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Research article

Classification of industrial engineering programs in Colombia based on state tests

Adel Mendoza-Mendoza [a,*], Enrique De La Hoz-Domínguez [b], Delimiro Visbal-Cadavid [c]

[a] Program of Industrial Engineering, Universidad del Atlántico, Barranquilla, Colombia
[b] Productivity and Innovation Department, Universidad de la Costa, Barranquilla, Colombia
[c] Program of Industrial Engineering, Universidad del Magdalena, Santa Marta, Colombia

A R T I C L E I N F O

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A B S T R A C T

This article proposes an approach for the classification of industrial engineering programs offered by different higher education institutions (HEIs) in Colombia, using data envelopment analysis (DEA) and validating the results with cluster analysis. To perform this classification, data from 5318 industrial engineering students from 93 higher education institutions are used as a basis for classification based on the Saber11 and SaberPro state tests. The state tests are used to measure graduates' academic performance in the data envelopment analysis. With the efficiency results it was possible to classify higher education institutions (HEIs) into three large groups. Subsequently, this classification was validated through cluster analysis. The results show a correct classification of 77%.

1. Introduction

Different higher education institutions (HEIs) contribute significantly to a nation's ability to remain globally competitive through the preparation of the qualified human resources they produce. The proliferation of HEIs has resulted in the vast majority of academic institutions facing problems of deterioration in the academic quality of graduates [1]. Additionally, some HEIs have fallen short of the standards set by the government in delivering a high-quality education service that satisfies a nation's labor needs and the demands of the present market [2]. To ensure quality academic training in the graduates of the different HEIs, it is necessary to continuously verify the standards established by the governing body of education and the latest trends in the labor market. This implies the evaluation of educational resources carried out by accreditation agencies to give HEIs a better level of their professors, better research projects, and adequate physical facilities for good educational practice [1].

Due to this, it is important to assess the effectiveness of the utilization of educational resources, which can aid HEIs in setting strategic goals, allocating resources and budgets, and funding the academic achievements of professors and students. Measuring efficiency in HEIs helps to make precise strategic decisions, either to take advantage of existing strengths or to develop new areas, all of which benefit graduates' academic performance.

The concept of academic performance is quite confusing, because while for teachers it is evaluated through assignments and exams,

* Corresponding author.
E-mail addresses: adelmendoza@uniatlantico.edu.co (A. Mendoza-Mendoza), edelahoz13@cuc.edu.co (E. De La Hoz-Domínguez), dvisbal@unimagdalena.edu.co (D. Visbal-Cadavid).

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for students it has to do with the quality and participation in classes, which involve different aspects, individual and collective, that affect academic learning. For this reason, some previous studies show that academic performance is a source of concern for many researchers and have identified several factors that affect the learning process of university students, among which we can highlight the following: aptitude, basic knowledge of mathematics, gender, age, motivation and other factors [3–6]. Academic performance can be considered as a measure of efficiency in higher education, which allows assessing the quality of the teaching process through student learning, this performance can be considered as a consensus indicator and be directly related to academic excellence and efficiency of the educational system [7].

In the case of large-scale evaluations, such as state exams, it is called educational, academic or school performance [8]. In Colombia, the Ministry of National Education, together with the Colombian Institute for the Evaluation of Education (ICFES) developed the application of standardized tests as a quantitative measure of quality at different levels of education, thus students take the standardized tests Saber11 and SaberPro at the end of their secondary and professional studies, respectively. The Saber11 is a standardized assessment whose objective is to verify the minimum levels of aptitude and knowledge of students who present it and aspire to enter higher education. The SaberPro is a standardized test whose objective is the external evaluation of the quality of higher education.

Bilge & Severengiz [9] mention that industrial engineering has emerged as an interdisciplinary branch by merging engineering and administrative management. Thus, becoming an essential factor in competitiveness and continuous improvement has caused industrial engineering jobs to grow at a higher rate than any other branch of engineering in recent years. This has caused the increase of industrial engineering programs, which implies a critical review of the quality to stay within the competition in the middle of many financial and market challenges, this requires higher education institutions (HEIs) must assess the quality of the services provided due to the deterioration that could be presented by different factors especially to the higher number of students [10,11].

Standardized tests can also be an indicator of academic performance can also be used as a classification tool, understanding this classification as a grouping of heterogeneous entities into subgroups in such a way that the entities of a subgroup have some characteristics in common while differentiating them from the entities of other subgroups [12]. A large body of research paper demonstrates that standardized tests are reliable as predictors of college grades [13,14].

Because of the above and also because of the importance of industrial engineering academic programs in a country, since they represent a fundamental pillar within the social and business context, and are the basis for the implementation and improvement of any productive process, this research aims to answer the following question: How can industrial engineering programs in Colombia be classified based on the state tests? Therefore, the objective of this research is to carry out a classification of Colombian higher education institutions (HEI) that offer industrial engineering programs based on the findings of the Saber 11 and SaberPro tests. This classification is performed through data envelopment analysis (DEA) and validates the results with cluster analysis. In 1958, the first Industrial Engineering Program in Colombia was created to study: labor movements, the measurement of the necessary costs of each operation and the establishment of work standards and production incentives. But currently Industrial Engineering programs should focus on the concepts of highly productive and environmentally friendly production processes and the training of independent liberal professionals or entrepreneurs [15]. With the classification proposed in this research, it would be possible to identify those HEIs that have adapted to the new situation demanded by society.

