

Belongingness of Chilean Engineering Students: A Gender Perspective Approach

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Abstract

Students' affective characteristics, such as motivation, attitudes, self-efficacy, expectations, and sense of belonging, are relevant topics for higher education research. Much research indicates that having a sense of belonging in academic, social, and community settings are critical to students' development, engagement, and persistence. Prior research on women's participation in Science, Technology, Engineering, and Mathematics (STEM) careers discusses the need to improve their sense of belonging as a socio-cognitive variable related to the gender imbalance in participation in STEM areas. Women's sense of belonging is crucial to higher education institutions, especially in highly masculinized careers such as engineering. It increases academic motivation and can influence their success in higher education. However, statistics worldwide show that the increase in the sense of belonging and, thus, in the participation of women in STEM areas has not risen enough to reduce the gender gap. In the current research work, we present data collected over one semester in an Engineering School at a large private university in Chile. Our main objective is to diagnose and analyze the students' sense of belonging in social and academic areas, their self-efficacy, and perceived institutional support from a gender perspective. With a quantitative approach, survey data was collected to assess students' sense of belonging as engineering students. The validated survey consists of 33 items distributed in four constructs: 1) Sense of belonging-general, 2) sense of belonging-interactions, 3) Self-efficacy and 4) Perceived institutional support. From this, we identify and discuss the student's sense of belonging and how it interacts with self-efficacy and perceived institutional support. This research allows us to have evidence that supports the visibility and creation of initiatives on the services offered to students, which impact their sense of belonging.

Keywords: *sense of belonging; self-efficacy; gender studies; women in engineering*

I. Introduction and theoretical framework

The sense of belonging is a basic human need by which positive results are highlighted and facilitated in the physical and psychological aspects of a certain person, such as in their perceptions, behaviors, creativity and desires for [1]. According to some authors, creating productive interpersonal bonds and developing a feeling of acceptance increases self-confidence, persistence, motivation, and performance of students [2-5]. In the specific field of Educational Research in the Science, Technology, Engineering, & Mathematics (STEM) areas, a sense of belonging has been found to correlate well with student academic performance [6, 7]. Previous research has indeed indicated that students with a greater sense of belonging and acceptance regarding their learning center were more likely to seek institutional help that would further their adaptation and improve their learning opportunities[5]. In addition to the above findings, the sense of belonging for male students has been found to increase as they further their university studies. However, this is not mirrored in women students, which translates into poor performance, lower self-confidence, and in some cases, given the above, female students fail to persist in their career [6, 8].

Persistence in the study area is a key factor in STEM disciplines, since historically these are areas having scarce representation due to the perceived difficulty that some people attribute them with. Consequently, female representation in these areas is even lower, not even reaching as in OECD countries [9] it does not exceed 20%. This affects how women feel in

careers that are dominated by men, having a lowered sense of identity within the community and difficulties in establishing interpersonal relationships with their male co-students [2, 10-11]. It may be stated that a sense of belonging is a fundamental element in understanding and, above all, meeting the socio-cognitive needs of students engaged in STEM disciplines, becoming a key factor in promoting student retention and subsequent success [2, 12]. Such situations are replicated in engineering disciplines specifically, exacerbated in those engineering fields where the student body is predominantly male. Such is the case in construction studies, such as civil engineering and construction engineering. These disciplines have a female participation of no more than 10%, both at the academic sphere and at work [13-14]. Some studies report that female students feel a low identity with their male peers, pointed out as being one of the causes of desertion at an early stage [10, 14]. While in careers related to computer science, Widdicks et al [15], mention that women have a lower sense of belonging, since these types of careers are contained within an environment of gender biased stereotypes, affecting their self-efficacy and academic performance.

In the case of engineering courses in industrial areas, current female participation is 19.2% (at the learning center where this study was carried out). Saavedra-Acuna and Quezada-Espinoza [16], report that there is a significant difference in self-confidence between male and female students, skewed against the latter given a perceived excessive academic load and an economic situation that does not lend itself well to staying the course. Another study reported that female students perceive that professors in their engineering classes have higher expectations from their male students than of themselves, associated with the use of inclusive language by professors [17]. Inclusive language, gender stereotypes and social bias are elements that are associated with students' sense of belonging, undermining such sense in those careers where female students are underrepresented [6, 13, 18].

