

Analysis of the enrollment of female students in STEM programs: a case study

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Abstract— In order to be able to propose any action to recruit female students in STEM programs, it is necessary to obtain a baseline with cross-referenced information that allows us to understand the behavior of this population in university higher education. In this article we present an analysis of the enrollment of male and female students in state and private universities. What has been the enrollment trend in a post-Covid-19 period. Finally, the distribution of students in science and engineering programs at the PUCP is presented.

Keywords— Engineering programs, private universities, science programs, state universities, university degree.

Resumen: Para proponer acciones destinadas a mejorar el reclutamiento de estudiantes mujeres en programas académicos de Ciencia, tecnología, ingeniería y matemáticas (STEM), es necesario obtener una línea base con información de alumnas inscritas en dichos programas. Esta línea base permitirá comprender el comportamiento de las alumnas en la educación superior universitaria. En este artículo, presentamos un análisis de la matrícula de estudiantes hombres y mujeres en universidades públicas y privadas, y analizamos su tendencia en el período posterior al COVID-19. Finalmente, se presenta la distribución del estudiantado en los programas de ciencias e ingeniería de la PUCP.

Palabras clave: Programas de ingeniería, universidades privadas, programas de ciencias, universidades públicas, título universitario.

I. INTRODUCTION

Concern for higher education in Latin America and the Caribbean continues to be a relevant issue for institutions such as UNESCO, the Inter-American Development Bank and others [1]. The populations of each country are diverse, as is their growth rate. Table I summarizes the population of the 20 most populous Latin American and Caribbean countries [2]. It is observed that Peru occupies fifth place with a population close to 35 million inhabitants.

TABLE I
TYPE SIZE DISTRIBUTION OF INHABITANTS BY COUNTRY IN LATIN AMERICA (2023-2024)

	Country	2023	2024
1	Brazil	216,422,45	217,637,30
2	México	128,455,57	129,388,47
3	Colombia	52,085,17	52,340,77
4	Argentina	45,773,88	46,057,87
5	Perú	34,352,72	34,683,44
6	Venezuela, República Bolivariana de	28,838.50	29,395,33
7	Chile	19,629,59	19,658,84

TABLE I
TYPE SIZE DISTRIBUTION OF INHABITANTS BY COUNTRY IN LATIN AMERICA (2023-2024) CONT'D.

	Country	2023	2024
8	Ecuador	18,190,48	18,377,37
9	Guatemala	18,092,03	18,358,43
10	Bolivia, Estado Plurinacional de	12,388,57	12,567,34
11	Haití	11,724,76	11,867,03
12	República Dominicana	11,332,97	11,434,01
13	Cuba	11,194,45	11,174,59
14	Honduras	10,593,80	10,759,41
15	Nicaragua	70,46.31	7,142.53
16	Paraguay	68,61,52	6,947.27
17	El Salvador	63,64,94	6,396.29
18	Costa Rica	5,212,17	5,246.71
19	Panamá	4,468,09	4,527.96
20	Uruguay	3,423,11	3,423.32
9	Latin America	652,451,08	657,384,264

Of the total population in Peru, not everyone has access to education. According to the National Institute of Statistics and Information (INEI) [3], there is still an educational gap in each educational level (Fig. 1).

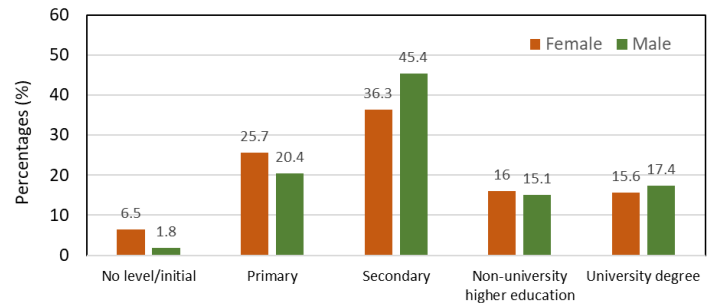


Fig. 1 Level of education achieved by the Peruvian population aged 25 and over, by sex, 2023.

It is observed that in addition to low university participation, there is a gender gap in accessing higher university education.

The educational system has evolved a lot in Peru in the last 150 years. By 1875 there were only 06 public universities in Peru. During the period from 1902 to 1969, 24 universities were registered, 14 being public universities and 10 private. From the period from 1983 to 1990, 03 public and 13 private universities were registered. At the end of the last century (1991-2000), 5 public and 17 private universities were registered [4]. Due to the change in University Law No.

23733, the creation of larger public and private universities in Peru was possible [5]. To date, Peru has 141 universities, both public and private. (Table II).

