with a lower participation of women—such as Physics and Mathematical Sciences, where engineers are formed—have the highest salaries, while faculties with a higher presence of women—such as the Institute of Nutrition and Food Technology—have lower-paying salaries [12]. Moreover, for knowledge production it can translate into increased biases in scientific production. From feminist theories, Fox Keller [13] advocates that this gender gap conditions, among other things, degree choices as well as the way observations are interpreted. In this manner, it becomes clear how the participation of different perspectives adds creativity, reduces potential biases, and creates more robust knowledge and solutions, which in turn promotes scientific excellence [14]. Lastly, from an economic perspective it is asserted that eliminating the barriers which hinder women's development in these occupations could increase labor productivity up to 25% in some economies [15].

The gender gap in STEM is not unique to Chile. In fact, it is considered a worldwide problem [14,16]. It is fundamental to understand the gender gap in STEM as a complex problem, which can be explained through several factors (cultural, economic, and social), and hence requires efforts from different disciplines and actors [7,17,18].

Regarding the third axis, there is a lot of literature that tends to analyze the reasons behind the gender gap in engineering in terms of 'deficits' [19]. That is, the reasons behind the low participation of women in these areas would be the absence of certain characteristics in them, for example a lack of socialization to hands-on tinkering. However, this approach does not take into account the institutional or structural barriers that may be intervening in the participation and persistence of women. Many of these studies have used the sense of belonging as a variable to explain the attrition of women in different STEM careers. However, the notion of belonging is either taken for granted or understood as Baumeister and Leary do, that is, as "the perception of social connectedness in groups, that is, of fitting in socially with others" [20,21] (as cited in [22]). Valuable though it has been, this conception of the term overlooks the analysis of the discourses of different agents in addition to the individual—such as institutional discourse, that of teachers and that of peers—which shape the different axes of the experience of belonging.

1.2. Review of the Concepts to Be Used

In view of the above, the multidimensional notion of belonging (which will be further developed in Section 3.1) appears as a very useful category to analyze the gendered

academic cultures in engineering (please see Section 3.1 for more details on these analytical dimensions) [23,24].

Moreover, in understanding gender as a category that observes the relational and sociocultural dimensions which arise from the biological differences between the sexes [25], it becomes imperative to understand the association between the identities linked to being a male engineer and the processes of the social construction of masculinities, with the subsequent impact this could potentially have on the pathways and trajectories of (most) women in engineering. For this purpose, we review the concept of hegemonic masculinity and the contributions that feminist technology studies have made to the question of masculinities in technology. We aim to highlight the importance of investigating how hegemonic masculinity is symbolically reinforced through technology.

This article is intended to propose a conceptual framework to investigate the reasons that might be behind the gender gap in STEM, particularly in engineering, taking as the object of study the culture of the engineering students' communities from an interdisciplinary and gender perspective. More precisely, we aim to propose hegemonic masculinity theory together with the concept of belonging, understood from the point of view of feminist studies and cultural studies, to analyze the engineering culture that generates differential experiences between men and women.

In addition to the reasons already given, the choice of belonging and masculinities theory as conceptual frameworks for understanding the causes behind the gender gap in engineering lies in the hypothesis that there is a relationship of dependence between them. We believe it is important to investigate whether the same discourses and symbols that reinforce the equation between masculinity and technology are at the same time those that construct gendered experiences of belonging and act as mechanisms of exclusion for women, as well as for other subjects who do not fit the ideals of hegemonic masculinity.

We will use Lave and Wenger's [26] notion of 'communities of practice', later revisited by Eckert and Mc Connell-Ginet [27] in their work on language and gender. According to them, a community of practice is a group of people gathered around a common commitment or purpose. Here, practices, understood as ways of doing things, ways of speaking, beliefs, values, and power relations, appear in the evolution of this shared purpose. Thus, we will understand the community as the wide community of practice of the engineering students at a given institution.