Consequently, the sense of belonging held by engineering students is influenced by elements anchored in various dimensions, mainly in the social and academic sphere. Among the social ones, it may be stated that peer and teacher interactions are salient. In the academic sphere, elements such as class participation, including academic discussions, performance assessment and institutional support are identified as key. The sense of belonging held by students, and their peer interactions are seen as important elements. Students, on feeling more confident and secure within their School, obtain greater and better quality peer interaction, promoting a positive attitude and perceived recognition among peers [19]. As can be seen and in line with the initial paragraphs in this section, a sense of belonging provides information about how students perceive their learning environment, ie, the extent to which this environment it makes them feel that they are a party to it.

Associated with the above, self-efficacy is a factor that has been widely studied in the field of STEM education due to its relevance for students to persist and successfully conclude their higher education. Unlike the sense of belonging, self-efficacy is an internal belief structure students hold, helping them define their perceptions about themselves, who they are and what their interests and capabilities are in successfully attaining their objectives [7]. However, a student's self-efficacy can be influenced by the environment. The type of teaching methodologies (traditional or student-centered), the lack of teacher recognition and peer interactions, influence student self-efficacy, especially in women [20]. Furthermore, research shows that self-efficacy is positively correlated with a sense of belonging [5].

Considering the factors mentioned throughout this literature review and as a summary thus far, this current work sees a sense of belonging as a socio-cognitive factor that helps explain

how students perceive their learning environment and to what extent it makes them feel that they are a part of the learning environment. While self-efficacy is an internal factor of the student, allowing them to define their identity, interests and self-perceived ability to successfully perform tasks and meet objectives. Both the sense of belonging and self-efficacy are influenced by external elements, such as the social and academic interactions that take place within the school environment with professors, fellow students, and any services and activities the institution offers [21]. This work aims to diagnose and analyze the sense of social and academic belonging of students in an School of Engineering from a Chilean private university, including their self-efficacy and perceived institutional support given a gender perspective.

The document is organized as follows: Section II presents a methodology that allows addressing the objective. Section III presents results and discussions in light of the theory. Finally, in section IV the conclusions are made, where the limitations of the study are included and future work is proposed.

II. Methodology

A. Participants

This present study administered a validated survey on a sense of belonging. The instrument was applied at the end of the second semester in 2022 to undergraduate students enrolled in various courses at the School of Engineering of a private Chilean university. From a universe of 2428 students, 369 voluntary responses were received, of which 328 responses were declared valid. As researchers we acknowledge that gender is a non-binary construct, however the data reported comes in binary terms, as less than 1% of responses originates from students who did not identify as male or female. Therefore, from the 328 responses, 10.4% came from female students and 89.6% from male students. The sample margin of error is 5.03% with a 95% confidence level. As for the age range, 50.9% were students aged between 17 and 21, 42.7% to students aged between 22 and 24, and 6.4% between 25 and 29 years old. In relation to the study year currently at, the sample is divided according to Table 1.

Table 1. Distribution of students according to current study year.

<i>Current study year</i>	<i>Frequency</i>	<i>Percent (%)</i>
First	130	39.6
Second	60	1.3
Third	65	19.8
Quarter	44	13.4
Fifth	29	8.8
Total	328	100.0

B. Survey

The measurement instrument was built out of other investigations having a similar purpose to that of this work [6, 22-26]. This version of the instrument included more statements that enabled further probing on student sense of belonging, in its various aspects, such as social, academic and general interactions within the institution; given that the other investigations placed their emphasis on items more related to other factors, such as self-efficacy, identity, attitudes, behavior, among others, and secondly, with fewer probing on items relating to a sense of belonging. During the survey validation process, a Cronbach's Alpha of 0.878 was

attained, while a factorial analysis yielded an adjustment of factors to 4 dimensions with a cumulative explanation percentage of 65 % (with a KMO equal to 0.812 and a Barlett's test of sphericity equal to 0.000). The Exploratory Factor Analysis performed in this study was Principal Component Analysis with Varimax rotation. Table 2 shows the items of each dimension and the correspondent Cronbach's Alpha.

Table 2. Items by survey dimensions on sense of belonging, self-efficacy and perceived support from the institution.

