Vocational Preferences Towards STEM Degrees in High School Students in Peru

Iván Montes-Iturrizaga[1], Eduardo Franco-Chalco[1] and Klinge Orlando Villalba-Condori [2]

[1] *Universidad María Auxiliadora, Canto Bello 431, San Juan de Lurigancho, Lima, 15408, Perú.*

[2] *Universidad Continental, Av. los Incas, Arequipa, 04002, Perú.*

Abstract

An research was carried out to determine the vocational preferences of 1159 students (764 males and 392 females) in the last two years of high school in the province of Arequipa (Peru) in the light of sociodemographic and family variables. The emphasis was directed towards STEM (Science, Technology, Engineering and Mathematics) degrees and with the intention of knowing their specific distribution by area of knowledge. The most relevant results show the existence of a predilection for engineering degrees, and where the natural sciences did not merit significant preferences. In this panorama, it was found that men showed interest in engineering and in comparison with women. These findings are discussed from an epistemological perspective based on critical realism, which proposes -among other aspects- the transcendental relevance of natural sciences and mathematics for the sustained, pertinent and harmonious development of engineering.

Keywords

Vocational preferences, technological development, scientific development, realistic epistemology, scientific planning

1. Introduction

Since the creation of the National Council for Science and Technology (CONCYTEC) in 1981, important promotion processes have been developed in light of competitive funds, access to specialized libraries and training spaces. However, since the enactment of the new University Law No. 30220 of 2014, a system of institutional licensing (universities) was built, which considers scientific production, the existence of qualified researchers before the National Registry of Science, Technology and Technological Innovation (RENACYT) [1] and special conditions (bonuses and reduced teaching load) for all academics involved in the scientific and technological fields. In this context, the country has been able to relate research and university development in a system of implications; and where failure to sustain scientific production or the required number of researchers (among other quality conditions or standards) is accompanied by measures such as the closure of universities (suspension of the license) [1].

CISETC 2021: International Congress on Educational and Technology in Sciences, November 16-18, 2021, Chiclayo, Peru
EMAIL: imontes@uc.cl (I. Montes-Iturrizaga) efranco1@uc.cl (E. Franco-Chalco); kvillalba@continental.edu.pe (K.O. Villalba-Condori).
ORCID: https://orcid.org/0000-0002-9411-4716 (I. Montes-Iturrizaga); https://orcid.org/0000-0002-7465-2365 (E. Franco-Chalco); https://orcid.org/0000-0002-8621-7942 (K.O. Villalba-Condori).

The aforementioned has led to an increase in national scientific production. Thus, we have gone from a handful of universities (32 out of 143) with research (in quantities greater than zero) to 95 universities with scientific production in frank growth [2]. In any case, these indicators (successful and favorable, by the way) lead us to think that in the renewed scheme of research, development and innovation (R&D&I), special interest has been given to technological studies and innovation (mostly industrial and environmental) to the detriment of science itself [3], [4]. In addition, and in view of the fact that this integrating denomination to understand science and technology (I+D+i or I+D) is used to study government investment (GDP in science and technology) and production (published articles), it is difficult to determine what science, technology and engineering really are. This fact was already noticed many decades ago by Mario Bunge and a group of epistemologists [5], [6], [3], [4].

Moreover, the government fund that has been financing research in Peru for the last 35 years has made a greater commitment to proposals in the field of engineering. It is also worth mentioning that the University Law itself, in several of its articles, confuses technological research and business incubators with basic research. What is worrying here is the almost imperceptible support of the natural sciences and mathematics under utilitarian prejudices that only give value to fields that solve practical problems, when the sciences are primarily concerned, in the first instance, with cognitive problems [7]. It could be added that in this series of confusions, science is misjudged from the point of view of technologies and is therefore underestimated for not directly solving practical problems [4], [5].

In allusion to the above, it could be thought that natural resources are poorly understood and, to a certain extent, prejudiced, since they are not considered relevant for the development of the company's business [8]–[10]. Therefore, behind these decisions we see that the relationships and transcendental importance of the natural sciences for the development of technologies and innovations aimed at solving specific problems are ignored. Without properly consolidated natural sciences in a country, we will be cognitively dependent on science from other latitudes. And, what is worse, technological development itself at all levels would be harmed by not having rigorous knowledge to be able to build their responses to the various challenges [5].