TABLE II
NUMBER OF PERUVIAN UNIVERSITIES ACCORDING TO THEIR CATEGORY

State	49	34.8 %
Private	92	65.2 %
Total	141	100%

The present work presents a statistical analysis of female participation in higher university education in Peru. Placing special emphasis on science and engineering (STEM) programs. This will allow us to better understand the problem of the decrease in the female population in Peruvian universities.

II. METHODOLOGY

To carry out the respective analysis, statistical data was collected from various sources such as the National Institute of Statistics and Information (INEI) [3], the Ministry of Education [5], and the National Superintendence of Education (SUNEDU) [6]. The data was selected for smaller periods, placing special emphasis on the last 5 years that include the COVID 19 pandemic. Finally, the population of students distributed in their various undergraduate programs in the area of science and engineering (STEM) of the PUCP was taken as a case study [7].

II. RESULTS

A. General description of higher education in Peru

The decrease in the number of undergraduate students in public universities in Peru has been evident in the last 5 years. Table III presents the population of students in public universities. It can be seen how after 2020 (year of the COVID pandemic), the population has been gradually decreasing.

TABLE III
NUMBER OF STUDENTS ENROLLED IN STATE UNIVERSITY (2020-2024).

	State Universities	Academic year			
		2020	2021	2022	2023
1	Universidad Nacional Mayor de San Marcos	33237	32784	33578	34 978
2	Universidad Nacional de San Agustín de Arequipa	26403	27460	27081	27 343
3	Universidad Nacional de San Antonio Abad del Cusco	20849	21713	21433	19 413
4	Universidad Nacional del Altiplano	18178	19218	20298	19 786
5	Universidad Nacional Federico Villarreal	17359	14712	13771	13 082
6	Universidad Nacional San Luis Gonzaga de Ica	16884	12741	11008	8 243
7	Universidad Nacional de Trujillo	15037	14252	14860	14 726
8	Universidad Nacional del Callao	13401	12315	11617	10 383
9	Universidad Nacional de San Cristóbal de Huamanga	12767	12690	13231	12 149
10	Universidad Nacional de Ingeniería	12721	12607	12668	12 514
11	Universidad Nacional Pedro Ruiz Gallo	12721	10120	8039	6 918

TABLE III
NUMBER OF STUDENTS ENROLLED IN STATE UNIVERSITY (2020-2024)
CONT'D.

	State Universities	Academic year			
		2020	2021	2022	2023
12	Universidad Nacional José Faustino Sánchez Carrión	11748	12703	12252	12 756
13	Universidad Nacional de Piura	11664	10774	10812	9 520
14	Universidad Nacional del Centro del Perú	11428	11946	11649	11 996
15	Universidad Nacional de Cajamarca	10686	10259	10208	10 409
16	Universidad Nacional de Educación Enrique Guzmán y Valle	9855	8925	8868	8 116
17	Universidad Nacional de La Amazonía Peruana	9628	11370	10047	11 601
18	Universidad Nacional Hermilio Valdizán de Huánuco	8907	8301	7138	7 572
19	Universidad Nacional Jorge Basadre Grohmann	7680	8774	9378	9 173
20	Universidad Nacional Santiago Antúñez de Mayolo	6900	7214	7245	6 701
21	Universidad Nacional Daniel Alcides Carrión	6892	6762	6770	6 615
22	Universidad Nacional Agraria La Molina	5936	6211	6126	6 434
23	Universidad Nacional de San Martín	5764	6345	6472	6 901
24	Universidad Nacional de Ucayali	5566	6436	7031	5 966
25	Universidad Nacional de Huancavelica	4573	4691	4886	5 181
	Total	316784	311323	306466	298476

Table III only presents the data of the 25 public universities with the largest population, since they are the ones that contribute with almost 90% of the student population in the 92 public universities of Peru. The decrease of almost 12% of enrolled students (Fig. 2) may be due to many factors, among which we can mention the economic issue, the postponement of studies due to activities that generate work, among others.

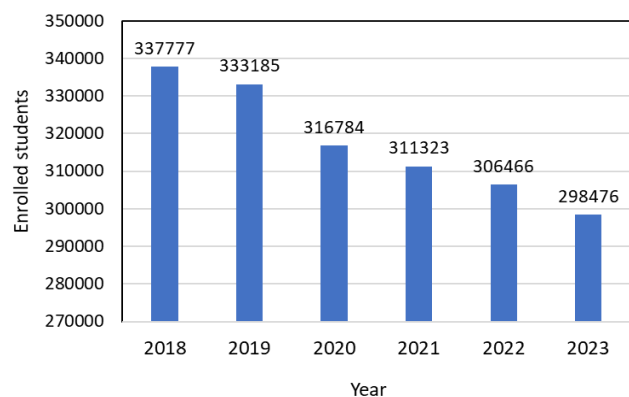


Fig. 2 Undergraduate student population trend in public universities (2018-2023).