<i>Dimensions</i>	<i>Items</i>
<i>Sense of belonging-interactions</i> ($\alpha=0, 749$)	1. I feel comfortable asking a teacher for help when I don't understand the subject matter. 4. The students here treat me with respect. 5. I feel comfortable contributing to class discussions. 6. If someone does not agree with my ideas, I can find ways and means to get them to change their mind. 8. It would be easy for me to join study groups with other students if I wanted to. 9. When I interact with the professors at this university, I feel that they care about my performance. 14. Professors here respect me. 25. I feel comfortable asking questions in my classes.
<i>Sense of belonging-general</i> ($\alpha=0, 827$)	7. I feel like I belong to this university. 12. I see myself as part of the university community. 13. I feel free to call another student if I have a question about a specific assignment. 17. It has been easy for me to make friends at the School of Engineering. 16. I feel like I really belong in my college career. 21. Other students at this university seem interested in my opinions, ideas and questions related to class work. 24. I can really be myself at this university. 27. The students of this university are friendly to me.
<i>Self-efficacy</i> ($\alpha=0, 844$)	2. I can always solve difficult problems if I try hard enough. 3. I can usually handle situations that come my way. 11. It is easy for me to stick to my objectives and achieve my goals. 15. Thanks to my ingenuity, I know how to handle unforeseen situations. 18. I prefer to study by myself. 19. I can solve most problems if I put in the necessary effort. 20. I see myself as an engineer. 23. I am able to stay calm when facing difficulties because I am confident in my problem-solving abilities. 26. When faced with a problem, I can usually find several solutions.
<i>Perceived institutional support</i> ($\alpha=0, 772$)	29. Psychological accompaniment 30. Planning my career with the academic secretaries 31. Receiving academic tutoring 32. Find health and wellness support services 33. Get involved in sports and complementary areas (leadership, diversity and gender, participatory meetings, etc.).

The process whereby the instrument presented in table 2 was designed, built and validated will be reported on in separate investigation. The survey response scale is of the Likert type that starts at 1. Strongly disagree, up to 5. Strongly agree. The statement for items 1 to 28 was: From your experience this last academic year at the School of Engineering at the Andrés Bello University, to what extent do you agree or disagree with the following statements? Whereas, for items 29 to 33 the initial statement was: In my School it is easy for me to find support services for (item). It should be noted that for cases in items 29 to 33, the possibility of answering with a 0 was included. I don't know about that service. Such considerations were taken into account when analyzing results.

C. Results Analysis

Descriptive statistics were used in sample characterization for data analysis. Likewise, non-parametric tests were carried out as there was no normal distribution, chi-square, Kruskal Wallis test, Spearman's correlations and, finally, correlation analyzes for independent samples were used. For all tests, the SPSS statistical software was used.

III. Results and data analysis

Firstly, descriptions of collected data are presented. Inferential analyzes are presented after. The dimensions addressed by the instrument correspond to self-efficacy (SEf), general sense of belonging (SB-g), sense of belonging-interactions (SB-i) and institutional support (IS). The results obtained for each of them can be consulted in Table 3.

Table 3. R descriptive analysis results for each survey dimension by gender.

<i>Dimensions</i>	<i>By gender</i>	<i>N</i>	<i>Min</i>	<i>Max</i>	<i>Mean</i>	<i>Std. Dev.</i>
<i>SEf</i>	<i>Total</i>	328	1.89	5.00	3.8980	0.51433
	<i>Women</i>	34	1.89	4.78	3.7419	0.71846
	<i>men</i>	294	1.89	5.00	3.9161	0.48367
<i>SB-g</i>	<i>Total</i>	328	1.25	5.00	3.8758	0.57619
	<i>Women</i>	34	2.25	4.63	3.8051	0.55408
	<i>Men</i>	294	1.25	5.00	3.8839	0.57905
<i>SB-i</i>	<i>Total</i>	328	2.00	5.00	3.8293	0.53069
	<i>Women</i>	34	2.75	5.00	3.7684	0.54454
	<i>Men</i>	294	2.00	5.00	3.8363	0.52957
<i>IS</i>	<i>Total</i>	328	0.00	5.00	2.7470	1.11700
	<i>Women</i>	34	.00	4.80	2.8471	1.09108
	<i>Men</i>	294	.00	5.00	2.7354	1.12121

As seen in Table 3, 10.4% of survey participants are female students. At first glance, it can be seen that mean values in SEf, SB-g and SB-i dimensions are lower for women, but not so in the dimension relating to perceived support from the institution. Further on in this discussion inferential group comparisons are presented.

As can be seen in Table 4, Kruskal Wallis test results did not show statistically significant differences between men and women in any of the variables of interest. However, it is interesting to analyze the existence of some different behavior when analyzed per groups.

Table 4. Kruskal Wallis test results reported per gender per dimension.