The next section discusses some research that has been carried out in our area of interest. This is followed by a section that presents the conceptual tools we propose for the study of the causes of the gender gap in engineering. We conclude the paper with a section of conclusions and some proposed research questions for this topic.

2. Background

2.1. Research Approaches in Gender, Engineering and Technology

Research surrounding gender, engineering, and technology can be described through at least two different approaches. On one hand, the perspective of 'women in technology' has been widely researched, and it carries within it the underlying question of 'why so few?' women in engineering [28]. Literature related to this question has tended to analyze women's low participation in engineering in terms of 'deficits'. In other words, young women's resistance to choosing engineering degrees is explained by an alleged deficit of women or in their socialization, for instance a lack of socialization to hands-on tinkering [19]. Nowadays, there seems to be consensus surrounding the limitations and inadequacy of this approach to explaining women's under-representation in engineering and mathematics degrees [29,30]. Despite years of focus on this question, with its subsequent 'women into engineering' sorts of campaigns, which seek to encourage girls to choose engineering degrees, women's participation continues to be very low worldwide. In the words of Faulkner, "the virtual failure of these initiatives indicates a failure to critically analyze the ways in which technology itself gets gendered in the eyes of would-be technologists" [28] (p. 79). Specifically, the author states that if this phenomenon is to be analyzed from a

gender perspective, it is imperative to shift the focus from the women's position and begin to integrate perspectives on masculinities. In other words, to expand research surrounding men and the masculinities of engineering and question "the enduring symbolic association of masculinity and technology by which cultural images and representations of technology converge with prevailing images of masculinity and power" [28] (p. 79). This question about masculinities would enrich the analysis and open space for a new approach: 'gender in/of engineering' [19].

Regarding retention, drop-out, and the continuation rates of women in STEM disciplines, many of the reasons put forward to justify the 'dripping-tap effect' relate to the difficulties in trying to reconcile work and family life. Additionally, it is common that actions proposed to increase the retention rates of women are associated with the following topics: decreasing pay gaps, providing more time flexibility or part-time options, promoting childcare services, and addressing sexual harassment. These factors are certainly important, but they are not the only ones. In fact, research suggests that setting the focus on women's participation and maternity policies disregards relevant discussions concerning academic culture [31] (p. 22).

Nowadays, there is vast evidence to assert that the low participation of women in STEM degrees is explained by multidimensional reasons [19,28,29,32–39]. One of them is the culture of these fields, which through subtle, generalized dynamics create an environment which is hostile and hard to inhabit for certain individuals, particularly women. These subtle and naturalized dynamics which shape both work and student communities of practice have an enormous influence in women's evolution within engineering degrees, and therefore constitute an additional trigger for the dripping-tap effect [19].

In this vein, it is necessary to research the case of engineering degrees from a gender and interdisciplinary perspective that does not solely address gender in a quantitative manner, as this would only draw attention to inequalities from a binary and essentialist framework, overlooking the processes that explain them [4]. This implies going beyond a perspective that only emphasizes the number of men and women, investigating how genders are performed within engineering communities. Therefore, this article proposes the use of a qualitative approach where gender is interpreted as a category that is both reflexive and constituent of practices, in this case engineering cultures. Thus, gender is understood as a concept that has many uses and meanings depending on local appropriations and the difficulties they carry [40]. From a qualitative approach, it is oriented to the comprehension of the structure of the symbolic difference, understood as a social construction and as an approach oriented to the study of diversity or democratic pluralism [41,42]. Here, gender is interpreted as performative, which means it is only real as long as it is performed or enacted [35], representing a "broadly construed 'act', socially shared and at the same time historically constructed" [43] (p. 313).

In addition, we propose some conceptual tools, such as belonging and masculinities, to analyze the causes behind the gender gap in engineering. Furthermore, we suggest investigating how these two concepts are related in the construction of engineering cultures.