Therefore, this problem would explain the lack of interest in studying natural sciences (physics, chemistry or biology) and formal sciences (mainly mathematics) in Latin America, the United States and most of Europe. We are probably facing a global problem that has put the aforementioned sciences in check. However, developed countries have partially solved this problem thanks to the high prestige of their universities, which attract thousands of students from countries such as India, China and Latin America in general to study in fields such as physics, mathematics or chemistry [11]–[13]. Thus, for example, at least two-thirds (approximately) of U.S. scientists (physics, chemistry, and biology) were born outside the United States; they are primarily graduate students who chose not to return to their home countries [13].

On the other hand, it is worth mentioning that in this study we recognize the transcendental importance of technologies and engineering for social development and science itself [9], [14]. This fact is undeniable and the great interest in STEM careers is praiseworthy; where the worrying thing is the scarce interest in natural sciences and mathematics. This is a very complex phenomenon present in many countries such as Spain [15], United States [16]–[19], England [20] or France [21]; and that would merit qualitative methodological approaches interested in learning about family, school and social influences, as well as those of the organizations in charge of promoting science and technology in the country.

This is in addition to other problems such as the low interest of women in studying STEM careers, gender stereotypes at home in the face of these inclinations and the conviction of many young people that the choice of career should be made for the supposed expectation of economic retribution (rate of return) rather than for a real vocation [22]–[26].

1.1 Professional degree choice as a complex process

Several studies have found that young people (80%) are faced with the situation of choosing a technical, technological or university degree after completing secondary or high school (80%). Thus,

this decision would be based on an analysis (superficial or deep) in which parents often play an important role in terms of support or resistance [22], [27], [28]. In any case, the greater number of young people finishing high school who neither work nor study is higher in rural areas (13.9% compared to 18.2% in urban areas). In Arequipa, we find that this region has the third highest rate of participation in higher education in Peru (38.4%) [29].

It is also worth noting that preferences are to some extent structured by productive emphases, labor traditions and the existing labor supply [22], [30], [31]. Therefore, and for example, in the city of Arequipa (where this study has been developed), agroindustry, public services, construction and mining activity stand out. In addition, the other regions adjacent to the Arequipa region also have (foreign) mines of great importance in the local GDP. In any case, this last productive deployment (mining) generates a large supply of jobs directly and through contracting companies would be associated with the marked interest in engineering degrees [30], [31], [32].

Under this scenario, it would be expected that this interest in technological degrees would be accompanied by their respective share of degrees identified with the natural and formal sciences. However, it should be mentioned that school psychology assumes that it is healthy for each young person to be able to apply for a university place in the degree that he/she really prefers and without any conditions associated with the supposed economic income or rate of return once the degree is obtained. In addition, and in relation to the above, it is considered important to transmit to students the idea that in order to work in a certain degree and be successful (socially and economically) it is necessary to be good at what one does; and, therefore, it is rare to find someone like this in a degree that does not arouse any interest other than monetary. For this reason, from a perspective concerned with the personal fulfillment of future professionals, it is necessary to promote free decisions, free of prejudices, stereotypes and economic reductionism [22], [27], [28], [33]. In this task, it has been found that parents often exert pressure on their children to abandon their true vocation and study degrees considered to guarantee higher salaries [23]. In summary, and taking into account the authoritarian family styles still present in Peruvian families, it is likely that scientific degrees (biology, mathematics, physics and chemistry) will be the best choice [34].

2. Research on vocational preferences

We have identified a series of research studies related to the preferences for natural science and mathematics degrees in young people who are about to finish high school. These studies, which are presented in the first place and which coincide with the one presented in this paper, correspond -mostly- to the fields of psychology, sociology and anthropology. The other studies are more sociodemographic in nature and offer us a quantitative overview of the governmental figures on the number of applicants in the statistical records of the National Superintendence of University Higher Education (SUNEDU).

In relation to the above, we have that a main variable that plays a major role in the way in which people choose careers is gender. In this way, stereotypes become evident and play a relevant role in the inclinations, preferences and concrete choices assumed by men and women. These investigations are projected in two recently published papers in the Arequipa region where the existence of gender stereotypes that would keep women away from STEM careers in general, parental resistance and motivations based on economic interests, especially among men in state or public schools, were found [22], [23].