2. Theoretical framework

2.1. Standardized tests

Standardized tests, as an important element in the evaluation of educational systems, is an exam generally administered and graded by governmental entities and for a long time have been a fundamental component of the educational system highlighting the use of this type of tests in countries such as the United States and the United Kingdom and its use has spread to other areas of the world such as Europe, Australia and Latin America [16]. One of the main reasons about the use of these tests is that they provide better objectivity in the results in relation to other types of assessment instruments [17]. SAT tests are used for university admission in the United States and have been It has been shown that the scores of these tests affect the prediction of university performance [18], this is how high school students in the world take a standardized test annually, since these are the most widely used as a requirement for university entrance [19].

In Colombia, the Colombian Institute for the Evaluation of Education (ICFES) developed the standardized tests, called Saber Tests, which are applied according to the level of education to be evaluated as follows:

Tests Saber11: must be presented by students who are finishing the eleventh grade, in order to obtain official results that allow them to enter higher education, it consists of 5 tests: Critical Reading, Mathematics, Social and Citizenship, Natural Sciences and English [20].

Test SaberPro: It is aimed at students who have passed 75% of the credits of their respective professional university education programs, which includes two components: A generic component of five modules: Critical Reading, Quantitative Reasoning, Citizenship Competencies, Writing and English Language. A specific component that according to the area of knowledge for industrial engineering has three modules: Formulation of engineering projects, Design of productive and logistic systems and Scientific-mathematical thinking and statistics [21].

2.2. Data envelopment analysis (DEA)

Data envelopment analysis (DEA) is a non-parametric technique proposed by Charnes, Cooper and Rhodes [22], which compares functionally similar entities, with which a relative efficiency indicator can be obtained that allows comparisons of decision-making units (DMU) that use multiple inputs or resources to obtain multiple outputs or results [23]. Solving a linear programming model (LP), DEA analysis performs a comparison between production units that manage the type of resources to produce the same type of outputs, thus obtaining an efficient frontier and relative efficiency indicators within the population of production units under study. Since its appearance, the application of the DEA technique as a tool for measuring the efficiency of organizations has been increasing at a very high rate, as indicated by the large number of research related to this topic [24]. Within these studies we can mention the evaluation of banking efficiency [25–27], in the performance of the manufacturing industry [28–30], in the health sector [31–33] among others.

Different studies on the application of DEA for universities (HEIs) include the following works: Agasisti & Salerno [34] analyzed 52 Italian public universities through DEA, finding evidence that the size of some institutions can be reduced and the financial resources of the State can be distributed more equitably. Nazarko & Šaparauskas [35] conducted a comparative efficiency study of 19 Polish universities making a selection of possible variables to describe the efficiency model in order to identify in which educational institution the results obtained are more influenced by the resources used, Wolszczak-Derlacz [36] evaluated the technical efficiency of European and American HEIs by DEA analysis, over a period of 10 years, using different data sets (input-output), then by continents and finally HEIs by each country, the results found showed a high positive correlation between the efficiency of each HEI with GDP per capita and the number of academic programs departments. Johnes & Li [37] determine the efficiency of research outputs for 109 universities in China using as input variables personnel (administrative and professors), students, economic and bibliographic resources to measure the impact they have on the output variables which are the different research outputs. Ekiz & Tuncer [38] evaluate 50 MBA programs from Financial Times 2018 rankings and compare the results with the evaluations of other methods. Singh et al. [39] consider 61 educational institutions of India to rank them according to their performances, the ranking is done based on the efficiency scores of the institutions.

2.3. Cluster analysis

Cluster analysis refers to data analysis techniques to discover natural groupings that are hidden in a database forming structures and classes, such that observations belonging to the same class are close to each other and separated from observations belonging to another class [40,41].

Clustering algorithms can be classified into partitioning, hierarchical network-based and density-based. Partitioning algorithms iteratively refine a set of k clusters based on the distance function, in hierarchical algorithms the dataset initially form a tree structured structure and can be agglomerative or divisive hierarchical, in the agglomerative form each point is considered as an independent cluster and in each iteration two clusters are merged based on a criterion, whereas in the divisive form all points are considered as a single cluster which is divided into a number of clusters taking into account certain criteria, density based algorithms allow generating clusters of arbitrary shapes and sizes with varying densities, clusters are described in terms of dense region separated through the less

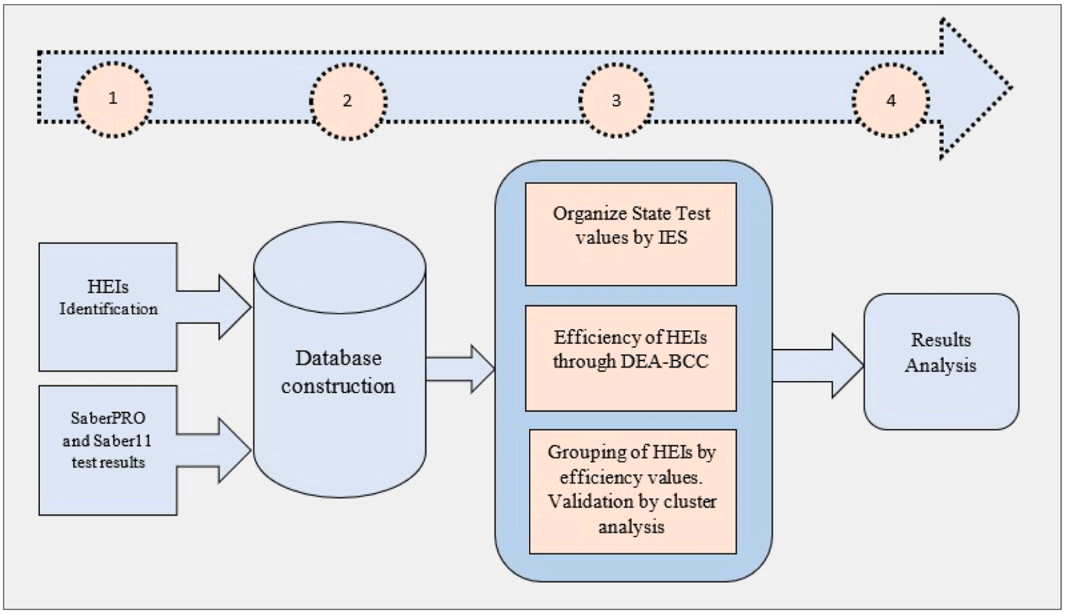

Fig. 1. Proposed methodology.

dense region [42–44].