Among the state universities that have lost the most students (have not enrolled) we have the U.N. Federico Villarreal, U. N. del Callao and U. de Piura (Fig. 3). Something to appreciate is that 3 of the top 5 universities are geographically located in Lima. Therefore, desertion has been higher in the capital than other regions of Peru.

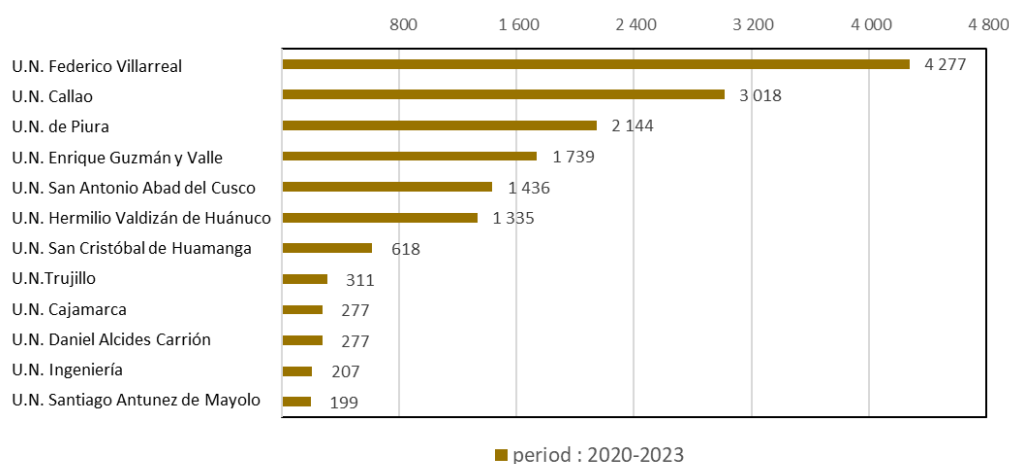


Fig. 3 Number of students not enrolled in state universities in the period 2020-2023.

A similar panorama, although to a lesser extent, has been experienced by private universities. Table IV presents the number of students enrolled in each private university in the period 2020-2023.

It is observed that although some private universities have lost student population, other universities have gained this population. This suggests a migration of potential university students who opt for private rather than public education. This may be due, among other factors, to: less study time due to the non-existence of a strike, more attractive study programs, among other aspects to consider.

Table IV only presents the data of the 25 private universities with the largest population, since they are the ones that contribute with almost 90% of the student population in the 41 public universities of Peru. The decrease of almost 12% of enrolled students (Fig. 2) may be due to many factors, among which we can mention the economic issue, the postponement of studies due to activities that generate work, among others.

TABLE IV
NUMBER OF STUDENTS ENROLLED IN PRIVATE UNIVERSITY (2020-2024).

	Private Universities	Academic year			
		2020	2021	2022	2023
1	Universidad Tecnológica del Perú S.A.C.	90 098	133 890	183 110	224 101
2	Universidad César Vallejo S.A.C.	112 934	153 492	169 879	173 490
3	Universidad Privada del Norte S.A.C.	99 644	117 629	133 099	144 821
4	Universidad Peruana de Ciencias Aplicadas S.A.C.	68 783	74 232	79 864	82 514
5	Universidad Continental S.A.C.	41 128	53 972	62 835	72 480
6	Universidad de San Martín de Porres	34 103	33 043	33 183	31 952
7	Universidad Privada Antenor Orrego	24 513	28 875	30 779	31 362
8	Universidad de Lima	24 436	26 460	27 243	29 833

TABLE IV
NUMBER OF STUDENTS ENROLLED IN PRIVATE UNIVERSITY (2020-2024) CONT'D.

	Private Universities	Academic year			
		2020	2021	2022	2023
9	Pontificia Universidad Católica del Perú	27 073	28 298	27 953	27 602
10	Universidad San Ignacio de Loyola S.R.L.	20 680	22 306	23 113	23 759
11	Universidad Privada San Juan Bautista S.A.C.	17 497	23 158	23 220	23 277
12	Universidad Privada Norbert Wiener S.A.	11 860	16 060	20 674	22 353
13	Universidad Señor de Sipán S.A.C.	15 859	19 005	20 910	21 358
14	Universidad Científica del Sur S.A.C.	11 205	16 320	17 252	21 303
15	Universidad Andina del Cusco	21 417	21 591	21 447	20 920
16	Universidad Católica de Santa María	17 053	19 306	20 507	20 732
17	Universidad de Huánuco	14 472	17 313	19 333	19 954
18	Universidad Peruana Los Andes	18 797	19 969	18 611	18 360
19	Universidad Autónoma del Perú S.A.C.	7 172	9 058	11 465	15 210
20	Universidad Peruana Unión	10 204	12 125	12 448	13 958
21	Universidad Católica Sedes Sapientiae	10 296	11 292	12 131	12 798
22	Universidad Ricardo Palma	13 003	13 229	12 965	12 395
23	Universidad Tecnológica de los Andes	11 280	11 913	12 022	11 687
24	Universidad Católica Santo Toribio de Mogrovejo	9 690	10 723	11 439	11 640
25	Universidad Católica San Pablo	8 855	9 684	9 707	9 720
Total		742 052	902 943	1 015 189	1 097 579