2.2. Some Previous Pork on STEM, Belonging, Membership and Masculinities

There are several research studies linking the sense of belonging and the gender gap in STEM. Most of them use quantitative methods to argue that belonging plays a fundamental role in the female students' persistence in STEM careers, thus proposing belonging as a predictor of women's permanence in STEM careers. For instance, there are some works in which the authors use the quantitative analysis of data collected through surveys to report the importance for female students of belonging and sense of community in choosing and persisting in mathematics and some engineering careers at certain U.S. universities [44,45]. There is also another research work analyzing the differences between men and women in the participation of a free online gathering place for STEM students. The authors found that female STEM students were both less likely to answer questions related to the course and more likely to use an anonymity tool than their male peers [46].

Similarly, other authors propose the concepts of social belongingness and self-efficacy to explain—also via quantitative analysis—the gender differences in the interest in STEM careers versus health care, elementary education, and the domestic spheres in Sweden [22].

On the other hand, Radovic et al. use a qualitative approach to explain why and how the mechanical engineering degree at a certain institution in Chile has built an academic culture in which women find it difficult to be included [47].

It should be noted that in the aforementioned studies, the notion of belonging is understood as "the perception of social connectedness in groups" [20,21] (as cited in [22]) or it is assumed that the lack of a sense of belonging is directly implicated by the isolation of women due to the low female enrollment numbers [46]. In this article we propose to understand belonging not only as being part of a certain community (membership), but to work with this concept as Yuval-Davis [23] and Antonsich [24] do, distinguishing two analytical levels of this concept, which we will develop in the following section.

Membership in the engineering community was extensively studied in Tonso's work [29], in which she developed empirical in-depth research within an Engineering School in the United States from an ethnographic point of view. The author attempts to explain why women do not seem to fit into the membership categories offered by the engineering cultures. With this aim, the author focuses on the cultural aspects of engineering degrees, looking into the subtle and normalized dynamics that somehow cause women to only be able to access a fragile membership to these communities, with the subsequent negative impact on their careers. This work in particular delivers a specific way of observing "how the campus took up or highlighted societal ideologies, how campus culture—the taken for granted ways that the world of engineering is supposed to work—reached into teams to structure or frame social interactions between individuals, just as simultaneously it allowed observing how agency—the actions of individuals- contributed to producing and reproducing campus culture" [29] (p. 16). It is also important to note that the author is clear in asserting that even though her findings demonstrate a hostility towards women in engineering, in most cases such hostility does not stem from actions carried out by individuals, but rather constitute cultural and institutional practices that make the environment and campus culture sexist and unfriendly to inhabit for most women and some men who perform masculinities that are beyond the hierarchical scale.

The aforementioned work also addresses the issue of masculinities in engineering. According to the author, engineering is widely acknowledged as a paradigmatic example of 'a degree for men' among professional degrees. She draws from the work of Carter and Kirkup, who described engineering classrooms as places where "male engineering students are involved in the process of masculinization of the thematic area, and therefore marginalize female students" [32] (as cited in [29]). Likewise, there is some evidence that workplaces with a predominance of engineers display stereotypically masculine behaviors, such as aggressive self-promotion, abrasive discourse styles and confrontational interaction routines [38]. Furthermore, the authors demonstrated that these circumstances operated to women's disadvantage, namely as exclusion mechanisms. From here, it seems appropriate to hypothesize an interdependent relationship between the construction of masculinities in engineering/technology and how this gives rise to different (gendered) models of belonging.

2.3. 'Gender in/Authenticity' and 'in/Visibility Paradox'

On the other hand, Faulkner [19,36] proposes concepts such as 'gender in/authenticity' and 'in/visibility paradox' to reflect on the apparent inconsistency women face between gender identity and engineering identity. In other words, they are useful notions to think about how gender performativity is enacted through everyday interactions and within social institutions in engineering communities.

