Analysis of generic competencies using a Linear Regression Model: A case study in short-cycle programs

Análisis de competencias genéricas con modelos de regresión lineal: Caso de estudio en programas de ciclo corto

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Highlights

- The findings offer valuable insights to guide educational strategies aimed at improving retention and graduation rates in short-cycle academic programs.
- The analysis of short-cycle programs revealed varying levels of performance in generic competencies, highlighting the need to refine and adapt pedagogical strategies.
- The study utilized linear regression models and association tests to explore the impact of prior competencies on Saber TyT performance, revealing significant positive correlations across several areas.

ABSTRACT

Introduction. The Saber tests, administered by the Colombian Institute for the Evaluation of Education (ICFES), assess students' competency performance across educational levels. This study evaluates the progress in competencies among students enrolled in three technological programs (online learning, in-person learning, and dual-online learning) at a university in eastern Colombia by comparing their Saber 11 and Saber TyT (refers to the Technical and Technological Knowledge Test) test results. **Materials and Methods.** This descriptive, cross-sectional study analyzed data from students who completed the Saber 11 test beginning in 2014 and subsequently the Saber TyT test starting in 2016. A multiple linear regression model and association tests were applied. **Results.** Among the 3.095 graduates, only 14.7% had complete scores for both tests, limiting the scope of the analysis. A moderate correlation was observed between Saber 11 and Saber TyT competency scores, with stronger relationships in English (r(409) = 0.65; $p < 0.01$) and quantitative reasoning (r(409) = 0.60; $p < 0.01$). Accompanying programs positively impacted these areas, whereas citizenship competencies and written communication demonstrated less consistent performance. Study modality and cumulative GPA significantly influenced Saber TyT results. These findings provide actionable insights for refining educational strategies to enhance retention and advance critical competencies. **Conclusions.** This study highlights the importance of adapting pedagogical strategies to integrate essential competencies into academic programs, supporting institutional self-evaluation and accreditation efforts.

RESUMEN

Introducción. Las pruebas Saber, aplicadas por el Instituto Colombiano para la Evaluación de la Educación (ICFES), miden el desempeño de los estudiantes en competencias según su nivel de formación. Este estudio analiza el progreso en competencias de estudiantes de tres programas tecnológicos (virtual, presencial y dual-virtual) de una universidad del oriente colombiano mediante la comparación de sus resultados en las pruebas Saber 11 y Saber Técnico y Tecnológico (Saber TyT). **Materiales y Métodos.** Este estudio descriptivo y transversal evaluó datos de estudiantes que presentaron Saber 11 desde 2014 y, posteriormente, Saber TyT desde 2016. Se aplicó un modelo de regresión lineal múltiple y pruebas de asociación. **Resultados.** De los 3.095 graduados, solo el 14.7% tenía resultados completos en ambas pruebas, lo que limitó el análisis. Se identificó una correlación moderada entre los puntajes obtenidos en las competencias del Saber 11 y del Saber TyT, siendo más fuerte en inglés (r (409) = 0.65; $p = 0.00$) y razonamiento cuantitativo (r (409) = .60; $p = 0.00$). Los programas de acompañamiento contribuyeron positivamente a estas áreas, mientras que competencias ciudadanas y comunicación escrita presentaron un desempeño menos consistente. La modalidad de estudio y el promedio general acumulado influyeron significativamente en los resultados de Saber TyT. Estos hallazgos orientan la optimización de estrategias educativas enfocadas en la retención y avance en competencias críticas. **Conclusiones.** Este estudio subraya la importancia de ajustar estrategias pedagógicas para integrar competencias clave en los programas académicos, contribuyendo a la autoevaluación y acreditación institucional.

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INTRODUCTION

The Organisation for Economic Co-operation and Development (OECD)[1] reports that Colombia ranked among the lowest-performing countries in mathematics (391 points), science (413 points), and reading (412 points) in the Programme for International Student Assessment (PISA) tests [2,3]. These results highlight significant gaps in key areas, raising concerns about the readiness of students entering higher education. Additionally, the report notes a decline in Colombian students' average scores compared to previous years, emphasizing the need for immediate academic improvement. Approximately 9,000 students from both urban and rural areas participated in the assessment, representing public and private educational institutions [1].

The Ministry of National Education (MEN) faces dual challenges: addressing low academic performance and tackling student attrition in higher education. In 2021, dropout rates reached 8.89% in university programs, 15.32% in technological programs, and 18.79% in technical programs, as reported by the System for the Prevention and Analysis of Dropout in Higher Education Institutions (SPADIES 3.0) [4]. Particularly concerning is the 42.5% increase in dropout rates for technological programs between 2018 and 2022, reflecting significant challenges in this educational segment.

National regulations mandate that higher education institutions (HEIs) ensure the quality of education throughout their students' academic journeys. A critical approach to achieving this goal involves comparing Saber 11 test results with those of Saber Pro and Saber TyT tests [5]. This analysis enables institutions to evaluate their contributions to students' educational development [6], offering insights into whether students demonstrate meaningful progress in generic competencies during their academic programs—a key measure of institutional impact.

Learning outcomes in higher education have become essential indicators for assessing educational quality at both national and international levels. The Colombian Institute for Educational Evaluation (ICFES, 2020) defines value-added models as tools that measure the extent to which educational institutions contribute to students' competency development, independent of their initial conditions upon admission [7]. These models utilize multilevel or hierarchical statistical analyses to evaluate variables at both the student and institutional levels, providing a comprehensive understanding of the educational process [8,9]. These analyses are essential for identifying institutional strengths and weaknesses, supporting quality assurance policies and program accreditation renewal.

