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Proposal to Characterize the Effectiveness of Engineering Education in Colombia

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***Abstract*– This text proposes a method to estimate the effectiveness of engineering training in Colombia based on data from 2012 to 2022 and on the purposes of Higher Education according to Law 30 of 1993.**

5 types of effectiveness are proposed: socio-technical, socioeconomic, graduation time, formative of the Higher Education Institutions (IES), of the student; The first two efficiencies cannot be obtained due to inconsistency in the information on the social added value of engineering activities that is different from the salary payments of engineers, and the inconsistency in the estimation of the variation in educational quality between the high school and the results of the Saber Pro tests.

An increase in efficiency is identified in the graduation time from 45% to 90%. An increase in training effectiveness within IES is identified from 25% to 68%. From the product of these two, the student's perspective is obtained with a change in effectiveness from 11% to 61%.

Therefore, although progress has indeed been made in aspects of the flow and management of IES, inter-comparable measures of academic and social quality are still not available. And it is still halfway between an initial value of 11% to 100%.

Keywords— Education, Engineering, Colombia, Efficiency, Quality.

I. INTRODUCTION

Here a procedure is proposed to estimate the effectiveness of aggregate training at the national level in engineering for Colombia from 2011 to 2022 from the perspectives of students, institutions, and society, based on available public information; For this, the average training time is estimated based on the entire first-semester enrollment for 15 engineering modalities.

In Colombia, Higher Education Institutions, IES, train people later as University Professionals, PU, after two cycles: the Secondary Education cycle, ES, of 6 years and the Primary Education cycle, EP, of 5 years.

The IES trains Technicians, TC, Technologists, TG, and University Professionals, PU, among which different modalities of engineering, IG, are included. The most frequent time for the PU offers in IG was 60 months until 2020, from there the increase in the formulation of virtual, remote, asynchronous, and other variants reduced this time to different values between 20 to 48 months, infrequent offers, and with little demand in Colombia before 2020.

The change and reduction of the time used in IG training can be associated with the technological possibilities and the interests of the different groups of actors in the training process in higher education: students, institutions, and society, who may or may not share criteria regarding what is considered relevant in education.

A. Data

The information from Colombia from 2001 on the training of University Professionals is for all educational sectors in

- Admitted until 2013 [1]:
- Enrolled in the first year from 2001 to 2013[2]:
- Total enrollment from 2001 to 2013 [3]:
- Graduates from 2001 to 2017 [4]:
- Display [5]:
- Detailed information for later dates is on the page of the National Higher Education System, SNIES, of the Ministry of Education of Colombia. [6]:
- Quality evaluation of Higher Education, ECAES Tests and Saber Pro 2004 to date [7]

The Colombian Association of Engineering Faculties, ACOFI, links and presents information regarding the organizational sub-units of the IES, Faculties, that offer the varied IG programs, in more than 100 IES, with more than 200-degree designations in IG; These degree modalities are grouped into: Agricultural, Agro-industrial, Food, Environmental, Earth Sciences, Civil, Electrical, Electronics, Forestry, Industrial, Mechanics, Chemistry, Systems, and Telecommunications.

The Report on Engineering Programs in Colombia 2023 [8] is the fourth in its series for the total number of Engineering Faculties in Colombia. It has semiannual data from 2012 to 2022 regarding the number of: students enrolled in any university program; students enrolled in IG in the first semester, students enrolled in IG in all semesters, graduated students in IG. This information is segmented for each GI type by type of institution, Official or Private, and gender, Men or Women. With infographics for each type of IG

B. Definitions

Higher Education Institutions, IES, are Professional Technical Institutions, University Institutions or Technological Schools, and the Universities, within the framework of Article 18 of law 30 of 1993[11]

Academic Program, PA, is the educational structure leading to a degree from an IES.

University Professional, PU is the final status of a graduated student who obtains a degree within the Academic Programs at the IES.

Education by Propaedeutic Cycles, educational modality for PAs that enables the student to obtain a sequence of ascending qualifications as a University Professional, for example from TC to TG, and from there to IG.

Terminal Education educational modality for PAs that enables the student to obtain the IG degree from the end of high school without preparatory cycles or stages.

Students, people enrolled in the first semester or any other in a PA of an IES

Admitted is the number of people who aspire to an academic program in higher education and who meet the conditions requested by the respective PA to potentially enter and be subject to educational transformation by the IES.