3. Materials and methods

The methodological approach for conducting the research is based on a descriptive, qualitative and quantitative study using an application of techniques for the classification and grouping of universities (HEIs) that offer the industrial engineering program in Colombia. When using historical data, it is considered to be a retrospective and non-experimental study since there is no alteration of the input variables to the model. This research's development follows a scheme as presented in Fig. 1.

With data envelopment analysis (DEA), the relative efficiency of the students is determined as a measure of the performance of each of the universities, the efficiency of each university is determined as the average efficiency of the students, with these efficiency values the classification and grouping of the HEIs is carried out. It should be noted that most of the contributions in DEA are made by two standard models: the CCR and the BCC [45]. The CCR model calculates efficiencies under the assumption of constant returns to scale, i. e., it compares homogeneous units; the BBC model calculates efficiencies with variable returns to scale where each inefficient unit is only compared with an efficient unit, but with the same characteristics. For this reason, in this research we will use the DEA-BCC model oriented to outputs, since the units to be compared are heterogeneous. Saber11 test scores are used as input variables and SaberPro test scores as output variables. The linear programming of the CCR model can be expressed as:

$$Max\ \theta = \frac{\sum_{r=1}^{s} u_{ro} y_{r0} + u_0}{\sum_{i=1}^{m} v_{io} x_{io}} \tag{1}$$

s.t:

$$\frac{\sum_{r=1}^{s} u_{rj} y_{rj} + u_0}{\sum_{i=1}^{m} v_{ij} x_{ij}} \leq 1, j = 1, 2, \ldots n$$

$u_{rj} \geq 0$, $v_{rj} \geq 0$, u_0 free in sign, r = 1,2, …s; i = 1,2, …m.

In model (1), x_{mo}, y_{ro} represents the m-th input and r-th output of the DMU, respectively, and u_m, v_r are the weights of the corresponding output and input variables.

In the cluster analysis, the optimal number of groups was initially determined and then a hierarchical algorithm was applied, hierarchical clustering algorithms clearly reflect an organization of the resulting clusters that facilitates a better analysis of the results, this is a notable advantage over the other cluster algorithms [46], in this research the cluster analysis was used as a validation tool of the results obtained by the DEA analysis.

The data used correspond to compilation of the Saber Pro and Saber 11 tests conducted by De La Hoz-Domínguez et al. [47], so the study population corresponds to 5318 industrial engineering students from 93 HEIs in Colombia who took the SABER PRO exam for the

Table 1
HEIs efficiency.

HEI	Efficiency	HEI	Efficiency	HEI	Efficiency	HEI	Efficiency
HEI 1	0,8498	HEI 25	0,8767	HEI 49	0,8786	HEI 73	0,8312
HEI 2	0,8530	HEI 26	0,8143	HEI 50	0,9492	HEI 74	0,8970
HEI 3	0,8327	HEI 27	0,7925	HEI 51	0,9241	HEI 75	0,9258
HEI 4	0,8235	HEI 28	0,8393	HEI 52	0,9814	HEI 76	0,6165
HEI 5	0,8665	HEI 29	0,8476	HEI 53	0,9028	HEI 77	0,9067
HEI 6	0,8409	HEI 30	0,9217	HEI 54	0,8440	HEI 78	0,8151
HEI 7	0,8560	HEI 31	0,7568	HEI 55	0,8668	HEI 79	0,9776
HEI 8	0,8118	HEI 32	0,8400	HEI 56	0,8703	HEI 80	0,9759
HEI 9	0,8322	HEI 33	0,9589	HEI 57	0,8505	HEI 81	0,9738
HEI 10	0,9825	HEI 34	0,9530	HEI 58	0,9276	HEI 82	0,9492
HEI 11	0,8766	HEI 35	0,8774	HEI 59	0,9105	HEI 83	0,8961
HEI 12	0,8736	HEI 36	0,8407	HEI 60	0,9701	HEI 84	0,9056
HEI 13	0,9043	HEI 37	0,9310	HEI 61	0,7997	HEI 85	0,8405
HEI 14	0,9355	HEI 38	0,9104	HEI 62	0,8998	HEI 86	0,8548
HEI 15	0,9095	HEI 39	0,8671	HEI 63	0,9494	HEI 87	0,9022
HEI 16	0,8830	HEI 40	0,8680	HEI 64	0,9614	HEI 88	0,8330
HEI 17	0,8905	HEI 41	0,8830	HEI 65	0,8446	HEI 89	0,9124
HEI 18	0,9192	HEI 42	0,8444	HEI 66	0,9696	HEI 90	0,8230
HEI 19	0,8374	HEI 43	0,8946	HEI 67	0,8624	HEI 91	0,8982
HEI 20	0,8171	HEI 44	0,8275	HEI 68	0,9627	HEI 92	0,9212
HEI 21	0,8569	HEI 45	0,9628	HEI 69	0,8547	HEI 93	0,8635
HEI 22	0,8837	HEI 46	0,8491	HEI 70	0,9340		
HEI 23	0,8089	HEI 47	0,8880	HEI 71	0,8658		
HEI 24	0,7990	HEI 48	0,8639	HEI 72	0,9157		

year 2018. The 93 HEIs were coded as HEI1, HEI2 to HEI93for the purpose of confidentiality of results. See Appendix A.