Academic programs are benchmarked against their reference groups, defined by basic knowledge areas under Resolution 359 of 2018. This allows institutions to better understand their contributions to student development and ensure alignment with the competencies required by the labor market. Strengthening the quality of higher education remains a national priority, as it supports Colombia's economic and technological advancement [10]. In this context, ICFES reports serve as essential tools for evaluating the effectiveness of educational institutions in particular concern is the 42.5% fostering students' learning and preparing them for labor market integration.

The 2022 results for the Pharmacy Regulation Technology (PRT) program at the Faculty of Technical and Technological Studies, Universidad Autónoma de Bucaramanga (UNAB), highlighted that performance in all five generic modules fell below the institutional average of 85 points. The gaps widened when compared to the program's reference group, with notable differences in quantitative reasoning (76 vs. 92 points) and English (88 vs. 103 points). Conversely, the Criminal Investigation and Forensic Sciences Technology (CIFST) program exceeded institutional averages across all evaluated modules, with particularly strong performance in quantitative reasoning (93 vs. 79 points) and English (104 vs. 92 points). However, citizenship competencies lagged by 4 points compared to the reference group.

Similarly, the Gastronomy Management Technology (GMT) program achieved results equal to or exceeding institutional averages in all modules, excelling in written communication with a substantial margin of 31 points (105 vs. 74 points). However, when compared to the reference group, the program exhibited minor lags in critical reading, citizenship competencies, and English, with marginal differences of just 2 points in each area.

Against this backdrop, the study posed the following research question: What is the relationship between the generic competencies acquired during technological education and students' performance on the Saber TyT tests, considering teaching modalities and accompanying programs? To address this question, the study aimed to analyze the performance trends of students from three technological programs at UNAB — Pharmacy Regulation (online learning), Criminal Investigation and Forensic Sciences (in-person learning), and Gastronomy Management (dual-online learning) — using the results of the Saber 11 and Saber TyT tests administered by ICFES.

MATERIALS AND METHODS

Population and Sample

The study was exploratory, employing a descriptive and cross-sectional design. The population was derived from the university's information system databases. Initially, a dataset was created comprising the test scores of students who had taken both the Saber 11 and Saber TyT tests. The primary dataset, provided by the Directorate of Student Success, included information on 3.095 graduates (2011–2023) from three short-cycle technological programs: Pharmacy Regulation (online learning, 83%), Criminal Investigation and Forensic Sciences (face-to-face modality, 13%), and Gastronomy Management (dual-online learning, 5%). The students' unique test registration number, SNP (Servicio Nacional de Pruebas), assigned by ICFES for the Saber 11 test, was verified along with the year the test was taken. Records spanned from 1977 to 2020.

In Colombia, the Saber 11 test, formerly known as the ICFES test until 2012, serves as a prerequisite for undergraduate admission to higher education institutions. During university enrollment, students provide sociodemographic information and their Saber 11 test results.

Additionally, the presence of the SNP number for the Saber TyT test, referred to here as EK, was verified among the graduates. From this, 462 graduates with an EK number were identified, but only 219 had data on Saber TyT test results readily available. Consequently, a manual search for the test results of the remaining 243 graduates was conducted using the ICFES microsite, recovering data for an additional 241 graduates. This process yielded a final sample of 460 complete records for analysis.

Inclusion and Exclusion Criteria

Data was collected from institutional databases for students who took the Saber 11 test starting in the second semester of 2014 and subsequently enrolled in the university. Results from the Saber TyT test taken from the second semester of 2016 onward were also included. Records with incomplete or incomparable data, or those that could not be matched between Saber 11 and Saber TyT tests, were excluded from the dataset.

Data Analysis

Careful consideration was given to changes in the composition of the modules and scoring scales of the Saber tests overtime. To ensure consistency, value-added estimations were performed only between results from test structures that were equivalent. The score vectors for each module of the Saber 11 and Saber TyT tests were standardized. Descriptive, bivariate, and correlation analyses were conducted, followed by a multiple linear regression model to evaluate factors associated with students' academic performance. This analysis compares the results of the Saber 11 and Saber TyT tests. The model estimated an Expected Value (EV) for the Saber TyT test scores based on the Saber 11 results and contrasted it with the Actual Value (AV) from Saber TyT. The following equation **(Equation 1)** was used:

$$Y_i = \beta_0 + \beta_1 \text{Mathematics}_i + \beta_2 \text{Critical Reading}_i + \beta_3 \text{Natural Sciences}_i + \beta_4 \text{Social and Citizenship}_i + \beta_5 \text{English} + \varepsilon_i \quad \text{(Equation 1)}$$