	<i>SEf</i>	<i>SB-g</i>	<i>SB-i</i>	<i>IS</i>
<i>Chi-Square</i>	1,474	.611	1,252	.351
<i>df</i>	1	1	1	1
<i>Asymp. Sig.</i>	.225	.434	.263	.554

a Kruskal Wallis Test

b Grouping Variable: Gender

Results obtained for male and female groups can be compared in the variables of interest. For example, as can be seen in Table 5, the Kruskal Wallis test failed to show statistically significant differences for the grouping variables "study year" and "age" in the case of women. In the case of men, there is a significant difference for the grouping variables "study year" and "age" in the SEf variable, as well as for the SB-g variable referring to the "age" grouping.

Table 5. Kruskal-Wallis test results reported per gender and per dimension. Study year and age separation variables

		<i>Study Year</i>				<i>Age</i>			
		<i>SEf</i>	<i>SB-g</i>	<i>SB-i</i>	<i>IS</i>	<i>SEf</i>	<i>SB-g</i>	<i>SB-i</i>	<i>IS</i>
<i>By Gender</i>	<i>Chi-Square</i>	3,364	1,830	6,403	1,574	2,511	3,306	.496	.926
	<i>df</i>	4	4	4	4	2	2	2	2
	<i>Asymp. Sig.</i>	.499	.767	.171	.814	.285	.191	.780	.629
Men	<i>Chi-Square</i>	11,015	5,957	1,356	3,066	8,472	8,909	2,490	3,966
	<i>df</i>	4	4	4	4	2	2	2	2
	<i>Asymp. Sig.</i>	.026	.202	.852	.547	.014	.012	.288	.138

a Kruskal Wallis Test

It is possible to delve into these statistically significant differences found for men for the separation variables "study year" and "age" by performing the Mann Whitney U Test for two independent samples. This was done analyzing the possible differences between the male students at: 2nd and 5th year of their degree career (SEf: $M_{nd=xx}$, $M_{5th=xx}$, $Z=-2.834$, $p=0.005$); 4th and 5th study year (SEf: $M_{nd}=3.809$, $M_{5th}=4.115$, $Z=-2.569$, $p=0.010$); age ranges 17-21 and 22-24 (SB-g: $M_{17-21}=3.971$, $M_{22-24}=3.767$, $Z=-2.951$, $p=0.003$); 17-21 and 25-29 (SEf: $M_{17-21}=3.884$, $M_{25-29}=3.915$, $Z=-2.830$, $p=0.005$); 22-24 and 25-29 (SEf: $M_{22-24}=3.750$, $M_{25-29}=3.015$, $Z=-2.246$, $p=0.025$). We can say that there is a significant difference between the second and fifth year groups and between the fourth and fifth year groups, for the separation variable " study year". Likewise, given this same variable, there is also a significant difference between the age groups from 17 to 21 years and the group from 25 to 29 years, as well as between the groups from 22 to 24 years and from 25 to 29 years, in the "age" separation variable. On the other hand, for the general sense of belonging variable (SB-g), it is possible to find significant differences between the 17 to 21 year old group and the 22 to 24 year old group.

In order to analyze the relationships between the variables of interest, Table 6 shows the results of the Spearman correlation test for the entire sample. In it, it is possible to see that there is a strong and statistically significant correlation between the variable SB-g and SB-i. It is also possible to observe that there are moderate and statistically significant correlations between the variables SEf and SB-g, and between SEf and SB-i. Likewise, between the variables SB-g and IS and between the variables SB-i and IS there are low and statistically significant correlations. It is also worth noting that there is no correlation between the SEf and IS variables.

As can be seen in Table 7, the same behavior for correlations found for the total sample is repeated for the group of men, only in this case the correlations are slightly intensified. While for the female group there are no longer statistically significant correlations between the SB-g and IS variables and the SB-i and IS variables.

IV. Discussion

The main objective of this research was to diagnose and analyze the sense of social and academic belonging that students may have to an School of Engineering in a Chilean private university, including their self-efficacy and perceived institutional support given a gender perspective. In light of the above the following reflections may be made given the literature review already reported on.

Table 6. Results of the correlation tests by using spearman's coefficient of correlation for the total sample.

		SEf	SB-g	SB-i	IS
SEf	CC	1,000	.503(**)	.493(**)	.083
	Sig. (2-tailed)	.	.000	.000	.136
	N	328	328	328	328
SB-g	CC	.503(**)	1,000	.640(**)	.246(**)
	Sig. (2-tailed)	.000	.	.000	.000
	N	328	328	328	328
SB-i	CC	.493(**)	.640(**)	1,000	.221(**)
	Sig. (2-tailed)	.000	.000	.	.000
	N	328	328	328	328
IS	CC	.083	.246(**)	.221(**)	1,000
	Sig. (2-tailed)	.136	.000	.000	.
	N	328	328	328	328

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Table 7. Results of correlation tests using spearman's coefficient of correlation by gender.