The growth of more than 62% of enrolled students (Fig. 4) may be due to the previously mentioned factors.

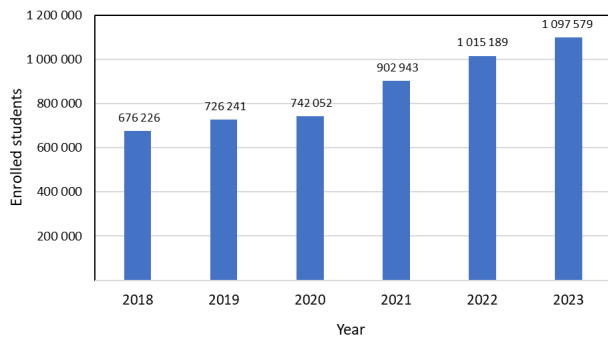


Fig. 4 Undergraduate student population trend in private universities (2018-2023).

Among the private universities that have lost the most students (have not enrolled) we have the U. Católica de Chimbote, U. Andina Néstor Cáceres Velásquez and U. San Pedro (Fig. 5). We must mention that these three universities are not geographically located in Lima. Only 3 of the top 10 private universities located in Lima are those that have lost student population.

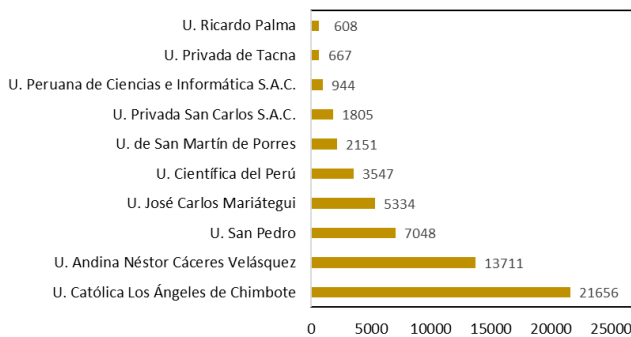


Fig. 5 Number of students not enrolled in private universities in the period 2020-2023.

According to the INEI report for the year 2022, the female population distribution is greater in a private university than in a State university (Fig. 6). Female participation in a private university (53.2%) is higher than in a state university (46.4%).

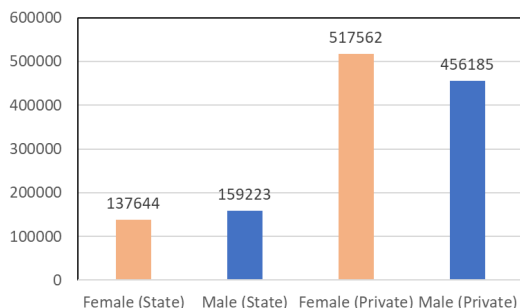


Fig. 6 Enrollment rate to higher education of women and men ages 17 to 24 (2022).

According to data from the INEI, the female population pursuing higher education has increased from 27.1% to 36% in the period 2020-2023 (Fig. 7). Here no distinction is made whether the university is state or public. A decrease in the population of both genders is observed in the year 2000, most likely due to COVID 19.

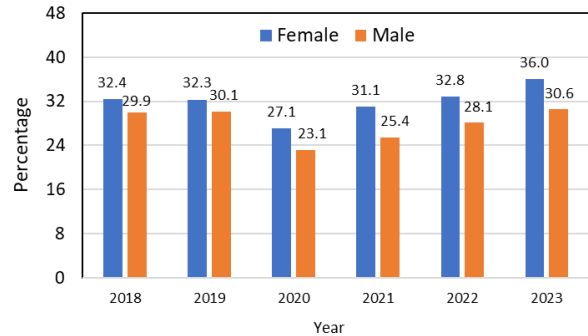


Fig. 7 Enrollment rate to higher education of women and men ages 17 to 24 (2018-2023).

In Fig. 8 it can be seen that the participation of both female and male students occurs in urban areas more than in rural areas. However, a slight increase in participation in rural areas is observed in 2022 and 2023.