Here: Y_i represents the actual performance (Actual values) of the student on the Saber TyT test, $\hat{Y}_i$ denotes the expected performance (Expected values) based on the Saber 11 scores, β corresponds to the coefficients estimated using the least squares method, and ε_i Error is the error term associated with the estimation. The difference between actual performance Y_i and expected performance $\hat{Y}_i$, —denoted as VA_i— defines the value-added contribution of the academic program **(Figure 1)**. The value VA_i can be positive, negative, or close to zero, indicating the extent of the university's contribution to the student's development. This approach enables the classification of students based on the educational impact they received, facilitating an evaluation of academic progress. The representation of actual versus expected performance on a Cartesian plane is referred to as the value-added plane, illustrating the program's impact on student outcomes
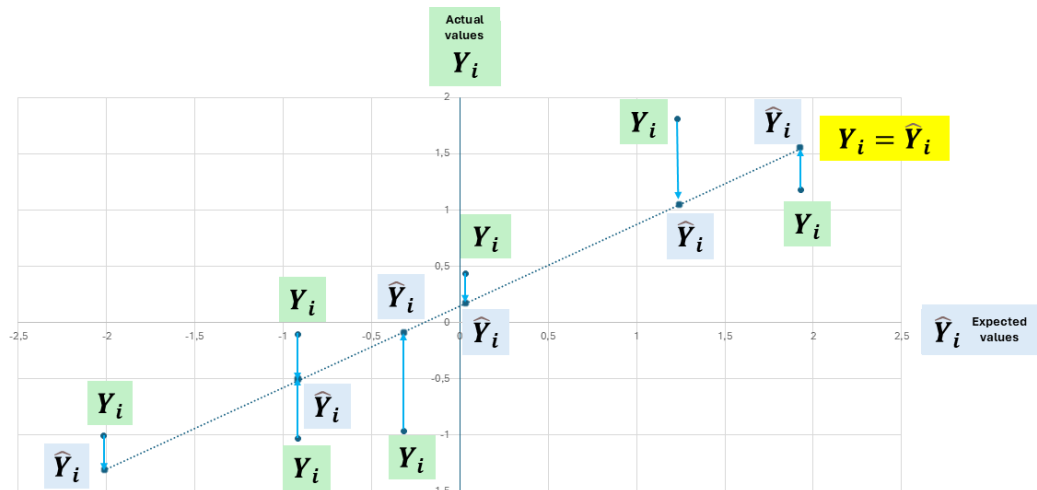
Figure 1. Value-Added Plane: Actual values (Y_i) vs. Expected values ($\hat{Y}_i$)

Software: MS Excel™, R Studio [11] with the Rattle and ggplot2 libraries, and SPSS version 28 [12] were used.

Ethical Considerations

This project adheres to Resolution No. 008430 of 1993 issued by the Colombian Ministry of Health, Article 11, Section A: Risk-Free Research. The results from the Saber 11 and Saber TyT tests were anonymized using codes assigned by ICFES, excluding sensitive data to ensure confidentiality.

RESULTS

Descriptive Analysis

Cross-referencing Saber 11 and Saber TyT Tests. The results of the Saber 11 test from 2014 to 2020 were cross-referenced with the results of the Saber TyT test from 2017 to 2023. The database comprised data from 455 students **(Table 1)**. Starting in the second semester of 2014, the Colombian Institute for the Evaluation of Education (ICFES) revised the Saber 11 test to align it with the structure of other evaluations it administers (Saber 3, 5, 9, Saber TyT, and Saber Pro). Consequently, data from seven students who took the Saber 11 test between the first semester of 2012 and the first semester of 2014 were excluded to avoid recalibration of the Saber 11 results.

Table 1. Cross-referencing Results of Saber 11 and Saber TyT Tests

Saber 11	Saber TyT							
	2017	2018	2019	2020	2021	2022	2023	Total
2014		10	18	12	15	12	15	82
2015	1	10	22	13	14	23	15	98
2016			19	14	26	26	10	95
2017				11	23	24	18	76
2018				1	11	29	14	55
2019						7	23	30
2020						1	18	19
Total	1	20	59	51	89	122	113	455

After performing data mining processes, only 14.7% (455) of the 3.095 graduates across the three programs had complete results for both the Saber 11 and Saber TyT tests. The distribution of these students by program is as follows: Gastronomic Management Technology: 32.41% (47 out of 145 students), Criminal Investigation and Forensic Sciences Technology: 28.94% (112 out of 387 students) and Pharmacy Regulation Technology: 7.58% (296 out of 2.563 students).

The Colombian Institute for the Evaluation of Education (ICFES) has established a standard score of 50 for the Saber 11 test and 100 for the Saber TyT test. However, researchers, based on the national global averages obtained by the TyT programs, calculated an adjusted mean using the national global data from 2016 to 2023 in both cases. For the Saber 11 test, semiannual data were analyzed **(Table 2)**, while for the Saber TyT test, annual data were considered **(Table 3)**. This approach allowed for the establishment of an average value that more accurately reflects the results of the evaluated population.

Table 2. National average score for Saber 11

Competency	NAM M(SD)	NACR M(SD)	NASCS M(SD)	NANS M(SD)	NAE M(SD)	NGA M(SD)
Average	57 (7.15)	58 (5.56)	55 (6.94)	56 (6.55)	61 (11.31)	285 (33.13)

M: Mean, SD: Standard Deviation, NAM: National Average in Mathematics, NACR: National Average in Critical Reading, NACSS: National Average in Social and Citizenship Skills, NANS: National Average in Natural Sciences, NAE: National Average in English, NGA: National Global Average.

Table 3. National average score for Saber TyT

Competency	NAM M(SD)	NACR M(SD)	NASCS M(SD)	NANS M(SD)	NAE M(SD)	NGA M(SD)
Average	94 (9.63)	90 (5.37)	97 (2.51)	96 (4.14)	100 (0.00)	95 (3.27)

M: Mean, SD: Standard Deviation, NAWC: National Average in Written Communication, NAQR: National Average in Quantitative Reasoning, NACR: National Average in Critical Reading, NACC: National Average in Citizenship Competencies, NAE: National Average in English, NGA: National Global Average.

