

Using an Expected Loss Function to Identify Best High Schools for Recruitment

Sonia M. Bartolomei-Suárez¹, David González-Barreto² and Antonio A. González-Quevedo³

Abstract - An objective of the strategic plan of the University of Puerto Rico Mayagüez (UPRM) is to identify and attract the best possible prospective students from high schools to the College of Engineering. To address this objective a good first step is to identify the high schools that produce, over a period of years, the students that better executed within our institution. The student performance (SP) at undergraduate level is currently available in databases on the institutional research office. In this work, the SP is combined through indicators to develop an index per high school based on the performance of their students in UPRM College of Engineering. The performance index (PI) is based on the concept of the expected loss function. In this function the actual performance for each indicator is compared against an expected or targeted value. The PI includes the distance between the actual and the targeted performance for all defined indicators, thus the objective is to minimize this index. The better schools will result in indexes that are very low, indicating very good SP for their respective students. The PI is a tool that can be used both by the UPRM admission office and by high schools to do benchmarking among them. This paper presents a case study for the high schools that supply students to the UPRM engineering college for a period of six years. The defined indicators for the case study includes: graduation GPA, average time to degree, and graduation rate.

Index Terms – Prospective students, recruitment, performance index, loss function.

INTRODUCTION

A study of our entering student profile demonstrates that a large number of them come from the Western part of the island of Puerto Rico, our geographic region. (1) The school of engineering is interested in attracting good students from all the geographic areas of Puerto Rico. With this goal in mind, this study was developed to identify the best schools in the island based on the performance of the engineering students in our university.

DESCRIPTION OF ADMISSION CRITERIA

The admission index, which is called the IGS, is composed of the high school grade point average, the verbal aptitude test score and the mathematics aptitude test score from the College Board Entrance Examination. The highest possible

value of the IGS is 400. The weight of the GPA is 50%, while the weight for each of the two aptitude tests is 25%.

Each academic department or program determines each year the minimum value of the IGS for the entering students. In general terms, no other measurement is used to admit a student in the first year of university studies. For the engineer class of 2004-2005, the minimum IGS fluctuated from to 313 for Surveying to 342 for Computer Engineering.

PERFORMANCE OF OUR ENGINEERING STUDENTS IN THEIR HIGH SCHOOLS

This study presents the best high schools, private and public, from the perspective of the student performance at the University of Puerto Rico at Mayagüez. The high schools that were included in the study have sent more than 50 students who have graduated from our School of Engineering in the past ten years (1995-2005). This study was generated using data obtained from the Office of Institutional Research and Planning of our university.

The 15 public high schools that have the greatest number of engineering graduates in the past ten years are shown in Figure 1. The top three schools: CROEM (397 students), Patria Latorre (182 students) and Eugenio María de Hostos (158 students) are in our geographic region, the Western part of Puerto Rico. As a matter of fact, eleven of the fifteen public high schools are located in our geographic region. Only two of the fifteen schools are located in the capital city of San Juan, which is the largest city in Puerto Rico. These schools are the University Gardens High School (146 students) and the High School of the University of Puerto Rico (108 students).

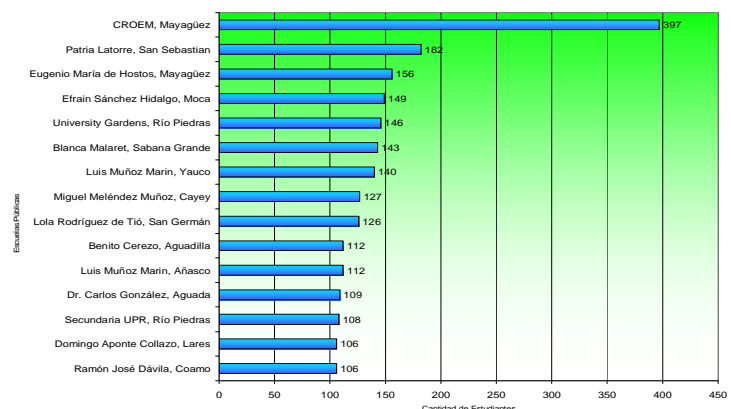


FIGURE 1
FIRST 15 PUBLIC HIGH SCHOOLS WITH 50 OR MORE GRADUATES AT UPRM FOR THE COLLEGE OF ENGINEERING (YEARS 1995-2005).