4. Results

As mentioned, the output-oriented DEA-BCC model was used and implemented within the DEA Solver 8.0 software environment. Saber 11 test scores are used as input variables and Saber Pro test scores are used as output variables. The optimal value of the objective function for each student is the efficiency indicator. The efficiency of each university (HEI) is determined as the average efficiency of the students, these results are shown in Table 1.

According to Bonaccorsi &. Cicero [48] we can classify the HEIs into groups that are statistically distinguishable with the results obtained with the DEA-CCR analysis, using Fischer's LSD test for the efficiency values of each HEI, forming in this case three groups. The efficiency varies between 62% and 98% during the study period. So the inefficiency is in the range of 2%–38% and an average efficiency of 88%. The value efficiency of the HEIs of each group are shown Table 2.

These groups were validated through cluster analysis. Before applying any clustering algorithm to the data set, the clustering tendency must first be evaluated. That is, whether it is feasible to apply cluster analysis to the data and, if so, to determine how many groups exist. The clustering algorithm is then applied.

Next, the existence of trend for the creation of clusters in the data is analyzed by means of the Hopkins statistic, using the "clustertend" package [49] of the R statistical software, the calculation of the Hopkins statistic to the database yields a value of 0.1812, which is well below the threshold value of 0.5, indicating that the data set is highly groupable. Subsequently with the "clValid" package [50] the most appropriate clustering method and the optimal number of clusters was determined, for this database the hierarchical algorithm and three clusters are recommended. Fig. 2 shows the number of clusters using the Silhouette and Euclidean distance methods.

Fig. 3 presents the result of grouping the different HEIs, showing how the 93 universities are successively grouped until a single cluster is formed.

The cluster analysis results show that the universities form three groups: Cluster 1 (*92 to 52*), Cluster 2 (*55 to 67*) and Cluster 3 (*13 to 76*). Table 3 shows the number of high, medium and low efficiency universities located in each of the clusters.

5. Discussion

Below is a brief description of the three groups found.

5.1. *High-efficiency group*

The universities in this group are characterized by having the best results in the SaberPro tests; the National University of Bogota stands out in this group. Most of the HEIs in this group have received state recognition of institutional accreditation as well as accreditation of their industrial engineering programs. Within their educational training plans, the most important components are: production, operations and basic sciences. It is also important to note that the HEIs in this group have the largest budgets for expenses and investments and are located in the country's large urban centers. This group includes 16.1% of the total number of HEIs.

Table 2
HEIs by group.

High-Efficiency		Medium-Efficiency						High-Efficiency					
n = 15, mean = 0.9651, sd = 0.011		n = 43, mean = 0.8956, sd = 0.022						n = 43, mean = 0.8251, sd = 0.041					
ID	score	ID	score	ID	score	ID	score	ID	score	ID	score	ID	score
10	0.9825	14	0.9355	84	0.9056	35	0.8774	21	0.8569	32	0.8400	61	0.7997
52	0.9814	70	0.9341	13	0.9043	25	0.8767	7	0.8560	28	0.8393	24	0.7990
79	0.9776	37	0.9310	53	0.9028	11	0.8766	86	0.8548	19	0.8374	27	0.7925
80	0.9759	58	0.9276	87	0.9022	12	0.8736	69	0.8547	88	0.8330	31	0.7568
81	0.9738	75	0.9258	62	0.8998	56	0.8703	2	0.8530	3	0.8327	76	0.6165
60	0.9701	51	0.9241	91	0.8982	40	0.8680	57	0.8505	9	0.8322		
66	0.9696	30	0.9217	74	0.8970	39	0.8671	1	0.8498	73	0.8312		
45	0.9628	92	0.9212	83	0.8961	55	0.8668	46	0.8491	44	0.8275		
68	0.9627	18	0.9192	43	0.8947	5	0.8665	29	0.8476	4	0.8235		
64	0.9614	72	0.9157	17	0.8905	71	0.8658	65	0.8446	90	0.8230		
33	0.9589	89	0.9124	47	0.8881	48	0.8639	42	0.8444	20	0.8171		
34	0.9530	59	0.9105	22	0.8837	93	0.8635	54	0.8440	78	0.8151		
63	0.9494	38	0.9104	16	0.8830	67	0.8624	6	0.8409	26	0.8143		
82	0.9492	15	0.9095	41	0.8830			36	0.8407	8	0.8118		
50	0.9492	77	0.9067	49	0.8786			85	0.8405	23	0.8089		