Subsequently, scatter plots **(Figure 2)** were created to compare the scores of the generic Saber 11 and Saber TyT tests. These plots are organized into four quadrants **(Figure 2)**: Quadrant 1 (upper right): Students with scores above the national average in both Saber TyT and Saber 11. Quadrant 2 (upper left) [13]: Students with scores above the national average in Saber TyT but below the national average in Saber 11. Quadrant 3 (lower left): Students with scores below the national average in both tests. Quadrant 4 (lower right): Students with scores below the national average in Saber TyT but above the national average in Saber 11. The national average scores for the Saber 11 and Saber TyT tests are indicated by dashed lines in **(Figure 2)**.

In all cross-referenced tests, instances were identified where graduates scored zero points in one or more components of the Saber TyT test (critical reading, written communication, quantitative reasoning, citizenship competencies, and English). These instances adversely impacted the group's average scores and were subsequently excluded from the analysis. After these exclusions, the final sample consisted of 45 out of 47 students from GMT, 103 out of 112 from CIFST, and 263 out of 296 from PRT, resulting in a total of 411 students analyzed out of the initial 455.

The Pearson correlation coefficient was computed to assess the association between several pairs of variables[14]. For CRSaberTyT and CRSaber11, a moderate positive linear correlation was observed, ($r(409)$ = 0.56; p = 0.00), indicating a moderate linear relationship between these two variables. Similarly, for QRSaberTyT and MATSaber11, the correlation was also moderate and positive, ($r(409)$ = 0.60; p = 0.00). The competencies in ESaberTyT and ESaber11 showed a high positive linear correlation, ($r(409)$ = 0.65; p = 0.00). For CCSaberTyT and SCSaber11, the correlation remained moderate and positive, ($r(409)$ = 0.60; p = 0.00). Finally, a low positive linear correlation was found between WCSaberTyT and CRSaber11, ($r(409)$ = 0.28; p = 0.00).

The descriptive analysis of Saber 11 and Saber TyT test scores reveals performance disparities across academic programs. In the Technology in Gastronomic Management (GMT) program, students had a mean age of 23 years (SD = 5) and a cumulative grade point average of 4.2 (SD = 0.2). The highest mean score in Saber 11 was in critical reading, with 56.1 points (SD = 8.8), while in Saber TyT, the English competency stood out with a mean score of 107.2 points (SD = 26.3). Median scores included 57 points in critical reading for Saber 11 and 108 points in English for Saber TyT. Additionally, students achieved 87 points in quantitative reasoning and 97 points in citizenship competencies.
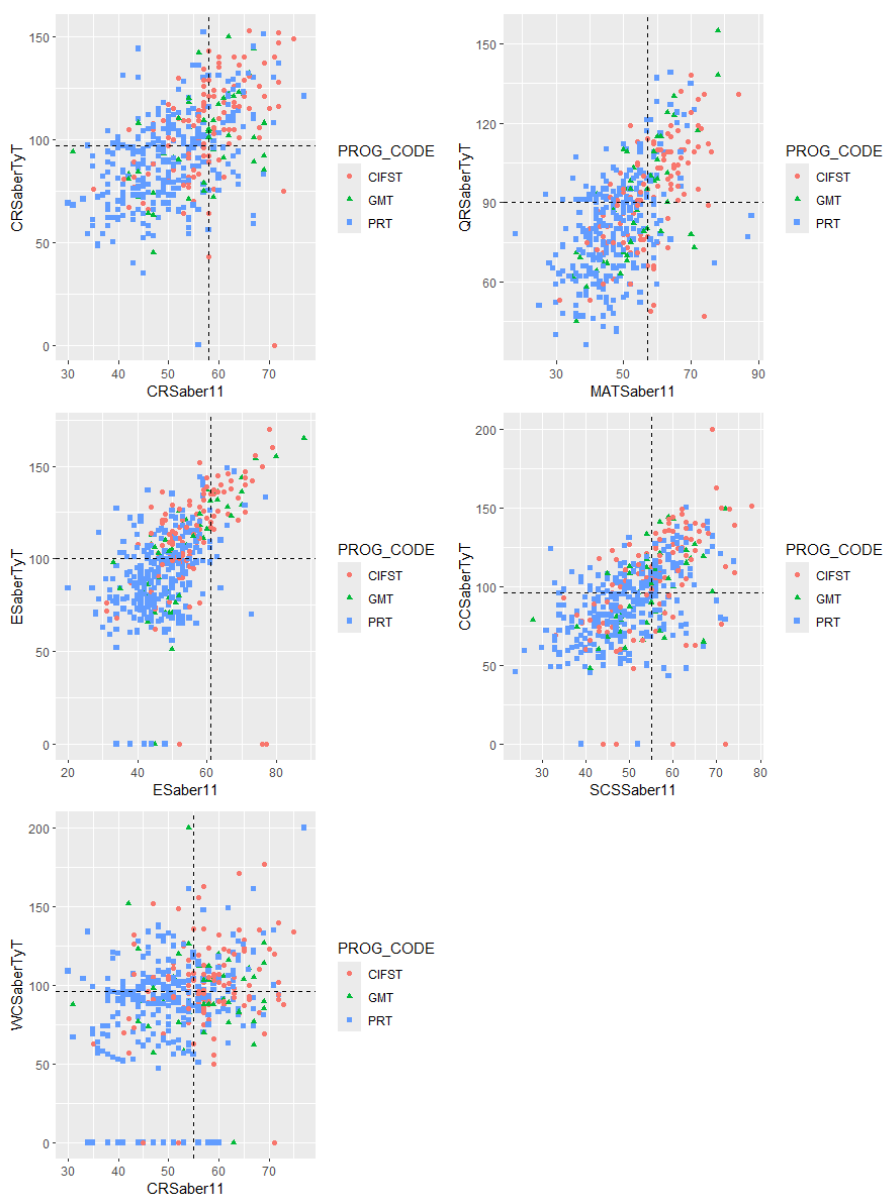
Figure 2. Scatter plots of generic test scores: Saber 11 vs. Saber TyT. GMT: Gastronomic Management Technology, CIFST: Criminal Investigation and Forensic Sciences Technology, PRT: Pharmacy Regulation Technology, CRSaber11: Critical Reading in Saber 11, CRSaberTyT: Critical Reading in Saber TyT, MATSaber11: Mathematics in Saber 11, QRSaberTyT: Quantitative Reasoning in Saber TyT, ESaber11: English in Saber 11, ESaberTyT: English in Saber TyT, SCSSaber11: Social and Citizenship Skills in Saber 11, CCSaberTyT: Citizenship Competencies in Saber TyT, WCSaberTyT: Written Communication in Saber TyT.