		Women				Men			
		SEf	SB-g	SB-i	IS	SEf	SB-g	SB-i	IS
SEf	CC	1,000	.427(*)	.459(**)	.047	1,000	.505(**)	.498(**)	.094
	Sig. (2-tailed)	.	.012	.006	0,791	.	.000	.000	.107
	N	34	34	34	34	294	294	294	294
SB-g	CC	.427(*)	1,000	.607(**)	.087	.505(**)	1,000	.642(**)	.267(**)
	Sig. (2-tailed)	.012	.	.000	.625	.000	.	.000	.000
	N	34	34	34	34	294	294	294	294
SB-i	CC	.459(**)	.607(**)	1,000	.085	.498(**)	.642(**)	1,000	.246(**)
	Sig. (2-tailed)	.006	.000	.	.631	.000	.000	.	.000
	N	34	34	34	34	294	294	294	294
IS	CC	.047	.087	.085	1,000	.094	.267(**)	.246(**)	1,000
	Sig. (2-tailed)	.791	.625	.631	.	.107	.000	.000	.
	N	34	34	34	34	294	294	294	294

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Following from the literature review presented in the introduction, students' sense of belonging is closely related to both the social and academic interactions they may have had in their schooling environment. An Engineering School that provides a suitable environment will foster more confident and secure students within its School. This will facilitate more and better interactions with their peers, which in turn generates a positive attitude and perceived recognition among peers and professors [19]. Thus the dimensions or variables investigated in this paper are related to self-efficacy (SEf), the general sense of belonging (SB-g), the sense of interactions based belonging (SB-i) and the perception of institutional support (IS).

As presented in Table 4, and in contrast to what has been previously reported by other authors [14-16], this sample did not show statistically significant differences between women and men in relation to self-efficacy or sense of belonging. Thus the sample of female students that

are part of this study did not show a lower sense of belonging nor having less self-efficacy than their male co-students. Although the differences between them are not significant, Table 3 shows that the mean self-efficacy is higher for men than it is for women ($M_{SEf.m}=3.92$, $ST_{SEf.m}=0.49$; $M_{SEf.w}=3.74$, $ST_{SEf.w}=0.72$), similarly to what happens with the sense of interactions based belonging ($M_{SB-i.m}=3.84$, $ST_{SB-i.m}=0.53$; $M_{SB-i.w}=3.77$, $ST_{SB-i.w}=0.54$). It is likely that this absence of statistically significant differences between males and females is due to a sample effect, as mentioned above, only 10.4% are women. As is to be expected in careers where women are under-represented, as mentioned by Kalender et al [20], it is necessary to incorporate strategies that promote equity and inclusion, such that discussions are not dominated by the mainstream.

In addition, it is impossible to find statistically significant differences in self-efficacy or in women's sense of belonging as they advance in their careers or in relation to their age (Table 5). Similar results were found in Lewis et al. [24]. Therefore, the authors propose mentoring initiatives and other activities where professional women share their experiences and concerns regarding the sense of belonging and how they have dealt with them. First, it is essential to improve women's self-efficacy from the first year of their degree since this factor is associated with the retention level of male-dominated careers [20]. Secondly, it is possible to discern that men have an increase in self-efficacy and sense of belonging concerning their age and an increase in self-efficacy as they advance in their careers. These findings concur with previous research [6. 8].

Table 6 shows how variables interrelate with each other; self-efficacy (SEf), sense of belonging (SB-g), sense of interactions-based belonging (SB-i), and the perception of institutional support (IS), as has been highlighted by various authors [5. 18-19]. The sense of belonging, both general and interactions-based, correlates with self-efficacy. This means that the greater the sense of belonging, the greater the self-efficacy, and vice versa, furthering what has been reported on in other investigations regarding the importance of relationships built with those people who make up the educational institution, not only in the general well-being of the students but also in the self-perception of its effectiveness [20-21].

While less noticeable, as significant correlations were low, it is also possible to highlight the relationship between the sense of belonging and institutional support. Students who have a greater sense of belonging also have a greater perception of institutional support, and vice versa. Institutional support, such as fostering extracurricular activities, academic consultancies aimed at increasing pass rates, psychological support, etc., help the student improve her level of interactions at the university. Other authors also reported this effect that interactions help foster a positive learning environment, which contributes to increasing self-efficacy, the sense of belonging, and academic performance [7. 21].