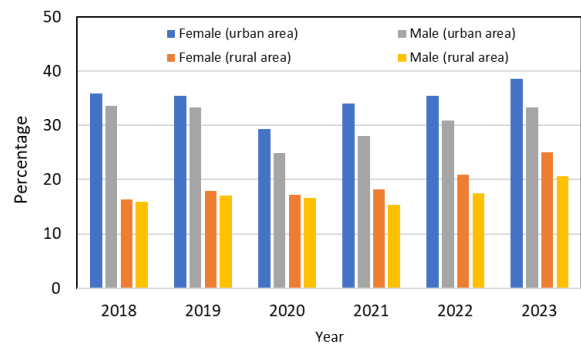


Fig. 8 Enrollment rate to higher education of women and men ages 17 to 24 in rural and urban areas (2018-2023).

It will also be necessary to evaluate the participation of students enrolled in higher education in the three main regions of Peru: coast, mountains and jungle. This is because each region shows its particularities and geographical problems, as well as different population densities.

Figure 9 shows the student population by gender in the coastal region of Peru. A decrease in the population is clearly observed in 2020 due to COVID 19, however this population recovers around 2023. An interesting fact is to observe that the recovery of the female population is much greater than the male population. This could be due to the fact that the male population prioritizes job search and postpones their university studies. A similar behavior is observed in the Alto Andina region (Fig. 10).

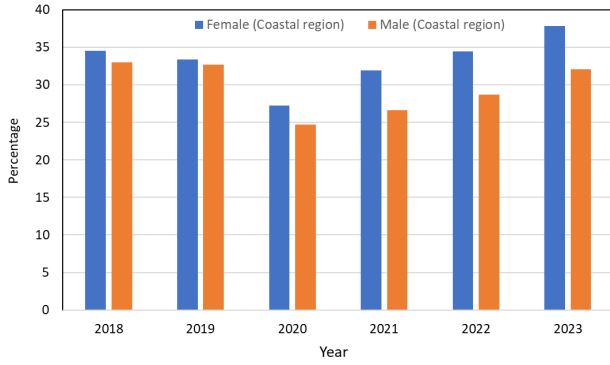


Fig. 9 Enrollment rate to higher education of women and men ages 17 to 24 in Coastal region (2018-2023).

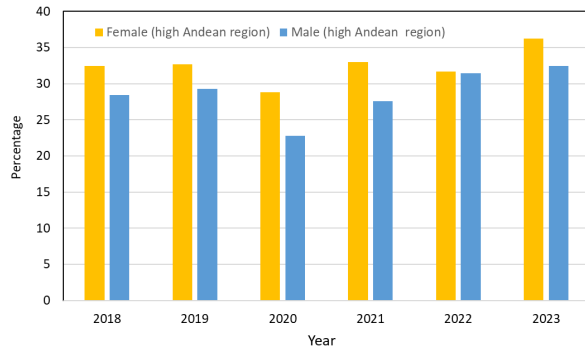


Fig. 10 Enrollment rate to higher education of women and men ages 17 to 24 in high Andean region (2018-2023).

In the case of the Tropical Rainforest region, it is observed that the male population does not increase after 2020, and that the female population does increase much faster, exceedingly almost 40% of the male population (Fig. 11).



Fig. 11 Enrollment rate to higher education of women and men ages 17 to 24 in Rainforest region (2018-2023).

If we compare the female population density in the three geographic regions of Peru, it will be observed that the tropical rainforest region is the one with the lowest number of

female students. The coast and the high Andean area being the ones with the highest enrollment (Fig. 12).

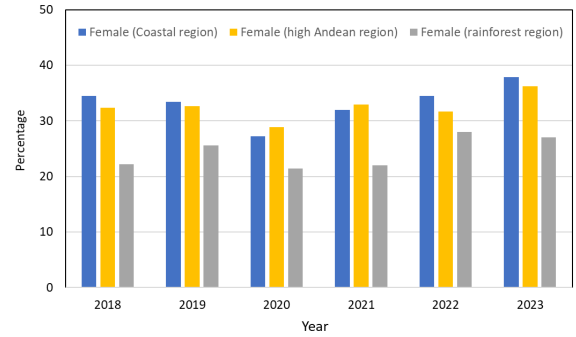


Fig. 12 Enrollment rate to higher education of women ages 17 to 24 in Coastal, high Andean and Rainforest region (2018-2023).

B. Distribution of students at the PUCP

PUCP is a private, non-profit university. It was founded in 1917 and to date has 16 Academic Departments, 13 Schools, 2 General Studies and Graduate School. PUCP offers 47 academic programs in different professional areas [7]. PUCP has a population of close to 25,000 undergraduate students distributed in similar percentages according to their gender.

TABLE V
DISTRIBUTION OF FEMALE AND MALE UNDERGRADUATE STUDENTS AT THE PUCP (2020-2024).