Among students enrolled in the Technology in Criminal Investigation and Forensic Sciences (CIFST) program, the mean age was 22 years (SD = 2), with an overall cumulative grade point average (GPA) of 4.1 (SD = 0.2). The highest mean score in Saber 11 was observed in critical reading, with 57.5 points (SD = 7.9), while in Saber TyT, the highest score was in English, with 115.3 points (SD = 22). Regarding medians, students achieved 57 points in critical reading for Saber 11 and 116 points in English for Saber TyT. Scores in quantitative reasoning reached 94 points, and those in citizenship competencies reached 109 points.

Within the Technology in Pharmacy Regulation (PRT) program, students had a mean age of 26 years (SD = 7) and an overall cumulative GPA of 4.1 (SD = 0.3). In Saber 11, the highest mean score was in critical reading, with 50.4 points (SD = 8.6), while in Saber TyT, written communication stood out with 94.1 points (SD = 21). Median scores included 50 points in critical reading for Saber 11 and 90 points in English for Saber TyT. Scores in quantitative reasoning reached 80 points, and those in citizenship competencies reached 88 points.

Multiple Linear Regression Model

A multiple linear regression model was employed to estimate the Expected Value (EV) in Saber TyT test results, following the approach of Hosmer & Lemeshow (2000) [15]. In this model, the scores obtained by each student on the Saber 11 test were used as predictors to estimate the Saber TyT results. The model included the following variables: the mode of study (in-person, online, and dual-online), the cumulative GPA value above or below 3.8 (1: students with GPA $\geq$ 3.8; 0: students with GPA < 3.8), and gender (0: female; 1: male). The inclusion of the GPA variable aligns with the institution's financial policies, as renewing certain economic benefits and tuition discounts requires maintaining a GPA of 3.8 or higher.

The regression model is represented by the following equation: **(Equation 2)**

$$Y_i = \beta_0 + \beta_1(\text{Saber11Mat})_i + \beta_2(\text{Saber11CR})_i + \beta_3(\text{Saber11SCS})_i + \beta_4(\text{SaberNS})_i + \beta_4(\text{SaberE})_i + \text{Modality} + \text{GPA3,8} + \text{Gender} + Error_i \text{ (Equation 2)}$$

Where Y_i: represents the actual values of the Saber TyT test for student i. $\hat{Y}_i$: denotes the expected or average result from the linear model, representing the estimated score the student might have achieved in Saber TyT based on their Saber 11 scores. $Error_i$ is the error term that adjusts the difference between the actual value (Y_i) and the expected value $\hat{Y}_i$. The coefficients β_0, β_1, β_2, β_3, β_4, and β_5 are the estimated parameters of the model corresponding to the predictor variables: Critical Reading (CR), Quantitative Reasoning (QR), Citizenship Competencies (CC), Natural Sciences (NS), and English (E). All models met the assumptions of linearity, independence, homoscedasticity, normality, and non-collinearity.

The analysis of the multiple linear regression model for Quantitative Reasoning (QR) in the Saber TyT test reveals that scores in various areas of the Saber 11 test significantly influence performance in this competency (Table 4). The model variables explain 44.4% of the variability in students' performance. Specifically, the results indicate that scores in Mathematics, Critical Reading, and Natural Sciences have a significant impact on QR performance, with coefficients of 0.32, 0.10, and 0.31, respectively. Additionally, it was observed that a cumulative GPA below 3.8 has a significant negative effect on performance, with a coefficient of -0.34. This suggests that students with a GPA below 3.8 tend to perform worse in the Quantitative Reasoning competency.

Table 4. Multiple Linear Regression Model for the generic competency Quantitative Reasoning in Saber TyT

Variable	Unstandardized coefficients		t	p	95% Confidence Intervals	
	B	Std. Error			Lower Limit	Upper Limit
Constant	0.25	0.10	2.37	0.01	0.04	0.46
MATSaber11	0.31	0.05	5.60	0.00	0.20	0.42
CRSaber11	0.10	0.05	1.99	0.04	0.00	0.20
NSSaber11	0.31	0.06	5.19	0.00	0.19	0.42
Gender	0.16	0.08	1.92	0.05	-0.00	0.33
GPA3,8	-0.34	0.11	-3.04	0.00	-0.55	-0.12
R^2: 0.44, Durbin-Watson Statistic: 1.91, Sample Size (N): 411						

MATSaber11: Mathematics Saber 11, CRSaber11: Critical Reading Saber 11, NSSaber11: Natural Sciences Saber 11, GPA 3.8: Indicator variable for cumulative GPA (1 = GPA ≥ 3.8, 0 = GPA < 3.8). Std. Error: Standard Error. $p < 0.05$.