When carrying out the analysis per female and male groups regarding correlations between a sense of belonging and self-efficacy and between institutional support and a sense of belonging (Table 7), it is seen that these correlations are more consolidated for the group of men. Also, for women, the sense of belonging does not correlate with the perception of institutional support. This must be considered since previous research suggests that students who felt greater belonging and acceptance in their institution were more prone to seeking institutional help that would allow for greater levels of adaptation and improvements in their learning [5].

V. Conclusions

This research aimed to diagnose and analyze the sense of social and academic belonging of the students of a School of Engineering of a private Chilean university, their self-efficacy, and perceived institutional support, using a gender perspective. Through implementing a four-dimensional survey: a sense of belonging-general, sense of belonging-interactions, self-efficacy, and perceived support from the institution, statistical tests were made (mean differences and correlations) to find out how these variables behave by gender, year of study, and age of students. Through these tests, we can conclude that:

- The sense of belonging and self-efficacy remained the same for the women who participated in this study during career advancement.
- The sense of belonging and self-efficacy increases with career advancement for the men who participated in this study.
- The sense of belonging, both general and interactions-based, correlates with self-efficacy, the greater the sense of belonging, the greater the self-efficacy, and vice versa for both men and women.
- The perceived support of the institution correlates with the sense of belonging and self-efficacy, so it is a crucial element to promote these socio-cognitive factors of student self-efficacy in an educational institution.

VI. Limitations and future work

There are several limitations in the present study. The first is a methodological limitation, as there were few female students who answered the survey. Thus, for future studies, greater response rates from women are needed so that their sense of belonging, self-efficacy, and perceived support from the institution can be better reflected and thus have more accurate results. The authors believe it is imperative to obtain a response from most of the School of Engineering students, both men, and women, to obtain generalized results and be more conclusive. Another area for improvement is that this study is limited to a single School of one University in Chile. The initiative must be replicated in other contexts to generalize results to a larger population with similar characteristics, undergraduate students in engineering and other areas.

The sense of belonging is a primary factor in the student's career at a university, triggering other factors such as self-efficacy and academic performance. The main factor that must be considered to promote a sense of belonging bears relation to social and academic interactions promoted within the School of Engineering. Both social and academic interactions can be promoted within the classroom through the promotion of student-centered activities, such as collaborative works designed with a gender perspective, peer discussions, constructive teacher feedback, use of inclusive language, among others. Social interactions can also be encouraged through extracurricular activities promoted by the institution, which make students feel that they are part of a community and that they matter to the institution as human beings—increasing the dissemination of the institution's support programs so that students are motivated to use them, such as psychological support, academic tutorials, student career advice. Creating inclusive learning environments for all students is of paramount importance.

All the actors involved in the operation of the School of Engineering must be sensitive to and aware of the findings of this type of investigation so that they may, given their position, help promote a better atmosphere in their academic circles. In addition, improving these indicators

will promote female student retention and improve the quality of life for the entire university community.

Our future work is directed towards teacher training with a gender perspective and investigating these elements (teaching, gender, and inclusion) to enrich the pedagogical approach of the School of Engineering. In addition to promoting the dissemination of student services and making better use of them, they will further their sense of belonging. Therefore, it is necessary to investigate thoroughly how the community of this University expects its social and academic needs to be met and what impacts it may have on the different factors, be they sense of belonging, self-efficacy, perceived support from the institution, and academic performance.

Aknowledgements

The authors would like to acknowledge the leadership and financial support of the School of Engineering of the Universidad Andres Bello, Chile. They also thank the Educational and Academic Innovation Unit (UNIDA) for its mentoring and guidance in developing scientific articles in higher education research.