	2020	2021	2022	2023	2024
Female	11501	12288	12051	12022	12314
Male	12306	13116	12764	12675	12865
Total	23807	25404	24814	24696	25179

Within its schools, the PUCP brings together the science and engineering programs in a single large school, where students take their courses from their last 3 years of curriculum. The first two years are taken in General Science Studies. For this study, the students enrolled in the 5 years have been taken as a basis.

Fig. 13 presents the student population of the science programs: Physics, chemistry, mathematics and statistics. It is observed that the highest population density is unique in Physics and with a lower participation in statistics.

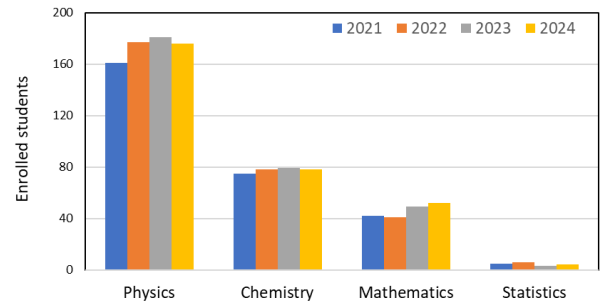


Fig. 13 Distribution of students in basic science programs (2021-2024).

Fig. 14 presents the distribution of students enrolled in the 12 engineering programs. It can be seen that the programs with the largest number of students are those of industrial, civil, computer science and mechatronics engineering. It is interesting to note that the computing population has increased rapidly in the last 3 years. Programs with small populations

(less than 500 students) are mechanics, electronics, telecommunications, mining and geology. A separate comment are the Environmental Engineering and Chemical Engineering programs, recently created in 2021 and 2024, respectively.

Table 6 presents in detail the number of students enrolled in science and engineering programs in the last 4 years.

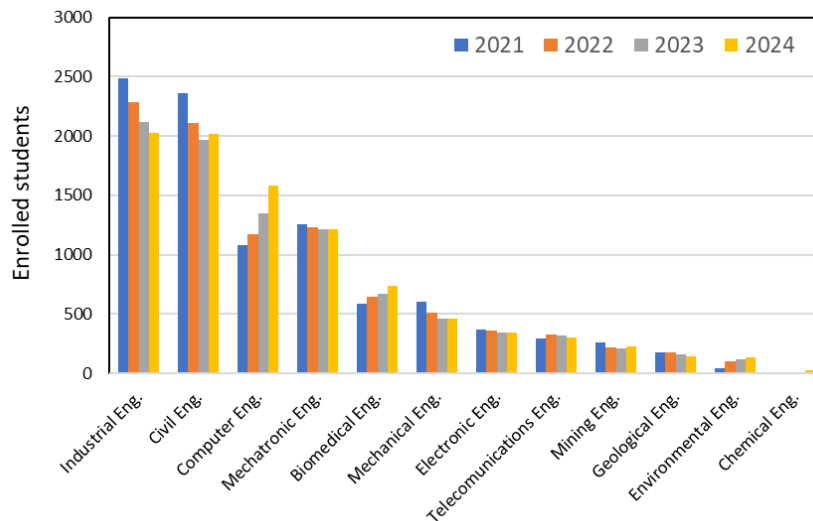


Fig. 14 Distribution of students in Engineering programs (2021-2024).

TABLE VI
DETAIL OF STUDENTS ENROLLED IN ENGINEERING SCIENCE PROGRAMS (2020-2023).

Program	Academic year			
	2020	2021	2022	2023
Industrial Eng.	2488	2287	2116	2026
Civil Eng.	2363	2114	1970	2017
Computer Eng.	1078	1176	1350	1585
Mechatronic Eng.	1259	1234	1217	1211
Biomedical Eng.	590	643	667	738
Mechanical Eng.	601	514	459	459
Electronic Eng.	370	359	347	346
Telecommunications Eng.	295	330	319	298
Mining Eng.	263	221	211	223
Geological Eng.	172	175	158	139
Environmental Eng.	40	100	120	136
Chemical Eng.	---	---	---	27
Physics	161	177	181	176
Chemistry	75	78	79	78
Mathematics	42	41	49	52
Statistics	5	6	3	4
Total	9802	9455	9246	9515

Table VII shows the distribution of students by gender. It is observed that although the number of students has increased, the percentage of female students enrolled remains at 25%, while the percentage of male students is at 75%.

In the case of science programs, it is observed that the highest density of students follows the chemistry program

(Fig. 15). A great difference in male students is observed in Physics (~89%) and mathematics (~80%).

TABLE V
DISTRIBUTION FEMALE AND MALE UNDERGRADUATE STUDENTS IN SCIENCE AND ENGINEERING PROGRAMS AT PUCP (2020-2024).