For the Critical Reading (CR) section in Saber TyT, the multiple linear regression model indicates that scores in various areas of Saber 11 account for 42.5% of the observed variability in performance **(Table 5)**. This suggests that the predictors considered have a moderate ability to explain performance in this competency. The results show that scores in Critical Reading, Social and Citizenship Skills, Natural Sciences, and English from Saber 11 are significantly associated with performance in Critical Reading, with coefficients of 0.20, 0.18, 0.24, and 0.14, respectively. These relationships indicate that students who perform better in these areas also tend to achieve higher performance in Critical Reading in Saber TyT, underscoring the importance of these skills for success in this specific competency.

The regression model for the Citizenship Competencies (CC) test in the Saber TyT test indicates that 42.1% of the variability in performance is explained by the scores from various areas of the Saber 11 test **(Table 6)**. This underscores the relevance of these areas in predicting performance in this competency. The coefficients obtained show that the scores in Social and Citizenship Skills, Natural Sciences, and English in Saber 11 are significantly associated with Citizenship Competencies performance, with values of 0.35, 0.30, and 0.08, respectively. The Social and Citizenship Skills variable has the highest positive influence, followed by Natural Sciences, while English was not statistically significant ($p = 0.08$), suggesting a possibly weaker or non-significant relationship. These findings highlight the importance of knowledge in Social and Citizenship Skills and Natural Sciences for strong performance in Citizenship Competencies.

Table 5 Multiple Linear Regression Model for the Generic Competency LCSaber TyT.

Variable	Unstandardized coefficients		t	p	95% Confidence Intervals	
	B	Std. Error			Lower Limit	Upper Limit
Constant	-0.00	0.03	0.00	1.000	-0.07	0.07
CRSaber11	0.20	0.05	3.63	0.00	0.09	0.30
SCSSaber11	0.18	0.05	3.41	0.00	0.08	0.29
NSSaber11	0.24	0.06	4.10	0.00	0.12	0.36
ESaber11	0.14	0.04	2.94	0.00	0.04	0.23
R^2: 0.42, Durbin-Watson Statistic: 1.74, Sample Size (N): 411						

MATSaber11: Mathematics Saber 11, CRSaber11: Critical Reading Saber 11, SCSSaber 11: Social and Citizenship Skills Saber 11, NSSaber11: Natural Sciences Saber 11, Esaber11: English Saber 11. Std. Error: Standard Error. $p < 0.05$.

Table 6. Multiple Linear Regression Model for the Generic Competency Citizenship Competencies in Saber TyT.

Variable	Unstandardized coefficients		t	p	95% Confidence Intervals	
	B	Std. Error			Lower Limit	Upper Limit
Constant	0.00	0.03	0.00	1.00	-0.07	0.07
SCSSaber11	0.35	0.05	6.75	0.00	0.24	0.45
NSSaber11	0.30	0.05	5.32	0.00	0.19	0.41
Esaber11	0.08	0.04	1.74	0.08	-0.01	0.17
R^2: 0.421, Durbin-Watson Statistic: 1.84, Sample Size (N): 411						

SCSaber11: Social and Citizenship Skills Saber 11, NSSaber11: Natural Sciences Saber 11, Esaber11: English Saber 11, Std. Error: Standard Error, *p < 0.05*.

In the case of the model for Written Communication (WC) in the Saber TyT test, the predictor variables explain only 10.1% of the variability in performance **(Table 7)**. This is the lowest value among the models analyzed, indicating that other relevant factors not included in this model also influence writing competence. The results show that Critical Reading and English scores from the Saber 11 test are significantly related to performance in Writing Competence, with coefficients of 0.18 and 0.17, respectively. Although both coefficients are significant, the Critical Reading score appears to have a slightly greater influence. These findings suggest that both reading skills and knowledge of English are relevant for writing performance.

Table 7. Multiple Linear Regression Model for the Generic Competency Written Communication in Saber TyT.

Variable	Unstandardized coefficients		t	p	95% Confidence Intervals	
	B	Std. Error			Lower Limit	Upper Limit
Constant	0.00	0.04	0.00	1.000	-0.09	0.09
CRSaber11	0.18	0.05	3.32	0.00	0.07	0.29
Esaber11	0.17	0.05	3.19	0.00	0.06	0.28
R^2: 0.1, Durbin-Watson Statistic: 1.77, Sample Size (N): 411						

CRSaber11: Critical Reading Saber 11, Esaber11: English Saber 11, Std. Error: Standard Error, *p < 0.05*.

The regression model for the English (E) test in the Saber TyT test explains 48.2% of the variability in performance, indicating that the model's predictive capacity is relatively high compared to the other competencies evaluated **(Table 8)**. The scores in Critical Reading, Natural Sciences, and English from the Saber 11 test are significantly correlated with performance in the English competency, with coefficients of 0.11, 0.16, and 0.46, respectively. Among all variables, the English score (Esaber11) has the greatest positive influence on performance, underscoring the importance of English knowledge for strong results in this competency.

Additionally, the variable Modality was found to have a significant negative coefficient (-0.18, $p = 0.001$), suggesting that the type of modality (in-person learning, online learning, or dual-online learning) influences

students' performance in the English competency. Specifically, students in certain modalities tend to score lower compared to their peers, revealing a negative impact of study modality on performance in this area.

Table 8. Multiple Linear Regression Model for the Generic Competency English in Saber TyT.