With 'gender in/authenticity', Faulkner [37] refers to the sensation and subsequent conflict of identities a woman could have when entering a male-dominated occupation. Faulkner elaborates this concept, drawing from E.F. Keller [48], who suggests this idea

for the case of sciences, and C. Cockburn [49], who proposes it for engineering. As a paradigmatic example, she mentions a certain norm—"or the pressures of 'the way things are'"—which mandates that engineering and the pleasure of technology are usually felt and perceived as 'authentic gender' options for men and 'inauthentic gender' options for women. Despite the essentialist weight this concept might suggest, it is useful insomuch as it allows to relate and measure how "real" is the membership of both engineering and genders. At the same time, "it signals how consequential it is to be an 'exception to the norm' and, conversely, how much easier life is for those who conform the norm" [19] (p. 173).

Furthermore, Faulkner [19,37] proposes the concept of the 'in/visibility paradox' to think about the phenomenon through which women in engineering are simultaneously highly visible as women, but invisible as engineers. For Faulkner, this paradox is key to understanding the obstacles between women and the sense of belonging to engineering communities. In her work, the author describes endless experiences of women engineers that have encountered different sorts of uncomfortable events related to this phenomenon. For example, female engineers that have been mistaken for the secretary within their workplace or that have to constantly display their credentials or elaborate a masculine performance to be taken seriously.

It is also interesting to analyze the strategies women develop when faced with this 'gender (in)authenticity' or invisibility paradox. In this vein, Kvande states that faced with such inauthenticity, "female graduate engineers have to be 'one of the boys', or social men", to be accepted and given career opportunities in organizations" [50] (p. 306). Parallelly, she wonders to what extent women can negotiate the meaning of femininity within these masculinized spaces. Furthermore, González Ramos asserts that women in science and technology have had to adopt a 'camouflage' strategy which, despite making them invisible, also "allows them to be understood by other women and endorsed by [male] classmates" [51] (p. 203). In fact, for this author the progress regarding the proportion of women in scientific and technological degrees (on the level of students and workers) is a consequence of this camouflage process rather than a genuine transformation of the masculinized culture of these degrees.

In the following section we will delve deeper into the concepts that we propose to study this phenomenon.

3. Belonging and Masculinities: Concepts for Understanding the Gender Gap in Engineering

As we saw in the previous section, there is a variety of research on the link between belonging (or the lack of it) and the gender gap in some STEM disciplines. However, the notion of belonging is either taken for granted or understood as "the perception of social connectedness in groups" [20,21] (cited in [22]). This notion of belonging, while useful, does not incorporate the formal-contextual dimension proposed by Yuval-Davis and Antonsich [23,24], i.e., "belonging as a discursive resource that constructs, claims, justifies, or resists forms of socio-spatial inclusion and exclusion" [52].

In this article, we propose to use the notion of belonging with the two analytical axes proposed by Yuval-Davis [23] and further developed by Antonsich [24], which will be discussed in more detail in the following.

In addition, we will review Connell's theory of hegemonic masculinity and the contributions that feminist technology studies have made to the question of masculinities in technology, as well as argue why this question is important for studying the gender gap in technology.

The choice of these two concepts for understanding the reasons behind the gender gap in engineering lies in the hypothesis that there is a relationship of dependence between them. We believe it is important to investigate whether the same discourses and symbols that reinforce the equation between masculinity and technology—which will be explained in this section—are at the same time those that construct gendered experiences of belonging and that for anyone who does not fit the ideals of hegemonic masculinity—in particular (most of) women—act as mechanisms of exclusion.