Enrollment in the first semester is the number of people who register and enter the IES.

Total Enrollment is the number of people who register as students for a particular period.

Graduate, a person who, within an IES, obtains a degree.

Non-Graduate, person who, within an IES, does not obtain a degree.

Admitted, people enrolled in the first semester.

Inputs, quantity, quality, and availability of the elements that enter a process and that are part of it.

Productivity, the number of complete and functional elements produced by a system.

Unproductivity, the number of incomplete or dysfunctional elements produced by a system.

Quality, Qualification of the level or degree of functionality of what is produced.

Efficiency, fulfillment of the purposes assigned to a system.

RIASEC, Acronym for the instrument for characterizing the different areas of performance of individuals in work and commercial activities, as follows: Realist, R; Researcher, I; Artistic, A; Social, S; Business, E; Conventional, C [12]

Efficiency, weighting of the relationship of the outputs of a process concerning the inputs used in it.

Little's law, mathematical formulation that for every existing system of physical flow objects within an institution or system relates the average inventory, L, in the system as equal to the multiplication between the number of units leaving, S, times time average duration of a unit within the system, [13]

$$L=ST \quad (1)$$

Administration are the choices regarding the way of relating inputs to meet the purposes assigned to a system.

From the previous definitions it is derived that: Engineering Education Administration is the choices regarding the inputs, processes, and results of productivity, unproductivity, and quality relative to the effectiveness of Engineering Education systems; in the present case, of the IES in the formation of IES.

The higher education process in the IES begins with admission to the respective PA, with which it is understood that the student meets the necessary, sufficient and adequate conditions to be transformed by the IES, and therefore it is assumed that it has didactic abilities. , pedagogical and organizational with high probabilities of achieving the degree sought within the framework of the commitment and availability of conditions on the part of the student. Otherwise, it is assumed that the admission process is superficial or ineffective for educational purposes.

Regarding IES, the inputs to the educational process include enrolled students but are not limited to them, since other resources, elements, and personnel are involved. Regarding products, the IES presents components of: productivity represented in graduates; unproductivity, represented in non-graduates, that is, those who leave the system or have a time that tends to infinity for their graduation; The quality evaluated at the end of the process would be associated with the assessment of quality attributes for system graduates; The quality of the use of what was produced would be associated with different types of attributes corresponding to the scope of evaluation of different types of evaluators.

Therefore, the definition of the effectiveness of the educational process will depend on the perspective of the user of the PU and its value attributes. Society as a whole can take several dissimilar and even contradictory criteria to characterize the social value delivered by the process of forming a PU.

II. METHODS

A. Social Economic Effectiveness

Social Effectiveness refers to compliance with the social use aspects of IG PAs. From the perspective of personal employability or commercial productivity of the subject as an economic agent, the contribution could be qualified in the areas proposed by the RIASEC approach. Therefore, to assess the quality of the output of the IES process in the PUs, it would be necessary to have this data.

Another complementary perspective could be to assess the economic salary contribution of graduates and their estimation of the added value of such jobs in society. This economic contribution goes beyond the economic salary payment, since these salaries are only part of the contribution that IG graduates make to society.

In both cases, neither of these two approaches will be used here due to the absence of data for these purposes, however, it is presented as a formula for reflection.

B. Technical Social Effectiveness

A third approach to characterizing social effectiveness is to use the technical-scientific aspect as an indicator. It would be expected to have information on the progress or socio-technical performance when using the State Quality tests in Higher Education, old ECAES tests, or current Saber Pro tests.

This would require that these records be: available, consistent in what they measure, constant in the recording system over time, inter comparable in the measurement categories, indicating differences between subjects evaluated at different moments in time.

Given the previous criteria, when reviewing the contents, it is found that: due to availability, the data is affordable; For consistency, the constructs characterized in the tests have changed 6 times in the period 2004 to 2022, and when comparing the components, they do not evaluate different dimensions, both in the tests for IG and for all PUs; The records are consistent when trying to quantify the quality of the PU of the IES. The records are not constant since testing moments with more than 1,000,000 students and testing moments with 18,000 students are recorded; The records are not inter-comparable, between unequal periods of time, unequal number of evaluators and unequal measurement concepts. This is after a purification process in the identification of the IES and the PAs, as well as the data in general.