References

- [1] E. Knekta, K. Chatzikyriakidou, y M. McCartney, «Evaluation of a Questionnaire Measuring University Students' Sense of Belonging to and Involvement in a Biology Department», *LSE*, vol. 19, n.º 3, p. ar27, sep. 2020, doi: 10.1187/cbe.19-09-0166. [Online]. Available in: <https://www.lifescied.org/doi/10.1187/cbe.19-09-0166>.
- [2] S. Banchevsky, K. L. Lewis, y T. A. Ito, «The Role of Social and Ability Belonging in Men's and Women's pSTEM Persistence», *Front. Psychol.*, vol. 10, p. 2386, oct. 2019, doi: 10.3389/fpsyg.2019.02386. [Online]. Disponible en: <https://www.frontiersin.org/article/10.3389/fpsyg.2019.02386/full>.
- [3] S. Cwik y C. Singh, «How perception of learning environment predicts male and female students' grades and motivational outcomes in algebra-based introductory physics courses», *Phys. Rev. Phys. Educ. Res.*, vol. 17, n.º 2, p. 020143, dic. 2021, doi: 10.1103/PhysRevPhysEducRes.17.020143. [Online]. Available: <https://link.aps.org/doi/10.1103/PhysRevPhysEducRes.17.020143>.
- [4] S. Al-Qudah, J. Davishahl, E. Davishahl, y M. Greiner, «Investigation of Sense of Belonging to Engineering in Undergraduate Introductory Classes», in *2018 ASEE Annual Conference & Exposition Proceedings*, Salt Lake City, Utah, jun. 2018, p. 30730, doi: 10.18260/1-2--30730 [Online]. Available in: <http://peer.asee.org/30730>.
- [5] S. Won, L. C. Hensley, y C. A. Wolters, «Brief Research Report: Sense of Belonging and Academic Help-Seeking as Self-Regulated Learning», *The Journal of Experimental Education*, vol. 89, n.o 1, pp. 112-124, ene. 2021, doi: 10.1080/00220973.2019.1703095.
- [6] S. Cwik y C. Singh, «Students' sense of belonging in introductory physics course for bioscience majors predicts their grade», *Phys. Rev. Phys. Educ. Res.*, vol. 18, n.º 1, p. 010139, may 2022, doi: 10.1103/PhysRevPhysEducRes.18.010139. [Online]. Available: <https://link.aps.org/doi/10.1103/PhysRevPhysEducRes.18.010139>.
- [7] K. M. Whitcomb, A. Maries, y C. Singh, «Progression in Self-Efficacy, Interest, Identity, Sense of Belonging, Perceived Recognition and Effectiveness of Peer Interaction of Physics Majors and Comparison with Non-Majors and Ph.D. Students», *Res. Sci. Educ.*, sep. 2022, doi: 10.1007/s11165-022-10068-4. [Online]. Available in: <https://link.springer.com/10.1007/s11165-022-10068-4>.

- [8] G. M. Walton, C. Logel, J. M. Peach, S. J. Spencer, y M. P. Zanna, «Two brief interventions to mitigate a “chilly climate” transform women’s experience, relationships, and achievement in engineering.», *Journal of Educational Psychology*, vol. 107, n.º 2, pp. 468-485, may 2015, doi: 10.1037/a0037461. [Online]. Available in: <http://doi.apa.org/getdoi.cfm?doi=10.1037/a0037461>.
- [9] OECD (2017), «The under-representation of women in STEM fields», *The Pursuit of Gender Equality: An Uphill Battle*, 2017. [Online]. Available in: https://read.oecd-ilibrary.org/social-issues-migration-health/the-pursuit-of-gender-equality/the-under-representation-of-women-in-stem-fields_9789264281318-10-en#page1
- [10] L. Benson, C. Bolding, J. Ogle, C. McGough, J. Murphy, y R. Lanning, «Engineering Students’ Perceptions of Belongingness in Civil Engineering», en *2019 ASEE Annual Conference & Exposition Proceedings*, Tampa, Florida, jun. 2019, p. 32737, doi: 10.18260/1-2--32737 [Online]. Available in: <http://peer.asee.org/32737>.
- [11] J. G. Stout, T. A. Ito, N. D. Finkelstein, y S. J. Pollock, «How a gender gap in belonging contributes to the gender gap in physics participation», Philadelphia, PA, USA, 2013, pp. 402-405, doi: 10.1063/1.4789737 [Online]. Available in: <http://aip.scitation.org/doi/abs/10.1063/1.4789737>.
- [12] R. M. O’Hara, C. Bolding, J. H. Ogle, L. Benson, and R. Lanning, «Belonging in engineering», in *2020 ASEE Annual Conference & Exposition Proceedings*, Virtual Online event, jun. 2020, p.29583, doi: 10.18260/1-2--34202 [Online]. Available in: <https://peer.asee.org/34202>
- [13] L. Debs and B. R. Kota, “Gender Differences in Construction Management Students’ Sense of Belonging,” in *ASEE Annual Conference and Exposition, Conference Proceedings*, 2021, no. 32440.
- [14] M. A. Silva and A. Dominguez, “Women in Construction Engineering: Improving the Students’ Experience throughout their Careers,” in *2021 ASEE Annual Conference*, 2021, p. 33830.
- [15] K. Widdicks, A. Ashcroft, E. Winter, y L. Blair, «Women’s Sense of Belonging in Computer Science Education: The Need for a Collective Response», in *United Kingdom and Ireland Computing Education Research conference.*, Glasgow United Kingdom, sep. 2021, pp. 1-7, doi: 10.1145/3481282.3481288 [Online]. Available in: <https://dl.acm.org/doi/10.1145/3481282.3481288>.
- [16] C. Saavedra-Acuna and M. Quezada-Espinoza, “Academic performance and factors that influence the desertion of engineering students: a study with a gender approach,” in *ASEE Annual Conference and Exposition, Conference Proceedings*, 2022, p. 37128.
- [17] C. Zapata and M. E. Truyol, «Factors identifying commitment to gender equality in a School of Engineering», *ASEE Annual Conference & Exposition Proceedings*, Minneapolis, Minnesota, jun. 2022, p. 36799 [Online]. Available in: <https://peer.asee.org/40699>.
- [18] U. Tellhed, M. Bäckström, and F. Björklund, “Will I Fit in and Do Well? The Importance of Social Belongingness and Self-Efficacy for Explaining Gender Differences in Interest in STEM and HEED Majors,” *Sex Roles*, vol. 77, no. 1–2, pp. 86–96, 2017.
- [19] Y. Li y C. Singh, «Effect of gender, self-efficacy, and interest on perception of the learning environment and outcomes in calculus-based introductory physics courses», *Phys. Rev. Phys. Educ. Res.*, vol. 17, n.º 1, p. 010143, jun. 2021, doi: 10.1103/PhysRevPhysEducRes.17.010143. [Online]. Available in: <https://link.aps.org/doi/10.1103/PhysRevPhysEducRes.17.010143>.
- [20] Z. Y. Kalender, E. Marshman, C. D. Schunn, T. J. Nokes-Malach, y C. Singh, «Damage caused by women’s lower self-efficacy on physics learning», *Phys. Rev. Phys. Educ.*