In the Latin American and North American spectrum, other studies tell us about the lack of interest in scientific and technological careers in general and especially among women, who prefer social and human sciences careers, perhaps due to stereotypes, family pressures and the influence of social communication [24], [35]–[41].

3. Methods

A survey (anonymous) was designed and applied to explore vocational preferences in the light of personal, family, and sociodemographic variables to 1155 students (66% males) in the last two years of secondary education (4th and 5th) in the province of Arequipa. The application of the instrument was carried out with the informed consent of the educational institutions (urban) and the students themselves. It should be noted that in this study (framed in a series of publications carried out this year) we have used a few items such as: gender (male and female); type of educational institution (public, private and parochial); and vocational preferences (What degree would you study if you had the "total freedom" to choose).

The test as a whole has theoretical and content validity determined through a system of judges. Likewise, and given that this test does not include additive items, it is not possible to determine validity and reliability from a statistical point of view.

The statistical analyses, descriptive and chi-square (χ^2), were carried out with SPSS for Windows ® software in its 26.0 version.

4. Results

The first general results (Table 1) show that the majority of preferences are for engineering degrees (18 specialties) with 33.1% (n = 384). It is also eloquent that only 1.6% (n = 18) were interested in natural science degrees such as biology, physics, chemistry, geology and others. In addition, it is worth mentioning that none of the students who participated in the study expressed a preference for the degree in mathematics, which is taught at the public university of the province (Universidad Nacional de San Agustín) at no cost, given the precept that these public institutions are free of charge. Finally, it is important to note that in the category "other degrees" we have grouped almost 60 from the fields of social sciences, human sciences, health sciences, armed and police forces, arts and technical careers such as mechanics, electricity and carpentry.

Table 1

Degrees preferred by the young people in the sample

Degrees	f	%
Natural Sciences	18	1,6
Engineering	384	33,1
Other degrees	757	65,3

Table 2 shows the test of association between the sex variable and the professional degrees. It is clearly perceived that men show a greater predilection for natural sciences and engineering degrees (this being more noticeable in the former). In the grouping we made around "other degrees", social sciences and human sciences predominate; which to a certain extent are fields mostly preferred by women and for this reason their predominance (80.1%), these results were statistically significant ($\chi^2 = 57.34$, df = 2, $p < 0.001$).

Table 2

Degrees preferred by the young people in the sample according to the sex variable

	Men		Women	
Degrees	*f*	*%*	*f*	*%*
Natural Sciences	15	2,0	3	0,8
Engineering	308	40,3	75	19,1
Other degrees	441	57,7	314	80,1

Table 3 shows the association between the type of school and the degree categories generated in light of vocational preferences. Natural science degrees were preferred to a greater extent in private and parochial educational institutions. This same tendency is also projected to engineering degrees. The opposite case is observed in the category "other degrees" where students from public schools are more oriented. These results were statistically significant ($\chi^2 = 11.37$, df = 4, p = 0.023).

Table 3
Degrees preferred by the young people in the sample according to the type of educational institution.

	Public		Private		Parochial	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Natural Sciences	4	0,7	4	2,0	10	2,7
Engineering	117	30,4	71	34,6	135	35,5
Other degrees	402	69,0	130	63,4	225	60,8

5. Discussion

The results show the scarce predilection for natural science (and mathematics) degrees in a large sample of students who are about to graduate from secondary education in the province of Arequipa. Likewise, these findings are worrying if we intend to achieve a harmonious development of science and technology in a given territory (province, region or country) [5], [6], [22]. For, as noted in the previous pages, we find the interest in engineering valuable, but the possibility of not having scientists who can support the technologies is disturbing.

In any case, we do not have a parameter or standard that tells us how many natural scientists and mathematicians are required in a given country or subnational state, except for the trends that tell us of a balance between scientists and engineers, as in England, where there are more scientists than engineers [42].