On the other hand, when studying the origin, the methodologies for obtaining the scores used in the ICFES for the Saber Pro tests, it is identified that the calculation methodology is from the Item Response Theory, IRT, with Rasch Models; The calculation of these scores depends on the questions selected, the construct or concept measured, and the responses of the participants, and therefore their measurement depends on these conditions.

Therefore, the test scores are adjusted to have a fixed mean and variance of the scores. Consequently, when using unrecalibrated scores in the data, which is what is available in the system, it is not possible to identify changes or advances in the Cognitive aspect between tests from different years, since they do not use the same scale, or They are not inter comparable.

For all the above, it was chosen not to use the ECAES or Saber Pro tests as an estimator of educational quality, since it is not possible to establish the Inter comparability of the tests, so it is not possible to have a measurement of the social effectiveness of the PU or GIs.

C. Institutional and Student Effectiveness

Here three calculations are proposed to identify the fulfillment of educational purposes from the perspective of the student and from the perspective of the IES. Effectiveness for the student is the multiplication of the two aspects of effectiveness of the IES.

The first aspect of the effectiveness of the IES is obtained from the estimation of the average graduation time (2), W, based on the usual training value in IG, 5 years or 10 semesters, to estimate this average time the formula is used of Little's Law (1), where the average observed time, W, is obtained from the number of total students enrolled each semester, A, divided by the total number of students graduated for that semester, C, as a result the number of semesters to graduate all students within the IES. This is called "Efficiency in average time to graduation."

$$D=A/C= L/S=W \quad (2)$$

The second aspect of effectiveness for IES is called "Training Effectiveness of the Institution", E, this relates the number of students who graduate in a semester, B, divided by the number of students who enter for that same semester C. this in equation (3).

$$E=B/C \quad (3)$$

This number approximates the ratio of students who graduate to each student who enters. However, given that there are students with a process delay period shorter than the PA deadline or significantly longer times, then in these cases there would eventually be values much higher or lower than unity.

From the perspective of the student in the process, the interim of the institution could be interested in the product of these two figures as the indicator of effectiveness as a user of the PA service in the IES. Thus, by multiplying the "Efficiency in the average time to graduation" by "Training Effectiveness of the Institution" in equation 4, an estimator of the proportion of graduating by the proportion of delaying the time proposed in the respective PA would be obtained.

$$F= D*E \quad (4)$$

If there is an estimate of the quality of education, Q, the social efficiency, P, would be obtained using equation (5),

$$P=F*Q \quad (5)$$

And also, with information on professional quality, social effectiveness could be calculated in equation (6), however, as previously noted, this information is not available.

$$G=F*K \quad (6)$$

The number of non-graduates is obtained as N, (7)

$$N=B-C \quad (7)$$

III. RESULTS

A. All Engineering

Table I shows for all engineering the numbers of: the date of the data; enrolled every semester, A; enrolled in the first semester, B; those who graduated, C; non-graduates, N; effectiveness in graduation time, D; Training effectiveness of the Institution, E; And effectiveness for the student, F.

TABLE I
DATA AND EFFICIENCY FOR ALL ENGINEERING

Date	Registration in every semester (A)	Registration in semester 1 (B)	Degree (C)	No Degree (N)	D= 100 %* 10 /(A/C)	. E= (B)/(C) *100 %	F= D* B* 100 %/C
02/2012	248.038	44.007	11.108	32.899	45	25	11
08/2012	240.511	32.727	15.249	17.478	63	47	30
02/2013	266.475	42.174	11.939	30.235	45	28	13
08/2013	267.007	35.154	16.183	18.971	61	46	28
02/2014	280.715	44.381	13.703	30.678	49	31	15
08/2014	276.739	34.330	16.607	17.723	60	48	29
02/2015	293.821	49.089	13.847	35.242	47	28	13
08/2015	289.445	35.927	17.534	18.393	61	49	30
02/2016	308.382	56.160	15.736	40.424	51	28	14