Variable	95% Confidence Intervals		t	P	95% Confidence Intervals	
	B	Std. Error			Lower Limit	Upper Limit
Constant	0.27	0.09	2.96	0.00	0.09	0.46
CRSaber11	0.11	0.05	2.22	0.02	0.01	0.20
NSSaber11	0.15	0.05	3.03	0.00	0.05	0.25
Esaber11	0.45	0.04	9.90	0.00	0.36	0.55
Modality	-0.18	0.05	-3.20	0.00	-0.29	-0.07
R²: 0.48, Durbin-Watson Statistic: 1.92, Sample Size (N): 411						

CRSaber11: Critical Reading Saber 11, NSSaber11: Natural Sciences Saber 11, Esaber11: English Saber 11, Std. Error: Standard Error, *p < 0.05*.

Bivariate Analysis of Generic Competencies vs. Academic Program
Programs and the Progress or Plateau in Saber TyT Competency Results

In these analyses, progress and plateau refer to changes in student performance in specific competencies assessed in the Saber TyT test. Progress applies to students who have improved their performance in a specific competency, indicating they have acquired or strengthened the necessary skills to achieve a higher performance level. In contrast, plateau applies to students whose performance has not improved in the evaluated competency.

Quantitative Reasoning Test

The analysis of the contingency table **(Table 9)** for the Quantitative Reasoning (QR) competency in the Saber TyT test reveals no statistically significant relationship between the type of program and the likelihood of progress or plateau in this competency, χ^2 (2, N = 411) = 1.42, p = 0.49. The values for progress and plateau are relatively evenly distributed among the three evaluated programs. This suggests that the type of program is not a relevant factor for performance in this area, opening the door to exploring other elements that may be impacting students' academic outcomes.

Critical Reading Test

The analysis of the contingency table **(Table 9)** shows a significant association between the type of academic program and students' performance in terms of progress or plateau in the Critical Reading (CR) competency, χ^2(2, N = 411) = 8.02, p = 0.02. Notably, the CIFST program stood out, with 63.1% of students achieving progress, which could indicate greater program effectiveness in developing this skill. Conversely, the PRT program showed an equitable distribution between progress and plateau. For the GMT program, 60%

of students experienced plateau, highlighting challenges in this area. These findings could guide future adjustments to the teaching methodology applied in the latter program.

Citizenship Competencies Test

The Saber TyT Citizenship Competencies test demonstrates a statistically significant relationship between the type of academic program **(Table 9)** and students' progress or plateau results, $\chi^2(2, N = 411) = 6.20$, $p = 0.045$. Students in the CIFST program tended to progress, with 60.2% showing improvements, whereas 60% of GMT students stagnated, underscoring the challenges faced in this area. The PRT program showed balanced performance, with no notable tendency toward progress or plateau. These results suggest that the specific training provided by the academic program may play a significant role in the development of Citizenship Competencies, requiring reflection on the pedagogical strategies and the effectiveness of the training approaches used in each program.

Regarding the Written Communication (WC) test in Saber TyT **(Table 9)**, the results indicate no statistically significant association between the type of academic program and students' performance in terms of progress or plateau, $\chi^2(2, N = 411) = 0.33$, $p = .85$, suggesting that the variables are independent. In other words, the type of academic program does not appear to influence whether students advance or stagnate in this specific competency. The results for plateau and progress are similarly distributed across the three programs evaluated, implying that students' performance in the Written Communication competency is not dependent on the type of training they receive.

These findings invite consideration of other factors beyond the academic program that may affect the development of Written Communication skills, such as individual pedagogical approaches or students' personal characteristics. They also encourage further research to identify these factors and improve performance in this key area.

For the English test in Saber TyT **(Table 9)**, a statistically significant association was identified between the type of academic program and students' performance in terms of progress or plateau, $\chi^2(2, N = 411) = 7.99$, $p = 0.02$. Specifically, students in the CIFST program showed favorable performance, with 62.1% achieving progress in their English skills.

In contrast, the PRT and GMT programs exhibited higher plateau rates, with 53.6% and 55.6%, respectively, suggesting that students in these programs face greater challenges in improving this competency. This highlights the need to adapt and strengthen pedagogical strategies for English learning to equip all students with the necessary tools to develop this skill, which is increasingly relevant in today's context.

Table 9. Competency Results in Saber TyT by academic program

	Quantitative Reasoning Test Saber TyT						
	Plateau		Progress		Total		
Program	n	%	n	%	n	Pearson's Chi-Square	p
CIFST	44	42.7	59	57.3	103		
PRT	129	490	134	51.0	263	1.43	0.49
GMT	23	51.1	22	48.9	45		
Total	196	477	215	52.3	411		
	Critical Reading Test Saber TyT						
CIFST	38	36.9	65	63.1	103		
PRT	131	49.8	132	50.2	263	8.02	0.02
GMT	27	60.0	18	40.0	45		
Total	196	47.7	215	52.3	411		
	Citizenship Competencies Test Saber TyT						
CIFST	41	39.8	62	60.2	103		
PRT	135	51.3	128	48.7	263	6.21	0.04
GMT	27	60.0	18	40.0	45		
Total	203	49.4	208	50.6	411		
	Written Communication Test Saber TyT						
CIFST	51	49.5	52	50.5	103		
PRT	128	48.7	135	51.3	263	0.34	0.85
GMT	24	53.3	21	46.7	45		
Total	203	49.4	208	50.6	411		
	English Test Saber TyT						
CIFST	39	37.9	64	62.1	103		
PRT	141	53.6	122	46.4	263	7.99	0.02
GMT	25	55.6	20	44.4	45		
Total	205	49.9	206	50.1	411		

CIFST: Criminal Investigation and Forensic Sciences Technology; GMT: Gastronomy Management Technology; PRT: Pharmacy Regulation Technology.