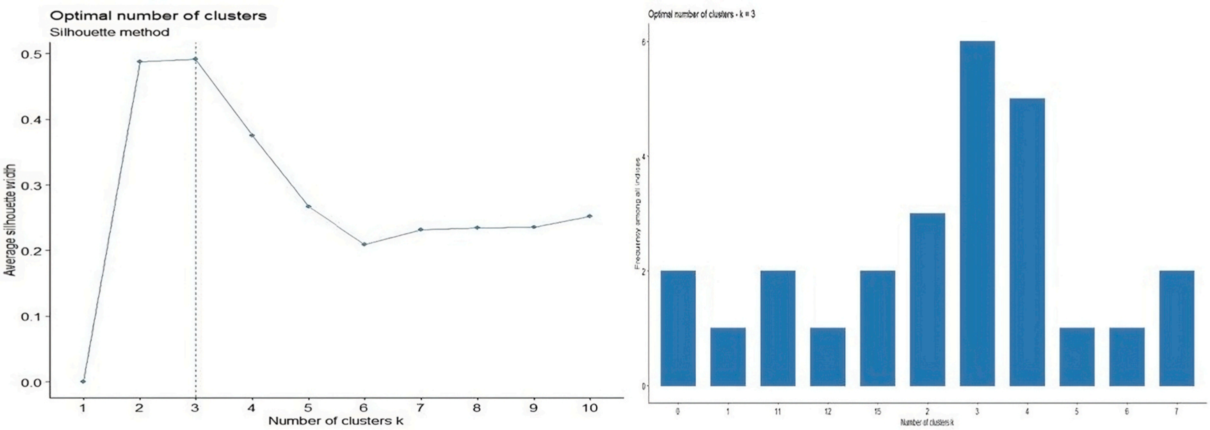

Fig. 2. Number of clusters.

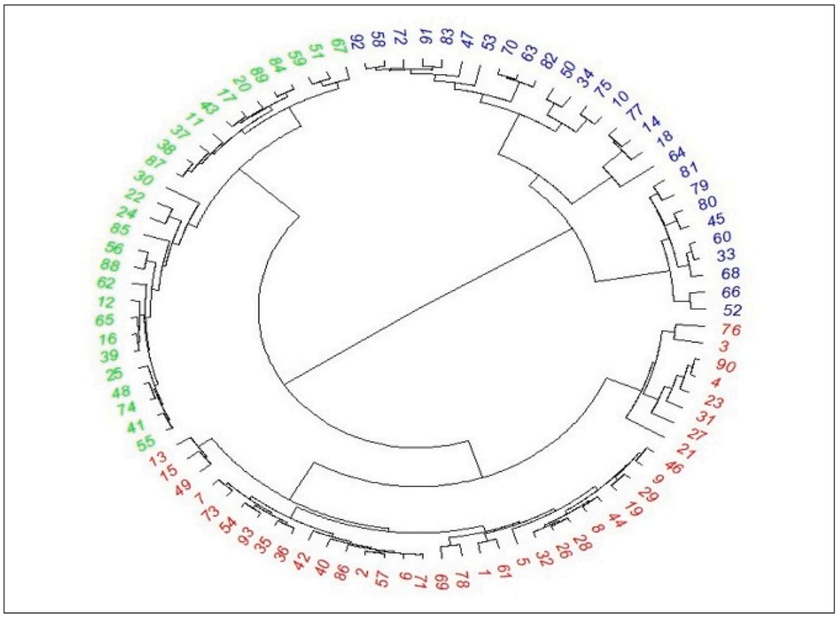

Fig. 3. Cluster analysis results.

Table 3
Validation of results.

High efficiency	Cluster 1	Cluster 2	Cluster 3	15
	15	0	0	
Average efficiency	Cluster 1	Cluster 2	Cluster 3	43
	12	23	8	
Low efficiency	Cluster 1	Cluster 2	Cluster 3	35
	0	5	30	
	27	28	38	93

These results indicate that all high efficiency HEIs are in Cluster 1, 23 of 43 medium efficiency HEIs are in Cluster 2 and 30 of 35 low efficiency HEIs are in Cluster 3, achieving a correct classification of 73.1%.

5.2. Medium-efficiency group

The universities that are located in this group present high to intermediate values in the SaberPro test results; in this group we can highlight the Universidad Industrial de Santander (UIS). This group, with respect to state accreditation recognition, is quite heterogeneous, since while some HEIs have institutional accreditation, others have accreditation of their industrial engineering program. Their curricular plans emphasize engineering and technological projects. This group includes 46.2% of the total number of HEIs.

5.3. Low-efficiency group

The universities located in this group are those that present the lowest values in the SaberPro test results. This group is characterized by the fact that most of them do not have recognition by the State, of the institutional accreditation or accreditation of their industrial engineering programs. Regarding their academic training plans, the areas of management and administration stand out. This group of HEIs is mostly located in medium-sized cities in the country. This group includes 37.6% of the total number of HEIs.

It is important to compare the results with other studies related to efficiency and classification of universities, thus Kantabutra & Tang [51] evaluate the efficiency of 250 faculties belonging to 18 universities in Thailand and then perform a grouping using as segmentation criteria predetermined values of efficiency ranks (every 0.25) in our research this segmentation is performed through Fischer's LSD test which is subsequently validated with cluster analysis. Nazarko & Šaparauskas [35] evaluate the efficiency of 19 Polish universities considering financial, administrative and qualitative aspects of the of university performance, the advantage of our research is that it uses standardized tests as inputs, which are objective measures. Wolszczak-Derlacz [36] has employed DEA to evaluate the relative efficiency of a sample of 500 higher education institutions being one of the most comprehensive studies due to the amount of information used which is comparable to our research.

Jiang et al. [52] in their study performs a classification of wastewater treatment plants by cluster analysis and then for each group performs an efficiency analysis by DEA, the advantage of our study is that in the DEA analysis all the universities that are part of the research are compared and then the classification or grouping is performed. Cinaroglu [53], evaluates public hospitals in Turkey initially performs clustering by k-means subsequently the efficiency of the hospitals in each group is determined finding that there is a low correlation between the efficiency scores of the hospitals in the different groups, in our study there is a high correlation between the efficiency scores and the clustering scores.

Comparing the results with other studies that estimate efficiency groups based on academic inputs is essential. For instance, De La Hoz et al. [54] developed an efficiency classification through a Random Forest model, identifying two efficiency groups clearly separated by the university's accreditation status. Other research explores the potential of DEA for estimating academic efficiency by articulating internal and external performance indicators plus research performance to estimate the efficiency of 20 public universities in Greece [55], which is different to our study by considering all the DMU's equals. Similarly, Cossani et al. [56] developed a network DEA analysis, obtaining an efficiency ranking involving teaching and research inputs; this approach is different by using a production function that intrinsically weights the variable.