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The top 15 private high schools that send more than 50 students to the College of Engineering at UPRM who graduate are shown in Figure 2. The top private high school is Notre Dame in the city of Caguas with 262 graduates. In second place is Immaculate Conception High School in Mayagüez with 182 graduates, followed by Colegio San José in Mayagüez with 145 graduates. Eight of the 15 schools are located in the metropolitan area of San Juan.

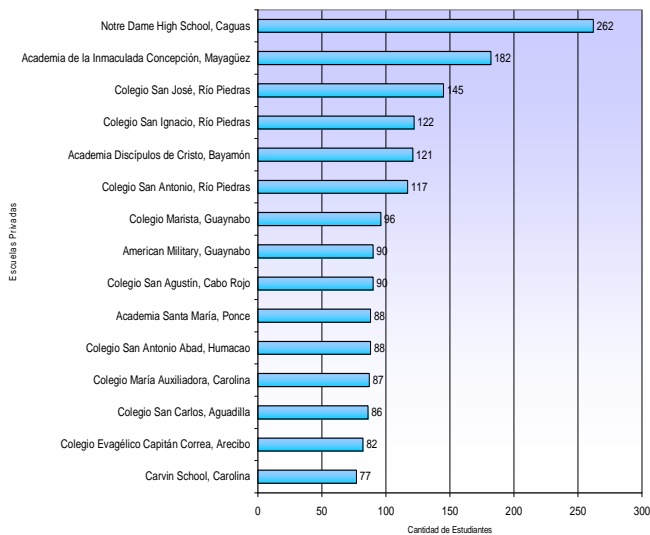


FIGURE 2
FIRST 15 PRIVATE HIGH SCHOOLS WITH 50 OR MORE GRADUATES AT UPRM FOR THE COLLEGE OF ENGINEERING (YEARS 1995-2005)

The top 15 public high schools with the highest admission index (IGS) for students of the College of Engineering at UPRM from 1995-2005 whom graduate are shown in Figure 3. The top public high schools are Antonio Luchetti Vocational School in Arecibo followed by the UPR High School (both with the same IGS of 341 points). Following these two schools are Ramón José Dávila in Coamo, Leonides Morales Rodríguez in Lajas and Emilio R. Delgado in Corozal with an average IGS of 340. These fifteen top public high schools are distributed throughout Puerto Rico.

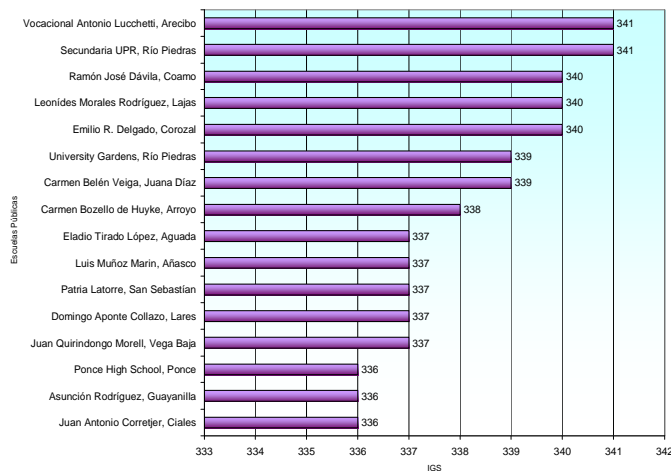


FIGURE 3
PUBLIC HIGH SCHOOLS WITH THE HIGHEST IGS FOR GRADUATES OF THE SCHOOL OF ENGINEERING WITHIN 1995-2005

The top 15 private high schools with the highest admission index (IGS) for students of the College of Engineering at UPRM from 1995-2005 whom graduate are shown in Figure 4. The top two schools are tied with an IGS of 343 and they are Colegio Ponceño in the city of Ponce and San José Academy in the city of Guaynabo. Following is Colegio San Antonio with an average IGS of 342. The cities represented in these 15 schools are Caguas (3), Ponce (3), Guaynabo (2), San Juan (2), and Bayamón, Mayagüez, Carolina, Arecibo, Humacao all with one school.