08/2016	297.245	38.496	19.516	18.980	66	51	33
02/2017	311.734	50.402	16.845	33.557	54	33	18
08/2017	297.454	35.056	21.337	13.719	72	61	44
02/2018	307.541	45.436	18.228	27.208	59	40	24
08/2018	293.187	32.368	22.350	10.018	76	69	53
02/2019	301.150	44.223	18.092	26.131	60	41	25
08/2019	291.360	32.220	24.367	7.853	84	76	63
02/2020	282.512	44.419	17.629	26.790	62	40	25
08/2020	267.262	27.933	23.500	4.433	88	84	74
02/2021	297.542	42.055	22.666	19.389	76	54	41
08/2021	288.131	32.677	25.740	6.937	89	79	70
02/2022	304.699	49.684	22.268	27.416	73	45	33
08/2022	294.972	39.006	26.521	12.485	90	68	61
Total	**6.305.922**	**887.924**	**410.965**	476.959	65	46	30

In 11 years, information is available for 22 semesters, with 6.3M students enrolled in all semesters, 888K students enrolled, and 410K graduates. For a graduation time efficiency indicator of 65% and a graduation efficiency of 46%. Obtaining a student efficiency of 30%.

Table II contains the descriptive statistics of the columns of Table I. The Number of students in a semester varied between 240K to 311K, the mean value was 286K with S.D. of 19K. Enrollment is positively correlated with the date, 0.56, that is, it increases over time, with a coefficient of determination of 0.32 being significant.

The number of students enrolled in the first semester varied between 28K and 56K, with an average of 40K and a S.D. 7.3K. No correlation with time, nor a significant coefficient, is identified. The number of graduates varied between 11K to 26K with an average of 19K; They correlate significantly with time with a correlation coefficient of 0.88 and explaining the coefficient of determination in 78%. Non-graduates vary between 4K to 40K, with a mean of 22K and a high S.D. of 10K, a slight decrease in non-graduates is identified with the correlation of -0.44.

The efficiency in the graduation time, D, is between 45% to 90% with an average of 65%; correlated with time with 0.80, which identifies that the more time passes, the greater the fulfillment of the graduation period within the system; and explained in 63% in its S.D.

The efficiency in the graduation rate, E, is between 25% and 84%, with an average of 49%; This is associated with the passage of time by 63% and explaining 40% of all the information.

The effectiveness for the student, F, varies between 11% and 74% with an S.D. of 19%. The association with time is 69%, and this is explained in 47%.

TABLE II
DATA AND EFFICIENCY STATISTICS FOR ALL ENGINEERING

Descriptive	(A)	(B)	(C)	(N)	(D)	(E)	(F)
Maximum	311.734	56.160	26.521	40.424	90	84	74
Half	286.633	40.360	18.680	21.680	65	49	34
Minimum	240.511	27.933	11.108	4.433	45	25	11
Range	71.223	28.227	15.413	35.991	45	59	63
Deviation E.	18.969	7.319	4.392	10.047	14	18	19
C. Cor.(t)	0,56	-0,08	0,88	-0,44	0,80	0,63	0,69
C. Det.(t)	0,32	0,01	0,78	0,19	0,63	0,40	0,47
C. Kurtosis	0,55	-0,61	-0,88	-0,93	-0,86	-0,62	-0,35
C. Asymmetry	-1,00	0,31	0,14	0,00	0,37	0,58	0,84

B. Engineering Enrollment and Graduation

Table III contains the time series of those enrolled for the first year from 2012 to 2022 and how this enrollment is broken down between Official and Private IES, as well as by gender.

Of the 887 K enrolled in the first semester 426K, 42% is official enrollment; Regarding gender, 616K are men with 69%.

TABLE III
REGISTRATIONS PER SEMESTER ALL ENGINEERING

Month /Year	First-course registration	Official Registration	Private Registration	Gender Male	Gender Female
02/2012	44,007	20,202	23,805	29,868	14,139
08/2012	32,727	17,648	15,079	21,786	10,941
02/2013	42,174	19,174	23,000	28,568	13,606
08/2013	35,154	18,241	16,913	23,705	11,449
02/2014	44,381	19,139	25,242	30,025	14,356
08/2014	34,330	17,769	16,561	23,243	11,087
02/2015	49,089	20,340	28,749	33,623	15,466
08/2015	35,927	18,171	17,756	22,107	13,820
02/2016	56,160	24,603	31,557	39,090	17,070
08/2016	38,496	18,732	19,764	26,841	11,655
02/2017	50,402	23,060	27,342	35,219	15,183
08/2017	35,056	18,373	16,683	24,236	10,820
02/2018	45,436	21,843	23,593	32,090	13,346
08/2018	32,368	17,414	14,954	23,280	9,088
02/2019	44,223	21,815	22,408	31,531	12,692
08/2019	32,220	17,251	14,969	23,095	9,125
02/2020	44,419	20,492	23,927	32,165	12,254
08/2020	27,933	14,774	13,159	19,657	8,276
02/2021	42,055	20,811	21,244	29,337	12,718
08/2021	32,677	18,135	14,542	22,765	9,912
02/2022	49,684	21,491	28,193	35,252	14,432
08/2022	39,006	17,352	21,654	27,983	11,023
Total	**887,924**	**426,830**	**461,094**	**615,466**	**272,458**