3.1. Belonging

On an intuitive level, belonging can be understood as the extent to which a subject feels connection or identification towards a community. Nevertheless, several academics from different fields assert that regardless of its intuitive understanding, it must be defined and problematized to make the most of its potential as an analytical category [24]. Even though some studies address this term as self-explanatory, research that focuses specifically on the concept of belonging has substantially increased during the 2000s, calling for a more accurate definition of the term [53]. Additionally, it is often argued that the term belonging stems from the trail of the concept of identity, while at the same time challenges it [54]. In this line, Probyn states that belonging "captures more accurately the desire for some sort of attachment, be it to other people, places, or modes of being, and the ways in which individuals and groups are caught within wanting to belong, wanting to become, a process that is fuelled by yearning rather than the positing of identity as a stable state" [55] (p. 19).

Nowadays, belonging is used as an analytical category in sociology, geography, anthropology, psychology, political science, history, and law to address topics such as citizenship, migration, and identity. It is particularly relevant to underline the work developed in the educational field through the use of this concept, asserting that "students who feel little or no connection to their school are more likely to suffer from a range of negative emotions and behavioural problems, tend to show lower school engagement and are more likely to be absent from school and to leave school early" [56] (p. 2). Other authors refer to 'modes of belonging', as an approach to apprehend the different attachment forms to places, groups, cultures, etc., [57]. In this sense, there is also the notion of 'differential belonging' from Rowe, which highlights the performative dimension of the ways in which this attachment is enacted [58] (as cited in [24]).

It is worth mentioning that the notion of belonging we are proposing here does not simply mean to be a part of a certain community, but on the contrary "it is an achievement at several levels of abstraction" [59] (p. 3). In fact, Butler's work has been a key influence in Bell's approach, arguing that even belonging to a certain sex or gender can be broadly problematized, not only by cultural and historic variations, but because of gender's performative nature. In Butler's words, "gender is, thus, a construction that regularly conceals its genesis. The tacit collective agreement to perform, produce, and sustain discrete and polar genders as cultural fictions is obscured by the credibility of its own production. The authors of gender become entranced by their own fictions whereby the construction 'compels' one's belief in its necessity and naturalness" [4] (p. 272).

For Yuval-Davis [23] (p. 199) belonging is a concept that is "always a dynamic process, not a reified fixity, which is only a naturalized construction of a particular hegemonic form of power relations". At the same time, she provides an analytical framework to research belonging, considering two analytical axes. The first axis understands belonging as the personal and intimate sense of feeling at home in a certain place, in other words an emotional bond. The second one relates to the study of the 'politics of belonging'; that is, it connects to the formal structure, the politics of membership and social discourse. This distinction is compatible with the assertions in [60] which distinguish between the 'sense of belonging' as a private feeling of attachment to a place, which is nurtured and constructed from everyday practices, and belonging as a formal structure of membership, linked to the public field.

With reference to the first analytical line, the 'sense of belonging´ constitutes an intimate feeling: feeling at ease, feeling at home. For Antonsich, this axis within the research of belonging is about understanding the process in which an emotion is created given the attachment an individual has towards a particular place [24]. The author refers to this notion as 'place-belongingness'. Accordingly, this place feels like 'home', and therefore, the aim of belonging requires finding a place in which the subject can feel 'at home'. It is important to emphasize that 'home' does not necessarily refer to a domestic space within four walls, but rather to a "symbolic space of familiarity, comfort, security, and emotional attachment" [61] (p. 213) (as cited in [24]). In other words, depending on the context, this

place could be a house, a neighborhood, a country, a football club, or an educational or student community, among others. In our case of interest, 'home' would be the community of practice of engineering students at a determined location.

Moreover, Yuval-Davis [23] (p. 199) states that 'social locations' fulfill an important role within this first axis. With 'social locations', the author refers to the position where the 'place' is located (understanding 'place' as a symbolic space) to which one can belong within an axis of power. For example, coming from a European or an African country constitutes different categories of social location, but in addition, these different categories have differential power positionings. In this sense, being a woman from a European country is different to being a man from a European country, and it is also different to being a woman from an African country. As an example, if we want to use the belonging category to study the engineering culture in over-centralized countries such as Chile, we should observe how being a female engineering student in a university in Santiago (the capital city) but coming from a different province or from a rural area is different to being a female student that comes from Santiago in the same university. Consequently, to research gender inequalities in students it is necessary to tackle how these inequalities operate with one another; that is, we need to understand how the intersections between gender discriminations and those of class, race, ethnicity, sexuality, and diversity of abilities influence each other [62]. In summary, it is crucial to address social locations from an intersectional perspective because they are never constructed along the lines of an isolated axis [63].