On the other hand, our study still shows a weak preference of women for science and engineering degrees, which tells us that there are still prejudices, self-exclusion and sexist segregation in these disciplines; a fact that is repeated in most of Latin America [24], [35], [43]. Similarly, with regard to the type of school, we see that scientific and engineering degrees (equally) are preferred to a greater extent by those who attend private and parochial schools (the same ones that have a lower pension or payment) compared to those who attend public institutions. Perhaps, given that those who attend public schools come from families with fewer resources, they may prefer degrees with greater possibilities of obtaining a stable job in the state sector, such as the human and social sciences. Also, those who attend public schools would prefer engineering degrees for a quicker and more profitable incorporation into the labor market.

However, for future research, it will be necessary to explore from qualitative perspectives (interviews, discussion groups and life histories) the thoughts, beliefs and stereotypes that could be behind the low preference for natural sciences (and mathematics). Finally, we highlight the significant preferences for engineering degrees in Arequipa, which are essential for economic and social development in every sense of the word [30]. The latter is not in question from any point of view and it is likely that these elections are triggered by the boom in Arequipa's productive vocations (mining, construction, industry and manufacturing in general) and the favorable action of the National Council

of Science and Technology (CONCYTEC) [31], [22]. In this scenario, no decisive and balanced actions have taken place for the natural sciences (and mathematics). In this context, it is likely that science fairs (at the school level) that take place in other scenarios can serve as an input for the country. [44], [45]. Perhaps, and this is only an explanatory hypothesis, the poor understanding of what science is and its confusion with technology could be important clues to elucidate the problems encountered. [4], [3].

6. References

[1] O. G. MEZA, "Registro necesario," Lima, pp. 2–4, 2019.

[2] L. Cervantes, L. Bermúdez, and V. Pulido, "Situación de la investigación y su desarrollo en el Perú: reflejo del estado actual de la universidad peruana," *Pensam. Gestión*, vol. 46, pp. 311–322, 2019, doi: https://doi.org/10.14482/pege.46.7615 Resumen:La.

[3] I. Montes-Iturrizaga, "Derechos humanos de los investigadores científicos: una propuesta desde la epistemología realista," 2016, [Online]. Available: https://www.fissnet.org/jfiss/.

[4] I. Montes-Iturrizaga, "Importancia del juicio de pares y el cumplimiento de estándares para las decisiones evaluadoras de los proyectos de investigación en C y T," 2002.

[5] M. Bunge, *Ciencia y Desarrollo*. Buenos Aires, 1980.

[6] M. Bunge, *Parte A: Ciencias Sociales Básicas*. Buenos Aires: Penguin Random House Grupo Editorial, 2014.

[7] I. Montes-Iturrizaga, "Apreciaciones en torno a la propuesta de nueva Ley Univeritaria," *Revista Signo Educativo*, Lima, pp. 26–28, May 2014.

[8] J. A. Lagos Figueroa, "El papel de la física en la formación profesional del ingeniero," *Rev. Lumen Gentium*, vol. 1, no. 1, pp. 91–96, 2017, doi: 10.52525/lg.v1n1a9.

[9] J. Lucerna and G. L. Downey, "Haciendo científicos e ingenieros para propósitos nacionales en USA: desde la guerra fría hasta la competitividad económica," *Hist. Crítica*, vol. 10, no. Enero 1995, pp. 29–38, 1995, doi: https://doi.org/10.7440/histcrit10.1995.02.

[10] C. Para and E. L. Desarrollo, "CIENCIA , TECNOLOGÍA , INGENIERÍA Y MATEMÁTICAS (STEM)," 2017.

[11] H. Okahana and E. Zhou, *International Graduate Applications and Enrollment Fall 2018*, no. February. Washington, DC: Council of Graduate Schools, 2019.

[12] P. Gaulé and M. Piacentini, "Chinese graduate students U.S. scientific productivity," *Rev. Econ. Stat.*, vol. 95, no. May, pp. 698–701, 2013, doi: https://doi.org/10.1162/REST_a_00283.

[13] I. Ganguli and P. Gaulé, "Will the U.S. keep the best the brightest (as Post-docs)? Career and location preference of foreing STEM PhDs," Cambridge, MA, Working Paper 24838, 2018. [Online]. Available: http://www.nber.org/papers/w24838.

[14] A. Valencia, "La relación entre la ingeniería y la ciencia," *Rev. Fac. Ing. Univ. Antioquia*, vol. junio, no. 31, pp. 156–174, 2004, [Online]. Available: https://www.redalyc.org/articulo.oa?id=43003113.