Regarding the time series of the graduates, it is recorded that there are 411K, of them 166K are from official entities, or 40%, and the male graduates are 65% with 265K.

B. By Engineering

Tables V and VI have the calculations for the indicators of total enrollment, first-semester enrollment, graduates, number of graduates, effectiveness in graduation time, institutional effectiveness, and effectiveness for the student for the engineering areas. defined in ACOFI.

While table V is for the year 2012, table VI is for 2022. The percentage increase between these two moments is identified in table VII. These tables V, VI and VII are as annexes.

For the area of agricultural engineering, it identifies an increase of 37% in enrollment for all semesters, a decrease in enrollment for the first semester of -21%, an increase in the number of graduates by 25%, a decrease in non-graduates in -3. 4%. The efficiency in graduation time changed by -9%;

Graduation effectiveness increased by 59% and student effectiveness increased by 45%.

TABLE IV
GRADUATES PER SEMESTER ALL ENGINEERING

Month /Year	First course registration	Official Registration	Private Registration	Gender Male	Gender Female
02/2012	11,108	4,805	6,303	7,314	3,794
08/2012	15,249	6,682	8,567	10,116	5,133
02/2013	11,939	5,174	6,765	7,793	4,146
08/2013	16,183	6,888	9,295	10,663	5,520
02/2014	13,703	5,823	7,880	8,951	4,752
08/2014	16,607	6,781	9,826	10,779	5,828
02/2015	13,847	5,413	8,434	9,274	4,573
08/2015	17,534	7,769	9,765	11,461	6,073
02/2016	15,736	6,723	9,013	10,239	5,497
08/2016	19,516	8,490	11,026	12,714	6,802
02/2017	16,845	6,790	10,055	10,743	6,102
08/2017	21,337	9,350	11,987	13,692	7,645
02/2018	18,228	6,728	11,500	11,712	6,516
08/2018	22,350	9,985	12,365	14,388	7,962
02/2019	18,092	6,091	12,001	11,323	6,769
08/2019	24,367	10,566	13,801	15,536	8,831
02/2020	17,629	5,395	12,234	11,247	6,382
08/2020	23,500	9,404	14,096	14,986	8,514
02/2021	22,666	8,262	14,404	14,495	8,171
08/2021	25,740	10,057	15,683	16,446	9,294
02/2022	22,268	8,310	13,958	14,529	7,739
08/2022	26,521	11,224	15,297	17,511	9,010
Total	**410,965**	**166,710**	**244,255**	**265,912**	**145,053**

For the area of agro-industrial engineering, it identifies the increase of 32% in enrollment for all semesters, the increase in enrollment for the first semester of 6%, the increase in the number of graduates by 35%, and the decrease in non-graduates by -12%. The efficiency in graduation time changed by 2%; Graduation effectiveness increased by 28% and student effectiveness increased by 31%.

For the area of food engineering, an increase of 27% in enrollment for all semesters is identified, an increase in enrollment for the first semester of 11%, an increase in the number of graduates by 3%, and increase in non-graduates graduates by 17%. Graduation time efficiency decreased by -19%; graduation efficiency decreased by -7%; and effectiveness for the student decreased by -25%.

For the area of environmental engineering, the increase of 1% in enrollment for all semesters is identified, the decrease in enrollment for the first semester of -52%, the increase in the number of graduates by 320%, and decrease in non-graduates. graduated at -105%. Graduation time efficiency increased by 315%; graduation efficiency increased by 777%; and effectiveness for the student decreased by 3540%; showing multiple very notable variations.

For the area of earth sciences engineering, a decrease of -35% in enrollment for all semesters is identified, a decrease in enrollment for the first semester of -43%, a decrease in the number of graduates by -8 %, the decrease in non-graduates by -78%. Graduation time efficiency increased by 42%; graduation efficiency increased by 60%; and effectiveness for the student decreased by 126%; showing multiple very notable variations.