The results obtained in this research represent an objective tool to evaluate the academic performance of industrial engineering programs; these results indicate that the accreditation processes play a fundamental role in the student's academic performance. As indicated by Kumar & Thakur [57], the measurement of the efficiency of non-profit organizations is a non-parametric situation, making the DEA technique a suitable methodology for comparing and classifying HEIs. The finding of three efficiency groups is valuable because it allows a fair comparison of academic efficiency, considering that universities are diverse in the quality of entry students, budget, and teaching methodology.

A limitation of the DEA model is that the efficiency values depend on the input and output data of the DMUs being compared, for example, adding a more efficient HEI could cause the efficiency scores of other HEIs to decrease.

6. Conclusion

In this study, 93 industrial engineering academic programs were classified using the results of the standardized tests Saber11 and SaberPro as data inputs. A methodology developed in two stages that evaluates the academic performance of universities was proposed. The main contribution of this research is the description of clustering using data envelopment analysis (DEA) and Fisher's LSD test validating the results with cluster analysis. In the first stage, the results of the Saber11 tests are used as inputs and those of the SaberPro tests as outputs for 5318 students to determine the efficiency of each of the 93 academic programs, identifying three groups that are statistically distinguishable using Fischer's LSD test for the efficiency values of each HEI. Subsequently, in the second phase, the results of this classification are validated with the cluster analysis, achieving a correct classification of 73.1%. The results show that 15 HEIs can be classified in the group called "High Efficiency", 43 HEIs can be classified in the group called "Medium Efficiency" and 35 HEIs can be classified in the group called "Low Efficiency".

One of the main strengths of this study is the large amount of information that was used for the application of the DEA model so that the classification results can be accepted for decision-making by the different control agencies. However, this study has some limitations: first, more cohorts of students should have been included; second, only the state tests were taken into account as input and output variables; using other variables could lead to better classification results for the HEIs.

Production notes

Author contribution statement

Adel Mendoza-Mendoza, Enrique De La Hoz-Domínguez, Delimiro Visbal-Cadavid: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data included in article/supp. material/referenced in article.

Additional information

No additional information is available for this paper.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

Average student scores on Saber11 tests

	Math	Critical Reading	Socials Science	Natural Science	English or Second Language
HEI1	56,31	53,62	52,69	54,69	55,15
HEI2	56,79	54,69	53,81	56,47	53,94
HEI3	55,33	48,67	34,33	56,67	53,00
HEI4	53,18	52,14	51,18	55,18	50,73
HEI5	56,06	51,72	53,56	54,44	48,56
HEI6	56,01	54,49	54,70	57,12	51,82
HEI7	58,79	55,68	56,26	58,87	52,06
HEI8	56,65	54,25	54,33	56,34	51,82
HEI9	53,51	55,10	55,26	53,74	49,87
HEI10	61,22	56,44	55,44	61,78	58,89
HEI11	56,88	59,88	60,63	60,50	54,88
HEI12	57,30	57,76	56,91	58,38	55,82
HEI13	52,36	49,64	49,00	51,50	50,93
HEI14	65,96	63,12	60,98	63,96	65,93
HEI15	53,24	54,24	54,12	53,53	53,18
HEI16	58,21	54,94	56,67	57,15	56,94
HEI17	60,49	58,51	59,36	61,35	59,17
HEI18	62,50	61,87	63,06	64,65	61,58
HEI19	54,71	54,61	55,52	55,65	53,87
HEI20	60,20	58,00	58,60	62,60	62,00
HEI21	45,00	44,67	47,00	49,33	44,67
HEI22	57,88	53,25	53,19	55,06	56,06
HEI23	52,35	52,49	52,27	53,95	49,35
HEI24	59,33	56,83	57,50	56,00	61,17
HEI25	57,77	58,46	55,92	58,38	56,54
HEI26	54,84	53,28	54,47	53,44	50,72
HEI27	51,75	47,50	48,75	51,88	45,75
HEI28	54,19	53,35	53,07	55,19	50,76
HEI29	55,00	53,58	52,68	53,32	50,53
HEI30	53,50	52,50	60,50	54,50	46,00
HEI31	51,00	49,18	51,65	51,12	48,65
HEI32	52,80	53,17	54,35	54,49	52,31
HEI33	70,97	65,77	65,19	69,14	77,53
HEI34	68,01	62,77	61,74	67,16	70,67
HEI35	54,28	56,69	54,31	55,38	51,93
HEI36	55,41	54,95	54,55	54,58	52,60
HEI37	57,65	56,12	56,59	61,12	58,00
HEI38	59,61	57,31	56,74	60,30	58,67
HEI39	57,91	56,20	55,57	57,51	55,93