	2020	2021	2022	2023	2024
Female	11501	12288	12051	12022	12314
Male	12306	13116	12764	12675	12865
Total	23807	25404	24814	24696	25179
Female	24.7 %	25.5 %	25.5 %	25.0 %	24.8 %
Male	75.3 %	74.5 %	74.5 %	75.0 %	75.2 %

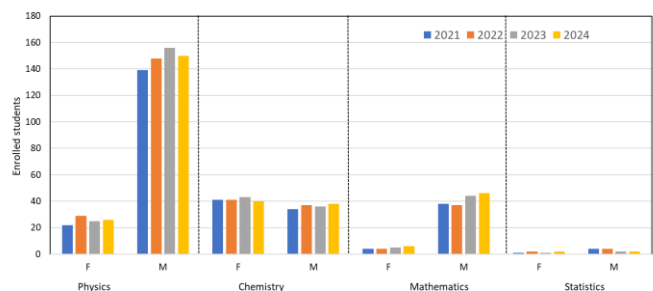


Fig. 15 Number of women and men enrolled in PUCP science programs (2021-2024).

Table VIII shows the details of the calculated ratios of male/female students enrolled in Sciences and Engineering programs.

TABLE VIII
RATIO OF MALE/FEMALE STUDENT POPULATION ENROLLED IN SCIENCE
AND ENGINEERING PROGRAMS AT PUCP (2020-2023).

Program	Academic year			
	2020	2021	2022	2023
Mechanical Eng.	10.56	9.08	8.00	8.18
Electronic Eng.	6.71	6.98	7.26	7.44
Mechatronic Eng.	7.39	6.62	6.38	5.73
Mining Eng.	5.74	5.31	4.55	4.72
Computer Eng.	4.83	5.19	5.28	4.47
Telecommunications Eng.	3.04	3.13	3.04	3.38
Civil Eng.	3.02	2.68	2.98	3.02
Geological Eng.	1.49	1.24	1.47	1.57
Industrial Eng.	1.39	1.43	1.46	1.33
Biomedical Eng.	1.36	1.40	1.45	1.31
Chemical Eng.	---	---	---	0.59
Environmental Eng.	0.82	0.47	0.48	0.51
Mathematics	9.50	9.25	8.80	7.67
Physics	6.32	5.10	6.24	5.77
Statistics	4.00	2.00	2.00	1.00
Chemistry	0.83	0.90	0.84	0.95

The proportion of male/female students in the science programs shows that for mathematics, for each female student there are on average 8 students, while in chemistry and statistics, for each female student there is one male student (Fig. 16).

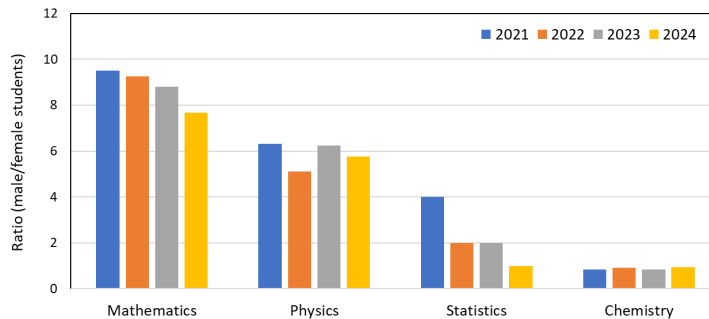


Fig. 16 Ratio of male/female student population enrolled in science programs at PUCP (2021-2024).

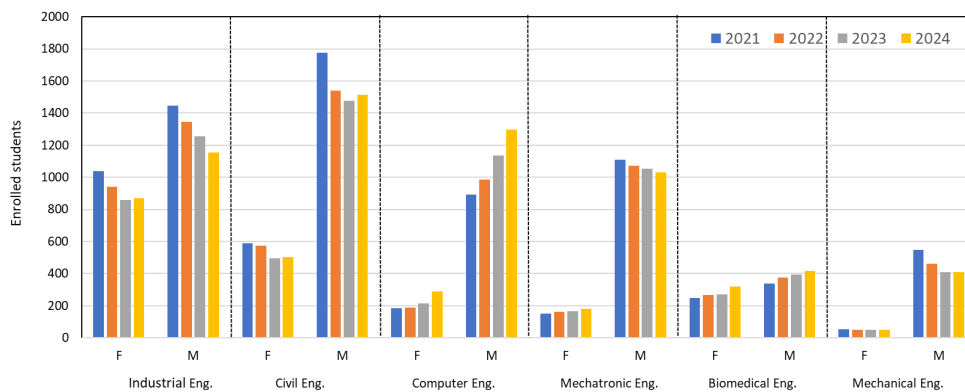


Fig. 17 Number of women and men enrolled in PUCP engineering programs- part 1 (2021-2024).