DISCUSSION

According to Arias, Soto, and Morera (2009), in value-added models, it is crucial to identify how much a school contributes to the educational development of its students. Among the main challenges are those related to the use of cross-sectional evaluations and selection biases, which may arise from students' initial characteristics, sociodemographic factors, and specific contextual elements of each school, highlighting the importance of high-quality data [16].

Although many students took the test in this study, only 411 could be matched, evidencing a limitation in the availability of information, particularly regarding sociodemographic aspects. This shortcoming underscores the need for comprehensive data to reduce methodological limitations and obtain conclusive results. Nevertheless, the study included explanatory variables such as Saber 11 scores, Modality (in-person, online, and dual-online), GPA 3.8 (1: students with GPA ≥ 3.8, 0: students with GPA < 3.8), and Gender (0: female,

1: male). However, these variables may be insufficient, as suggested by studies like Muñoz Gómez (2016), which included individual student variables such as parental education, gender, dropout rates, university type, school calendar, and tuition fees. Although the evaluated institutions were not specified, some were found to generate a higher value-added compared to a reference group, as demonstrated in a proposed hierarchical linear model [17].

At Universidad Autónoma de Bucaramanga (UNAB), analyses on value-added in Citizenship Competencies in higher education in Colombia revealed that higher education institutions contribute limited value to this competency. While the overall impact is low, public institutions were observed to be more effective than private ones in citizenship training [18].

A study by Burgos (2019) at a university in Nariño found an average value-added of 10% in its students. The English module contributed the most, with a value-added of 13.50%, followed closely by Quantitative Reasoning at 13.37%. Conversely, Citizenship Competencies showed the least contribution at 2.89% [19]. In the case of Quantitative Reasoning, a maximum value-added of 40% was observed, while the lowest values were found in the English module, with -35% [19].

At another university in eastern Colombia, previous studies focused on value-added showed that 63% of students maintained or improved their competency level above the expected average in the Saber Pro test, compared to their Saber 11 scores. Detailed results showed that 56% of students improved in Quantitative Reasoning, 39% in Written Communication, 56% in English, and 61% in Communicative Competencies [20].

Few studies have tested short-cycle programs in this context. In one such study, Ovalle (2023) conducted value-added research in technical and technological institutions (TyT), specifically addressing the impact of these programs. Data from 7,532 students across 60 technical institutions in Bogotá were evaluated using Saber 11 results (2006–2014) and Saber Pro results (2016-1 and 2016-2). However, the study also found limitations due to incomplete information on the universities, recommending improvements in public records or the Formal Education Survey (C-600). The study also highlighted that some technical institutions labeled as low-quality by the public can positively contribute to their students' competency development [21].

Most universities have conducted research focused on measuring value-added in undergraduate programs [14,19,22,23,24].

For instance, Corporación Universitaria del Caribe (CECAR) reported a value-added of 2.45% for students in the Bachelor of Basic Education program from the second semester of the 2013 cohort. This relatively low magnitude is explained by the below-average prior achievement of students and the limited contribution by CECAR to their learning outcomes [25]. Sociocultural level was not associated with academic achievement, nor was socioeconomic status, given the relatively homogeneous groups served, where key variance contributors were parental occupation and socioeconomic stratum. However, institutional academic-administrative practices and organization were strongly correlated with academic achievement, highlighting their significance in student success.

At Universidad de Santander (UDES), a study encompassing 89% of all program records found that students at the Cúcuta campus who participated in the Accompaniment Program for Admission and Student Retention (APASR) from technical schools in socioeconomic strata 1 and 2 achieved better results in English and Quantitative Reasoning in Saber Pro [26]. Another study at the Bucaramanga campus showed that 93% of students improved in at least one generic competency evaluated in Saber Pro compared to their Saber 11 performance. The most common improvements were in Quantitative Reasoning, Critical Reading, and Citizenship Competencies, with 49% of evaluated students achieving progress in these categories. These findings emphasize the need to account for students' diverse academic, economic, and social backgrounds upon entering UDES, emphasizing institutional efforts to help students meet graduate profile objectives [14].

The main limitations of this research include the sample size, and the number of programs evaluated, constrained by the testing periods from the second semester of 2014 to 2016 for the TyT test. Additionally, ICFES databases present potential biases, as some students did not take the Saber 11 and Saber Pro tests during the selected periods. Selection bias stemming from high dropout rates in higher education, particularly in technological programs, was also identified. These considerations must be addressed in future analysis to obtain more robust conclusions.

CONCLUSIONS

This study highlights key factors influencing performance in core competencies, emphasizing the positive impact of support programs in areas such as English and Quantitative Reasoning. However, limitations in data availability underscore the need to improve information systems to refine conceptual models and implement effective educational policies.
The findings stress the importance of integrating generic competencies like Written Communication and Citizenship Competencies into the curricula, moving beyond preparation workshops toward embedding these skills in course activities. Variability in student performance suggests a need for targeted support programs, particularly for those with low entry-level results or at academic risk.

Recognizing the diverse academic, economic, and social composition of short-cycle program students is crucial for designing strategies that support their success and meet professional and occupational profile expectations. These insights provide the university with valuable guidance for enhancing retention and graduation quality, supporting accreditation processes.

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