[15] J. Solbes, R. Montserrat, and C. Furió, "Desinterés del alumnado hacia el aprendizaje de la ciencia: implicaciones en su enseñanza," *Didáctica las Ciencias Exp. y Soc.*, vol. 117, no. 21, pp. 91–117, 2007, doi: 10.7203/dces..2428.

[16] F. Grobart, "Ciencia y tecnología en estados Unidos: crisis sistémico-estructural en los cimientos del capitalismo monopolista transnacionalizado," *Econ. Desarro.*, vol. 149, no. 1, pp. 117–138, 2013, [Online]. Available: https://www.redalyc.org/articulo.oa?id=425541207008.

[17] Andrea Widener, "Science in the US is built on immigrants. Will they keep coming?," *C&EN Global Enterprise*, vol. 97, no. 9, pp. 35–40, 2019.

[18] E. B. R. Manalansan, M. A. Fogata, and D. J. V. Rogayan, "Exploring Prospective Teachers' Reasons for Choosing General Science as a Specialization," *J. Sci. Learn.*, vol. 3, no. 3, pp. 149–155, 2020, doi: 10.17509/jsl.v3i3.23493.

[19] S. Jiang, K. Schenke, J. S. Eccles, D. Xu, and M. Warschauer, "Cross-national comparison of gender differences in the enrollment in and completion of science, technology, engineering, and mathematics Massive Open Online Courses," *PLoS One*, vol. 13, no. 9, pp. 6–13, 2018,

doi: 10.1371/journal.pone.0202463.
[20] D. Higgins and J. Pethica, “A picture of the UK scientific workforce,” London, 2014. [Online]. Available: https://royalsociety.org/~/media/Royal_Society_Content/policy/projects/leading-way-diversity/picture-uk-scientific-workforce/070314-diversity-report.pdf.
[21] J. Powell and J. Dusdal, “Science Production in Germany, France, Belgium, and Luxembourg: Comparing the Contributions of Research Universities and Institutes to Science, Technology, Engineering, Matthematics, and Health,” *Minerva*, no. 55, pp. 413–434, 2017, doi: https://doi.org/10.1007/s11024-017-9327-z.
[22] I. Montes-Iturrizaga and E. Franco-Chalco, “Women’s preferences towards stem majors in peru: a study from social stereotypes and parental resistance,” in *INTED2021 Proceedings*, 2021, pp. 8740–8746, doi: 10.21125/inted.2021.1820.
[23] I. Montes-Iturrizaga and E. Franco-Chalco, “Attitudes towards the choice of a professional career: a study in secondary education students from peru,” 2021, doi: 10.21125/edulearn.2021.1725.
[24] A. García-Holgado, A. Camacho Díaz, and F. J. García-Peñalvo, “La brecha de género en el sector STEM en América Latina: una propuesta europea,” no. Cinaic, pp. 704–709, 2019, doi: 10.26754/cinaic.2019.0143.
[25] M. Hamilton *et al.*, “Gender equity in computing: International faculty perceptions & current practices,” *Proc. 2016 ITiCSE Work. Gr. Reports, ITiCSE 2016*, pp. 81–102, 2016, doi: 10.1145/3024906.3024911.
[26] Z. Cai, X. Fan, and J. Du, “Gender and attitudes toward technology use: A meta-analysis,” *Comput. Educ.*, vol. 105, no. November 2016, pp. 1–13, 2017, doi: 10.1016/j.compedu.2016.11.003.
[27] I. Montes-Iturrizaga, “¿Cómo decidir una carrera con responsabilidad?,” *Revista Signo Educativo*, Lima, p. 28, Mar. 2014.
[28] I. Montes-Iturrizaga, “Sobre la orientación vocacional,” *Diario El Comercio*, Arequipa, Mar. 16, 2013.
[29] INEI, *Perú: Indicadores de Educación por Departamentos, 2008-2018*. Lima, 2019.
[30] J. L. Nolazco, “Impacto de la dinámica en la industria minera sobre el desarrollo regional de Arequipa : Un análisis de género 1,” vol. 2014, pp. 1–63, 2015.
[31] Grupo Propuesta Ciudadana, “Región Arequipa: ingresos y gastos generados por concepto de canon y regalías mineras,” Arequipa, 2018. [Online]. Available: http://propuestaciudadana.org.pe/wp-content/uploads/2018/02/Regi%23U00f3n-Arequipa-ingresos-y-gastos-generados-por-concepto-de-canon-y-regalías-mineras.pdf.
[32] C. Hoyos, Diego; Aguinaga, Valeria; Carranza, Víctor; Ramírez, Deivid; Valdivia, Frances; Abanto, “Anuario Minero 2019 Perú,” Lima, 2019.
[33] I. Montes-Iturrizaga, “Como decidir una carrera La República 6 Feb 2014,” Arequipa, Feb. 2014.
[34] Comisión Económica para América Latina y el Caribe, *Familia y políticas públicas en América Latina: Una historia de desencuentros*. Santiago de Chile: División de Desarrollo Social de la CEPAL.
[35] V. Prieto-echagüe and V. Prieto-echagüe, “Gender inequality in STEM careers in Uruguay. Building culture and records: the experience at the Institut Pasteur de Montevideo with InMujeres (Uruguay),” pp. 143–163, 2020.
[36] A. K. Sánchez Jasso, E. Rivera Gómez, and J. J. Velasco Orozco, “Desigualdades de género en ciencia, el caso de las científicas de la UAEMéx,” *Cuad. Inter.c.a.mbio sobre Centroamérica y el Caribe*, vol. 13, no. 2, p. 83, 2016, doi: 10.15517/c.a..v13i2.26691.
[37] Á. Vázquez-Alonso and M.-A. Manassero-Mas, “La voz de los estudiantes de primer año en seis países: evaluación de sus experiencias en estudios superiores científico-técnicos,” *Ciência Educ.*, vol. 22, no. 2, pp. 391–411, 2016, doi: http://dx.doi.org/10.1590/1516-731320160020008.
[38] ComunidadMujer, “Mujer y trabajo: Brecha de género en STEM, la ausencia de mujeres en Ingeniería y Matemáticas,” *Ser. ComunidadMujer*, pp. 1–15, 2017, [Online]. Available: http://www.comunidadmujer.cl/biblioteca-publicaciones/wp-content/uploads/2017/12/BOLETIN-42-DIC-2017-url-enero-2018.pdf.