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	Math	Critical Reading	Socials Science	Natural Science	English or Second Language
HEI40	53,76	55,69	56,14	55,28	53,66
HEI41	58,47	57,72	57,07	57,84	56,77
HEI42	56,24	55,66	55,79	55,50	58,68
HEI43	59,13	59,15	59,20	58,95	57,92
HEI44	54,30	54,84	53,87	54,64	53,07
HEI45	67,84	67,24	66,36	65,72	65,64
HEI46	53,82	53,00	54,33	54,76	50,73
HEI47	68,48	64,76	65,08	67,00	60,55
HEI48	57,95	57,33	56,35	58,47	57,05
HEI49	52,79	52,08	53,24	53,71	51,03
HEI50	63,68	62,03	60,91	63,90	70,00
HEI51	61,26	59,02	60,40	61,23	59,56
HEI52	78,32	69,55	69,08	76,09	84,60
HEI53	58,20	63,20	66,00	59,80	62,40
HEI54	56,78	55,78	54,73	58,09	51,90
HEI55	57,95	55,64	56,14	58,36	53,27
HEI56	61,75	55,58	56,75	57,08	58,17
HEI57	56,56	55,71	55,39	56,61	54,31
HEI58	64,92	63,81	62,19	65,70	61,66
HEI59	59,08	59,07	57,72	60,82	57,24
HEI60	72,92	67,01	65,64	70,59	76,60
HEI61	53,57	56,00	56,07	55,07	51,50
HEI62	54,00	58,60	59,40	59,00	54,20
HEI63	69,78	65,16	63,92	67,89	60,16
HEI64	74,33	68,64	68,56	72,93	66,40
HEI65	55,93	56,71	56,80	56,95	53,79
HEI66	73,66	69,03	70,76	70,52	81,59
HEI67	61,46	59,25	59,05	61,98	54,50
HEI68	70,04	65,08	63,67	68,63	70,86
HEI69	51,96	55,56	53,36	52,76	50,48
HEI70	68,98	65,16	64,10	69,12	63,64
HEI71	55,72	54,45	54,88	55,42	52,68
HEI72	62,14	60,49	60,34	64,78	59,46
HEI73	56,86	54,62	54,62	55,83	51,55
HEI74	59,96	56,70	57,61	60,26	56,87
HEI75	59,64	58,21	59,43	59,79	58,71
HEI76	51,00	41,00	44,00	48,00	54,00
HEI77	61,81	59,90	60,48	61,98	62,34
HEI78	54,20	56,20	57,00	53,80	51,80
HEI79	75,74	69,06	72,35	74,24	69,68
HEI80	71,56	66,12	66,28	69,74	67,94
HEI81	72,63	69,59	69,44	72,03	72,28
HEI82	70,03	63,27	63,00	69,42	60,97
HEI83	64,54	61,46	60,65	63,77	64,89
HEI84	59,90	58,93	57,33	59,27	61,28
HEI85	63,00	60,00	56,25	59,50	50,75
HEI86	56,03	55,71	52,97	55,85	53,29
HEI87	60,92	58,59	57,10	58,61	57,86
HEI88	61,82	57,03	56,88	60,03	59,39
HEI89	59,35	59,09	58,95	58,48	61,79
HEI90	54,05	52,07	51,71	54,22	50,00
HEI91	63,78	62,48	61,62	63,64	61,15
HEI92	63,76	62,91	62,60	63,31	61,98
HEI93	56,86	55,08	55,66	57,62	51,88
Average	59.55	57.67	57.54	59.47	57.55
s.d	6.45	5.42	5.69	5.85	7.60

Average student scores on SaberPro tests

	Quantitative Reasoning	Critical Reading	Citizenship Competencies	English or Second Language	Written Communication	Project Formulation and Evaluation	Design of Production and Logistics Systems
HEI1	51,46	35,69	36,31	55,15	36,77	123,85	140,08
HEI2	58,14	48,56	46,47	56,50	49,52	141,99	148,69
HEI3	38,33	33,00	42,67	59,00	49,33	127,33	141,33
HEI4	53,41	39,45	35,45	42,68	36,50	138,77	139,09