For the area of civil engineering, the increase of 32% in enrollment for all semesters is identified, the decrease in enrollment for the first semester of -19%, the increase in the number of graduates by 198%, the decrease in non-graduates. graduated at -87%. Graduation time efficiency increased by 125%; graduation efficiency increased by 266%; and effectiveness for the student increased by 725%; showing notable variations.

For the area of electrical engineering, the increase of 42% in enrollment for all semesters is identified, the decrease in enrollment for the first semester of -7%, the decrease in the number of graduates by -3%, the decrease in non-graduates by -11%. Graduation time efficiency decreased by -7%; graduation efficiency increased by 4%; and effectiveness for the student decreased by -3%.

For the area of electronic engineering, the increase of 22% in enrollment for all semesters is identified, the decrease in enrollment for the first semester of -1%, the increase in the number of graduates by 37%, the decrease in non-graduates. graduated at -27%. Graduation time efficiency increased by 12%; graduation efficiency increased by 4%; and effectiveness for the student decreased by 3%.

For the area of forestry engineering, a 15% increase in enrollment for all semesters was identified, a drop in enrollment for the first semester of -23%, an increase in the number of graduates by 14%, and a decrease in non-graduates by 50%. %. The efficiency in graduation time decreased 1%; graduation efficiency increased by 47%; and effectiveness for the student increased by 216%.

For the area of industrial engineering, the increase of 12% in enrollment for all semesters is identified, the increase in enrollment for the first semester of 21%, the increase in the number of graduates by 107%, non-graduates decrease by - 22 %. Graduation time efficiency increased by 85%; graduation efficiency increased by 71%; and effectiveness for the student increased by 216%. For the area of industrial engineering, the increase of 12% in enrollment for all semesters is identified, the increase in enrollment for the first semester of 21%, the increase in the number of graduates by 107%, non-graduates decreased by -22%. Graduation time efficiency increased by 85%; graduation efficiency increased by 71%; and effectiveness for the student increased by 216%.

For the area of mechanical engineering, the increase of 12% in enrollment for all semesters is identified, the drop in enrollment for the first semester of -9%, the increase in the number of graduates by 58%, the decrease in non-graduates. graduated at -49%. Graduation time efficiency increased by 40%; graduation efficiency increased by 73%; and effectiveness for the student increased by 143%. For the area of chemical engineering, the decrease of -2% in enrollment for all semesters is identified, the decrease in enrollment for the first semester of -23%, the increase in the number of graduates by 40%, the decrease of no graduates -73%. Graduation time

efficiency increased by 42%; graduation efficiency increased by 81%; and effectiveness for the student increased by 158%.

For the area of systems engineering, the increase of 66% in enrollment for all semesters is identified, the increase in enrollment for the first semester of 132%, the increase in the number of graduates by 59%, the increase in non-graduated at 196%. The efficiency in graduation time decreased by -4%; graduation efficiency fell by -31%; and the effectiveness for the student decreased by -34%.

For the area of telecommunications engineering, the increase of 21% in enrollment for all semesters is identified, enrollment for the first semester decreased by -9%, the increase in the number of graduates by 30%, non-graduates decreased by - 38%. Graduation time efficiency increased by 7%; graduation efficiency increased by 43%; and effectiveness for the student increased by 54%.

For all areas of engineering, the increase of 23% in enrollment for all semesters is identified, the increase in enrollment for the first semester of 16%, the increase in the number of graduates by 85%, the decrease in non-graduates at -21%. Graduation time efficiency increased by 31%; graduation efficiency increased by 65%; and effectiveness for the student increased by 121%.

III. CONCLUSIONS

Although a substantial change is identified in the number of engineering enrollees, going from 793K to 600K, this trend is expected to continue. Therefore, reasons of a demographic nature, birth rate, change in labor supply and demand, psychosocial reasons must be sought for the study, use, employability of engineering in its different branches, the substitution of the workforce. by foreigners, and by automation and robotics among other alternatives as motivations for studying or not studying engineering.

Across diverse engineering fields, enrollment trends vary, but generally show positive growth. Graduation rates and efficiency metrics also fluctuate, suggesting both advancements and challenges in student outcomes and program efficacy, highlighting the need for tailored improvements and interventions.