[39] A. I. Basco, C. Lavena, and Chicas en Tecnología, “Un potencial con barreras: La participación de las mujeres en el área de Ciencia y Tecnología en Argentina,” *Bid*, 2019, [Online]. Available: https://publications.iadb.org/es/un-potencial-con-barreras-la-participacion-de-las-mujeres-en-el-area-de-ciencia-y-tecnologia-en.
[40] K. I. Martínez Méndez, “Tienen sexo las profesiones. Hombres y mujeres en profesiones femeninas y masculinas, el caso de los enfermeros y las ingenieras mecánicas electricistas,” Colegio de San Luis, ac, 2015.
[41] M. Caballero Wangüemert, “Mujeres de ciencia: El caso del consejo superior de investigaciones científicas,” *Arbor*, vol. 192, no. 778, 2016, doi: 10.3989/arbor.2016.778n2003.
[42] J. Montgomery, “The culture of scientific research in the UK,” 2014.
[43] B. Cantero Riveros, M. Izquierdo i Aymerich, and D. Couso, “Inclusión del género en la enseñanza de las ciencias,” *TDX (Tesis Dr. en Xarxa)*, 2016.
[44] L. V. Oppliger, P. Nuñez, and S. Gelcich, “Ferias Científicas como Escenarios de Motivación e Interés por la Ciencia en Estudiantes Chilenos de Educación Media de la Región Metropolitana,” *Inf. Tecnológica*, vol. 30, no. 6, pp. 289–300, 2019, doi: http://dx.doi.org/10.4067/S0718-07642019000600289.
[45] Fundación Española para la Ciencia y la Tecnología, *Libro Verde Ferias de la Ciencia*. Madrid: Fundación Española para la Ciencia y la Tecnología, FECYT, 2018.
[46] M. Albornoz, “Ciencia y tecnología para el desarrollo,” *Rev. Int. Investig. en Ciencias Soc.*, vol. 11, no. 2, pp. 161–163, 2015, doi: http://dx.doi.org/10.18004/riics.2015.diciembre.