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	Quantitative Reasoning	Critical Reading	Citizenship Competencies	English or Second Language	Written Communication	Project Formulation and Evaluation	Design of Production and Logistics Systems
HEI5	59,22	50,94	45,50	49,44	33,39	148,72	143,33
HEI6	57,11	44,51	42,45	51,11	51,09	144,75	145,47
HEI7	61,40	45,23	41,94	48,28	46,04	147,32	144,62
HEI8	57,34	42,98	40,96	46,81	39,81	138,43	142,46
HEI9	57,46	46,64	45,85	42,79	41,21	142,44	144,23
HEI10	76,89	57,89	70,22	76,00	67,67	165,22	169,44
HEI11	69,75	63,63	54,38	64,00	55,75	143,88	159,25
HEI12	67,93	57,00	54,83	59,24	53,39	148,19	154,77
HEI13	64,36	39,86	46,07	45,21	60,93	143,14	148,07
HEI14	86,55	62,22	59,04	77,29	59,96	61,22	167,78
HEI15	55,41	57,24	47,12	51,24	58,71	147,00	150,71
HEI16	67,82	53,30	51,55	56,73	49,09	147,76	153,06
HEI17	73,75	51,59	49,01	68,45	53,52	154,96	156,61
HEI18	81,45	65,87	64,87	70,58	50,95	70,58	165,03
HEI19	54,45	42,94	47,00	48,45	51,23	142,29	142,65
HEI20	67,70	51,60	56,30	67,90	52,30	145,10	156,10
HEI21	20,67	30,00	24,00	20,00	19,67	142,00	119,00
HEI22	58,44	46,44	40,63	76,31	33,81	144,69	146,25
HEI23	46,11	39,04	38,51	35,44	43,15	136,80	137,07
HEI24	65,67	47,50	50,67	61,00	33,67	132,00	146,00
HEI25	76,46	53,69	49,85	57,62	40,69	156,46	154,00
HEI26	58,63	44,47	38,50	46,97	45,78	137,16	144,13
HEI27	59,13	25,13	17,63	35,63	33,38	134,88	128,63
HEI28	56,15	44,57	40,68	46,17	44,57	133,72	142,38
HEI29	56,32	41,89	43,84	50,05	51,05	141,74	144,26
HEI30	74,00	41,00	66,50	48,50	29,50	170,50	146,00
HEI31	42,00	31,29	38,24	29,41	41,65	126,59	129,53
HEI32	52,74	46,33	43,10	43,45	46,55	136,06	141,60
HEI33	86,59	74,41	71,64	89,57	66,83	170,05	178,61
HEI34	81,89	67,38	63,73	84,18	64,55	162,29	172,16
HEI35	66,86	45,45	46,00	51,07	51,38	147,90	148,34
HEI36	62,00	44,41	45,44	46,05	47,21	145,11	145,48
HEI37	72,53	64,35	55,00	70,35	47,06	164,76	157,76
HEI38	73,73	59,91	56,90	65,59	58,00	163,13	159,90
HEI39	66,76	48,79	53,11	58,09	47,21	149,20	152,17
HEI40	57,59	50,28	45,76	62,83	50,38	144,93	148,45
HEI41	72,52	55,26	52,67	62,71	46,42	151,67	154,41
HEI42	60,50	44,76	50,84	59,18	45,29	142,08	147,84
HEI43	71,23	57,53	53,13	66,35	55,60	150,92	157,95
HEI44	53,69	39,37	40,43	50,54	44,49	138,46	142,03
HEI45	90,76	79,12	79,72	78,68	56,44	177,64	178,84
HEI46	59,55	47,00	52,42	47,88	47,03	140,45	147,48
HEI47	79,17	62,97	57,61	62,88	47,64	156,85	159,30
HEI48	67,64	51,87	47,91	59,99	44,96	148,16	151,27
HEI49	47,37	42,66	56,76	41,24	60,68	141,66	146,68
HEI50	77,85	64,81	69,65	84,10	77,45	165,35	173,97
HEI51	80,63	57,88	49,60	66,81	46,56	166,00	157,91
HEI52	92,28	78,84	78,80	94,61	76,61	169,06	189,79
HEI53	79,20	78,20	46,00	71,60	58,80	164,80	163,00
HEI54	66,41	49,17	45,91	42,24	50,22	145,86	147,77
HEI55	70,18	54,36	56,36	61,45	44,64	150,73	153,95
HEI56	74,75	37,42	46,25	61,00	48,83	143,00	149,58
HEI57	57,42	47,04	45,22	53,15	50,79	144,93	147,71
HEI58	79,96	65,94	61,96	75,92	52,46	166,45	165,56
HEI59	76,56	59,13	50,27	59,25	47,51	159,07	155,68
HEI60	88,88	78,22	73,45	87,13	66,71	175,50	180,89
HEI61	47,21	36,71	37,57	56,21	45,21	132,64	140,64
HEI62	67,40	54,00	61,60	64,00	42,40	154,00	154,00
HEI63	87,45	73,98	65,57	69,67	54,70	169,86	169,11
HEI64	92,09	83,07	76,05	78,99	67,54	76,05	180,07
HEI65	67,02	47,82	54,00	54,84	51,07	149,73	151,95
HEI66	89,62	75,21	74,55	92,17	68,07	181,45	182,83
HEI67	72,37	54,93	51,50	48,15	48,10	148,39	152,37
HEI68	86,87	74,97	77,97	85,08	71,52	174,53	178,81
HEI69	60,40	42,36	40,20	39,20	56,12	135,04	144,72
HEI70	84,66	74,03	68,55	71,85	52,37	167,69	169,36
HEI71	60,05	49,92	43,30	51,88	48,62	147,95	147,07
HEI72	79,76	67,18	64,17	67,34	57,66	160,88	163,91

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	Quantitative Reasoning	Critical Reading	Citizenship Competencies	English or Second Language	Written Communication	Project Formulation and Evaluation	Design of Production and Logistics Systems
HEI73	60,55	40,66	40,10	53,97	47,69	139,90	146,17
HEI74	66,91	50,83	52,30	62,13	45,39	148,70	151,91
HEI75	75,57	63,36	63,29	67,93	66,57	166,29	164,29
HEI76	43,00	36,00	39,00	30,00	50,00	109,00	138,00
HEI77	77,78	61,82	54,72	75,96	58,69	60,12	163,21
HEI78	71,00	34,40	41,80	37,60	48,00	147,00	144,60
HEI79	94,47	84,44	80,62	86,82	68,35	187,24	188,09
HEI80	91,38	81,54	81,68	79,06	60,80	176,92	179,52
HEI81	93,78	79,47	70,19	84,22	63,31	177,25	179,91
HEI82	90,21	73,61	69,48	69,15	51,18	160,79	170,55
HEI83	76,74	59,08	57,63	71,93	52,38	156,53	161,17
HEI84	68,49	53,43	52,60	73,03	57,40	155,42	158,57
HEI85	66,00	70,00	44,00	46,00	41,75	130,25	152,25
HEI86	58,68	51,41	47,12	54,97	46,24	138,47	148,12
HEI87	72,34	65,63	52,80	68,05	54,81	157,81	159,39
HEI88	66,52	48,18	47,21	59,70	50,61	144,55	148,76
HEI89	72,12	55,74	57,11	75,33	56,06	157,39	160,70
HEI90	55,00	38,22	37,15	46,10	40,46	137,07	139,94
HEI91	73,07	62,25	57,27	67,45	58,95	153,91	161,46
HEI92	79,62	64,37	63,72	70,64	55,45	162,05	164,51
HEI93	65,32	52,44	45,30	49,58	50,42	149,34	148,32
Average	68.32	54.29	52.61	60.33	51.08	147.05	154.74
sd	13.80	13.63	12.53	15.12	9.99	21.98	13.53

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