- Res.*, vol. 16, n.º 1, p. 010118, abr. 2020, doi: 10.1103/PhysRevPhysEducRes.16.010118. [Online]. Available in: <https://link.aps.org/doi/10.1103/PhysRevPhysEducRes.16.010118>.
- [21] M. Y. Ahn y H. H. Davis, «Students' sense of belonging and their socio-economic status in higher education: a quantitative approach», *Teaching in Higher Education*, pp. 1-14, jun. 2020, doi: 10.1080/13562517.2020.1778664. [Online]. Available in: <https://www.tandfonline.com/doi/full/10.1080/13562517.2020.1778664>
- [22] M. E. Andrews, M. Borrego, y A. Boklage, «Self-efficacy and belonging: the impact of a university makerspace», *IJ STEM Ed*, vol. 8, n.o 1, p. 24, dic. 2021, doi: 10.1186/s40594-021-00285-0. [Online]. Available in: <https://stemeducationjournal.springeropen.com/articles/10.1186/s40594-021-00285-0>.
- [23] D. Ingram, «College students' sense of belonging: dimensions and correlates», Ph D, Stanford University, 2012 [Online]. Available in: <http://purl.stanford.edu/rd771tq2209>
- [24] K. L. Lewis, J. G. Stout, S. J. Pollock, N. D. Finkelstein, y T. A. Ito, «Fitting in or opting out: A review of key social-psychological factors influencing a sense of belonging for women in physics», *Phys. Rev. Phys. Educ. Res.*, vol. 12, n.º 2, p. 020110, ago. 2016, doi: 10.1103/PhysRevPhysEducRes.12.020110. [Online]. Available in: <https://link.aps.org/doi/10.1103/PhysRevPhysEducRes.12.020110>.
- [25] K. Rainey, M. Dancy, R. Mickelson, E. Stearns, y S. Moller, «Race and gender differences in how sense of belonging influences decisions to major in STEM», *IJ STEM Ed*, vol. 5, n.o 1, p. 10, dic. 2018, doi: 10.1186/s40594-018-0115-6. [Online]. Available in: <https://stemeducationjournal.springeropen.com/articles/10.1186/s40594-018-0115-6>.
- [26] E. R. Wester, L. L. Walsh, S. Arango-Caro, y K. L. Callis-Duehl, «Student Engagement Declines in STEM Undergraduates during COVID-19–Driven Remote Learning», *J Microbiol Biol Educ.*, vol. 22, n.o 1, p. ev22i1.2385, abr. 2021, doi: 10.1128/jmbe.v22i1.2385. [Online]. Disponible en: <https://journals.asm.org/doi/10.1128/jmbe.v22i1.2385>.