At the same time, the construction of belonging originates from the stories people tell one another and themselves about who they are (and who they are not). In particular (and more often than not) these stories are associated with the perceptions and wishes appertaining to a certain community. This does not only happen on a cognitive level, but also reflects emotional investments. Hence, another level within the first axis can be distinguished: identifications and emotional attachments, which are related to constructions of the self and identity. In fact, from the field of social psychology, some authors question if belonging is the basis of identity or if, reciprocally, identity and bonds operate as the basis of belonging [64]. Whatever the direction of the question, it is true that they are deemed correlated concepts. In this sense, the question: who am I? cannot be detached from the questions: where do I belong? where am I from? [65] (p. 106).

Regarding the second analytical axis (the politics of belonging), Crowley [66] (p. 30) defines the politics of belonging as "the dirty work of boundary maintenance". The limits the author refers to are those of the community to which one belongs (or not); in other words, they represent the borders that separate individuals between 'us' and 'them' [23] (p. 204). Thus, the discourses and practices that make this delimitation effective are considered the essence of the 'politics of belonging' [23,67,68] (as quoted in [24]). Furthermore, Antonsich points out that the 'politics of belonging' are "a discursive resource which constructs, claims, justifies, or resists forms of socio-spatial inclusion/exclusion" [24] (p. 645). That is to say, all 'politics of belonging' bear two opposite facades: one that wants to belong and one that holds the power to grant this belonging. The implication of this is an ongoing negotiation process, whether on a personal level, a collective level, or both [69].

In consequence, the sense of 'feeling at home' can be spawned from certain cultural expressions, such as language, shared traditions, rituals, etc. It is thus interesting to analyze which are the cultural expressions of engineering careers that contribute when it comes to the construction of this sense of belonging; what the frontiers are that arise when 'us' and 'them' are outlined.

It is relevant to underline the importance of language within cultural expressions: "a particular language stands for a particular way of constructing and conveying meaning, a certain way of interpreting and defining situations" [70] (as cited in [24], p. 648). In this article, mathematical language will be understood as a shared language between engineering students [71]. Therefore, it is useful for this type of research to be interdisciplinary so that the mathematical language and the social sciences perspectives converge.

Additionally, fields of geography and urbanism encourage the interest in studying the use of space in places with collective usage as they are understood as an "articulator that allows the integration of the territory, conferring representative elements that provide meaning and contribute to consolidate processes of identity and place belonging" [72] (p. 5). This is because such disciplines understand that places are defined by socio-spatial practices [73] (as cited in [74]), in other words that "spaces arise from power relations, power relations establish norms, and norms define limits, which are social as well as spatial because they determine who belongs to a place and who is excluded, as well as the situation or position of certain experience" [74] (p. 15). Moreover, feminist geography suggests to "research and draw attention to the relationship between gender and spatial divisions to uncover how they mutually constitute each other, and hence display the hidden problems behind their apparent naturalization" [74] (p. 27). Ultimately, to carry out an in-depth investigation about the different dimensions of 'belonging', it is paramount to look into the differentiated ways in which men and women experience places and spaces, as well as evidencing that these differences model social understandings of both gender and place [74] (p. 27). Therefore, we propose the analysis on the use of collective-use spaces on campus (dining rooms, playgrounds, libraries, and classrooms) in order to study how models of belonging are constructed within engineering cultures.