Also, the identification of emigration from Colombia, the preference for technical trades or business, the skill formed in high school can be taken as motivations for the use or not of engineering.

On the other hand, the efficiency and effectiveness in engineering graduation has increased in the different engineering areas and their behavior has improved.

It should be noted that it is not possible to characterize the effective level of engineering between a couple of points due to the lack of methods to compare the effect of education.

IV. RECOMMENDATIONS

Create a system of indicators of the relevance of education and the added value provided by engineering graduates. Propose improvements in deep learning and didactics as means of improving the contextualization and use of engineering.

Use advances in neurology, psychology, education, and group teaching as a way to improve the added value to students of engineering programs.

THANKS

They will be filled out after the review for the purpose of maintaining the refereeing method.

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ANNEXES

TABLE V.

ALL ENGINEERING 2012

Date	Registration in every semester (A)	Registration in semester 1 (B)	Degree (C)	No Degree (N)	D= 100%*10 /(A/C)	. E= (B)/(C) *100%	F= D* B* 100%/C
Agricultural	6,978	1,182	290	892	42	25	10
Agro Industrial	13,171	1,918	740	1,178	56	39	22
Food	16,070	2,246	839	1,407	52	37	20
Environmental	71,184	13,235	3,768	9,467	53	28	15
Earth sciences	22,295	2,520	1,377	1,143	62	55	34
Civil	115,125	17,159	6,976	10,183	61	41	25
Electric	22,109	2,870	1,257	1,613	57	44	25
electronics	63,825	8,650	4,046	4,604	63	47	30
Forest	5,284	667	308	359	58	46	27
Industrial	194,772	32,594	12,579	20,015	65	39	25
Mechanics	49,487	6,929	2,951	3,978	60	43	25
Chemistry	26,347	3,155	1,679	1,476	64	53	34
Systems	171,770	30,531	10,618	19,913	62	35	21
Telecommunications	14,831	2,762	1,197	1,565	81	43	35
Total	**793,248**	**126,418**	**48,625**	**77,793**	**61**	**38**	**24**

TABLA VI

ALL ENGINEERING 2022

Date	Registration in every semester (A)	Registration in semester 1 (B)	Degree (C)	No Degree (N)	D= 100%*10 /(A/C)	. E= (B)/(C) *100%	F= D* B* 100%/C
Agricultural	5,648	643	222	421	39	35	14
Agro Industrial	10,388	1,275	615	660	59	48	29
Food	12,506	1,540	592	948	47	38	18
Environmental	47,067	4,967	5,448	-481	116	110	127
Earth sciences	10,768	1,100	893	207	83	81	67
Civil	90,805	9,569	8,438	1,131	93	88	82
Electric	16,616	1,854	1,057	797	64	57	36
electronics	43,292	5,221	2,763	2,458	64	53	34
Forest	3,839	356	226	130	59	63	37
Industrial	138,837	23,528	13,503	10,025	97	57	56
Mechanics	35,232	4,144	2,695	1,449	76	65	50
Chemistry	17,162	1,697	1,366	331	80	80	64
Systems	156,609	31,198	9,999	21,199	64	32	20
Telecommunications	10,902	1,598	972	626	89	61	54
Total	**599,671**	**88,690**	**48,789**	**39,901**	**81**	**55**	**45**

TABLA VII

ALL ENGINEERING 2012

Date	Registration in every semester (A)	Registration in semester 1 (B)	Degree (C)	No Degree (N)	D= 100%*10 /(A/C)	. E= (B)/(C) *100%	F= D* B* 100%/C
Agricultural	37	-21	25	-34	-9	59	45
Agro Industrial	32	6	35	-12	2	28	31
Food	27	11	3	17	-19	-7	-25
Environmental	1	-52	320	-105	315	777	3.540
Earth sciences	-35	-43	-8	-78	42	60	126
Civil	32	-19	198	-87	125	266	725
Electric	22	-1	37	-27	12	38	56
electronics	4	-7	-3	-11	-7	4	-3
Forest	15	-23	14	-50	-1	47	46
Industrial	12	21	107	-22	85	71	216
Mechanics	12	-9	58	-49	40	73	143
Chemistry	-2	-23	40	-73	42	81	158
Systems	66	132	59	196	-4	-31	-34
Telecommunications	21	-9	30	-38	7	43	54
Total	23	16	85	-21	31	65	121