Due there are 16 engineering programs, the distribution of male and female students is presented in two figures (17 and 18). In Fig. 17 it is observed that the highest density of male students is enrolled in the Civil Engineering program followed by industrial engineering. A low female population is observed in computer science, mechatronics and mechanics programs.

Similar behavior is observed in electronics, telecommunications and mines (Fig. 18). More homogeneous populations are observed in biomedical and geology programs. The environmental engineering program is the only one in which the female population exceeds the male population (Fig. 18).

The proportion of male/female students in Engineering programs shows that for mechanical engineering and civil engineering, for every female student there are on average 8 male students, while in industrial and biomedical engineering, for every female student there is approximately one male student (Fig. 19). This great difference could be due to many factors, mainly insertion in the labor field. For a graduate of engineering programs, it is much easier to find a job in certain areas of engineering.

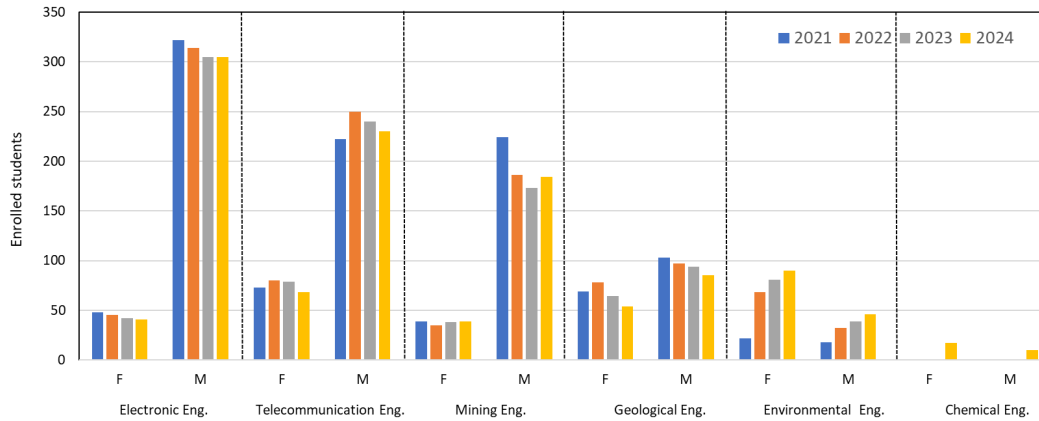


Fig. 18 Number of women and men enrolled in PUCP engineering programs- part 2 (2021-2024).

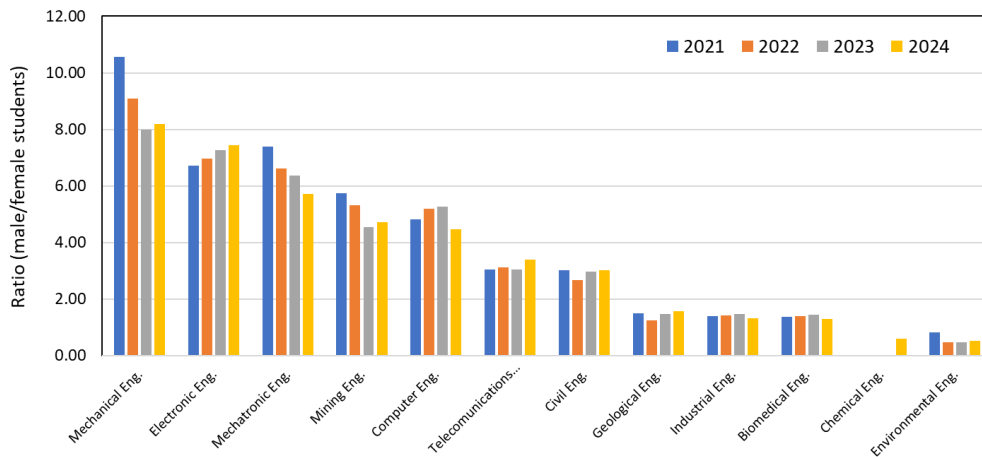


Fig. 19 Ratio of male/female student population enrolled in engineering programs at PUCP (2021-2024).

IV. CONCLUSIONS

The enrollment of students in state or private universities depends on several factors, which may be: demographic or economic.

It is evident that in the last four years there has been a migration of students from state universities to private universities.

In the specific case of PUCP students, the proportion of enrolled female students has remained almost constant in the last five years.

There are traditional programs such as mechanical, electronic and mining engineering that continue to have a low rate of female students enrolled. New programs, such as environmental engineering, geological engineering, and biomedical engineering, appear to be more attractive to female students.

ACKNOWLEDGMENT

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