Figure 1 provides an illustration of the belonging concept, its analytical dimensions, and how to relate them to the other concepts presented so far.
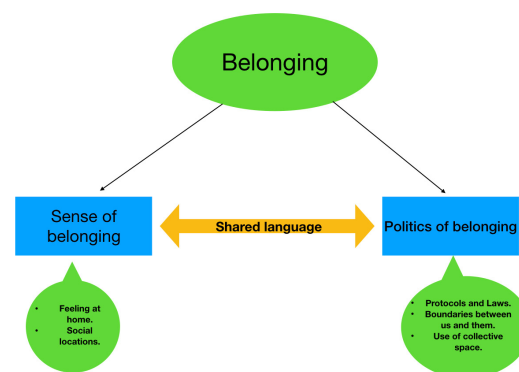

Figure 1. Belonging and its analytical dimensions.

Within these directions and in the context of researching racism and diversity within institutional spaces (particularly universities), Sarah Ahmed suggests studying "how some [individuals] more than others will be at home in institutions that assume certain bodies at their norm" [75] (p. 3).

Various authors assert that the majority of women do not seem to fit into membership categories offered within engineering cultures, namely there exists a certain fragility in women's sense of belonging to the community and the identity of 'engineer' [29,30,32,45]. In contrast, it would seem to be easier for (the majority of) men to secure their sense of belonging to these communities. This opens up the question about how the development of a fragile or absent sense of belonging affects women's engineering careers. This question is reinforced by Faulkner [36,76], who states that in spite of the common affirmation that women who enroll in engineering degrees are forced to fit into a masculine culture, there is still limited empirical research that provides systematic evidence of this fact, in addition to the almost null analysis about what constitutes 'the masculine' of engineering cultures.

3.2. Men/Masculinities and Technology: The Equation between Masculinity and Technology

Emerging from academic feminism and science and technology studies, a new area of interdisciplinary research has been developing over recent decades, introducing a perspective commonly referred to as 'feminist technology studies'. This approach is based on the idea of the reciprocal configuration of gender and technology; that is, it

is assumed that both gender and technology are under permanent construction and are socially modeled, hence being potentially mutable [28,77]. In other words, technology is no longer understood as an aseptic entity but rather conceived as a social practice which, far from neutrality, constitutes a source of masculine power and a constant exclusion of (the majority of) women and sexual dissidences. Thus, technology is analyzed from a constructivist approach, which is paradigmatic within social research on technology and, at the same time, questions technology's determinism and its alleged neutrality. Therefore, it is worth questioning what the role is that technology plays in the construction and consolidation of gendered power relations, as well as "how is technology gendered?" [28,77].

Additionally, Oldenziel [78] reminds us that the fact that "masculine machines (rather than feminine fabrics)" are current technology's reference point is a consequence of engineering's status as a masculine, white, middle-class profession. Furthermore, technological knowledge has been considered as the heart of engineering culture from decades past [79–81] (as cited in [38]) until now [33]. Indeed, western engineering culture consists of three features: "first and most important, its ideology emphasizes the centrality of technology and of engineers as producers of this technology. Second, it stresses acquisition of organizational power as the basis of engineering success. Finally, it requires that interest in technology and organizational power be 'presented' in an appropriate form-a form closely tied to the male gender role" [38] (p. 405).

For Faulkner, it is fundamental to inquire into engineering cultures to understand the equation between masculinity and technology, understanding this as the cultural association between these two concepts which shapes the relationships between gender and technology [33]. Thus, engineers constitute powerful symbols within this equation and are therefore key elements to study as this formula seems to be so stable, long-standing, and omnipresent [28,33,82].

All this suggests that to understand the continuous masculine predominance in engineering degrees it is imperative to look into the relationship between the construction of masculinity and technology. Considering this, it is important to understand 'masculinity' as a frame of reference rather than as men's 'real' behavior. In this line, the concept of 'hegemonic masculinity' [83] becomes useful, defined as a combination of practices, "things done, not just a set of role expectations or an identity" [84] (p. 832) which uphold the legitimacy of the dominating position of men over women and other forms of masculinity: "Hegemonic masculinity was distinguished from other masculinities, especially subordinated masculinities. Hegemonic masculinity was not assumed to be normal in the statistical sense; only a minority of men might enact it. But it was certainly normative. It embodied the currently most honored way of being a man, it required all other men to position themselves in relation to it, and it ideologically legitimated the global subordination of women to men." [84] (p. 832).

For Bonino, hegemonic masculinity is a social model that "imposes a particular configuration of subjectivity, corporality, the existential positionality of commonalities between men and of common men and inhibits and nullifies the social hierarchy of other masculinities" [85] (p. 13). Consequently, it is a hierarchical positionality that leaves all of which does not belong with this mandate in an inferior location by basing itself on the ideology of exclusion and subordination of the 'otherness', among others." [85] (p. 13). The notion of hegemonic masculinity has been used as an analytical category within diverse fields of study, i.e., education, criminology, law, press representation, geography, organizational studies, and social studies of science and technology, among others [84]. Regarding this case of interest, Tonso, drawing upon Hacker and O'Neal's [86,87] previous work, states that the similarities between engineering and the institutions that respond to a masculine archetype, such as the military, suggest that hegemonic gender identities in engineering are incompatible with what is traditionally associated with the feminine [29].

Given that science and technology are considered "powerful motifs of hegemonic masculinity" it is imperative that this axis is integrated into research about gender, science, and technology [82].

4. Discussion and Conclusions

In this article, we have proposed the concepts of belonging and masculinities to analyze qualitatively the causes behind the gender gap in engineering. In addition, we have reviewed different perspectives and research that have developed the issue of gender in STEM. We believe that the incorporation of these theoretical tools into gender gap studies in STEM is necessary to go a step further in research on this topic that does not continue to study these issues in terms of deficits, that is, explaining the gender gap by a deficit of women or in their socialization. Additionally, the approach of the construction of masculinities is necessary when gender is understood as a social construct and its relational dimension is considered.

It is especially necessary to make progress in research that observes and analyzes the dynamics of engineering cultures, using these concepts as analytical categories. In these cases, it would be important to state as research questions how genders are performed within engineering communities; how engineering models of belonging and identity are constructed within the engineering culture; and what the connection is between belonging structures, symbols, and identities within the relationship of gender-technology-engineering, to find out to what extent the discourses that model both the formal structure of belonging and the intimate feeling of being at home are related to the discourses that construct the equation between masculinity and technology [24]. Figure 2 illustrates the relationship between these concepts.
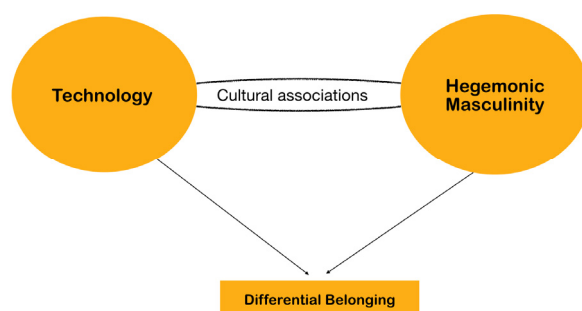

Figure 2. Relationship diagram: belonging-masculinity-technology.

The impact of such approaches extends throughout several disciplines. In Science and Technology Studies, it will incorporate a gender approach, and in Feminist and Gender Studies it will integrate the idea of gender relations being continuously modeled by the design and use of technology. The impact on the construction of mathematical and technological knowledge is particularly important, which comes from the subsequent transformation of these scientific communities. From an epistemological perspective, approaching scientific knowledge from different points of view helps in understanding a broader scenario of situations, which result in a better quality of scientific production [88].

This is of tremendous scientific and political potential. In this sense, women in STEM fields have an epistemic privilege to study the gender gap in STEM, identify its causes, and subsequently propose measures to close it.

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