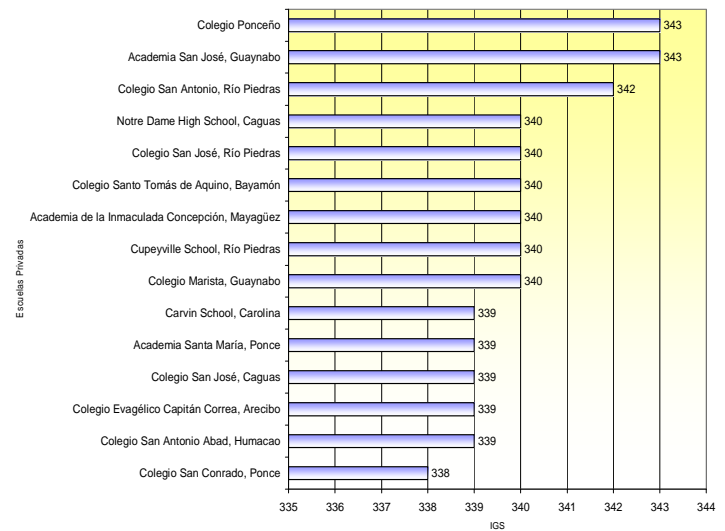


FIGURE 4
PRIVATE HIGH SCHOOLS WITH THE HIGHEST IGS FOR GRADUATES OF THE SCHOOL OF ENGINEERING WITHIN 1995-2005

It can be concluded that the first four charts show high school students characteristics as they enter the university. In the next section, the student performance in the College of Engineering will be analyzed.

PERFORMANCE OF THE STUDENTS AT THE COLLEGE OF ENGINEERING

The top fifteen public high schools with the shortest time to graduate with a bachelor's of science degrees in engineering from 1991-2006 are shown in Figure 5. The top school in this category is the UPR High School in San Juan with 5.59 years. In second place is Ana J. Candelas School in Cidra with 5.65 years. In third place there is a tie with 5.79 years for Ramón José Dávila in Coamo with Patria Latorre School in San Sebastián. Among the fifteen top public high schools in this category, two are from the metropolitan area of San Juan, five are from the Western region, three are from the Southern region, four are from the Central region, and one from the Eastern region.

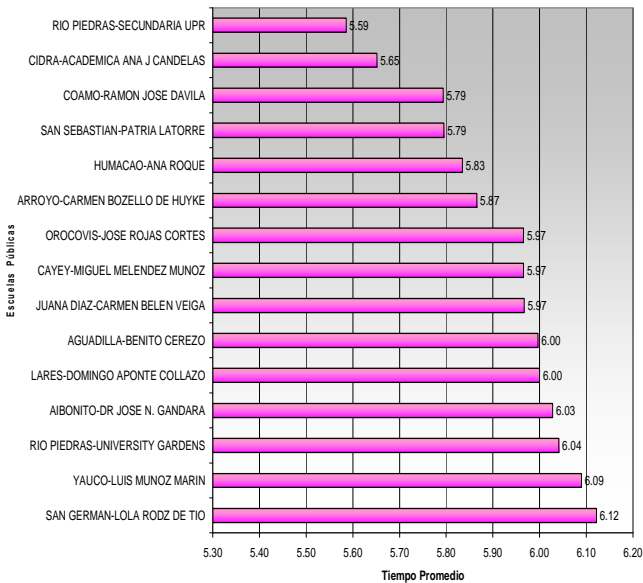


FIGURE 5

TOP 15 PUBLIC HIGH SCHOOLS WITH THE LOWEST AVERAGE TIME TO COMPLETE THE BACHELOR'S DEGREE IN ENGINEERING (1991-2006)

The top fifteen private high schools with the shortest time to graduate with a bachelor's of science degrees in engineering from 1991-2006 are shown in Figure 6. The shortest time belongs to Colegio San Antonio Abad in Humacao with 5.48 years. In second place is Colegio San Conrado in Ponce with 5.52 years and in third place is Colegio Espíritu Santo in San Juan with 5.55 years. Among the fifteen top private high schools in this category, six are from the metropolitan area of San Juan, three are from the Western region, three are from the Southern region, two are from the Central region, and one from the Eastern region.

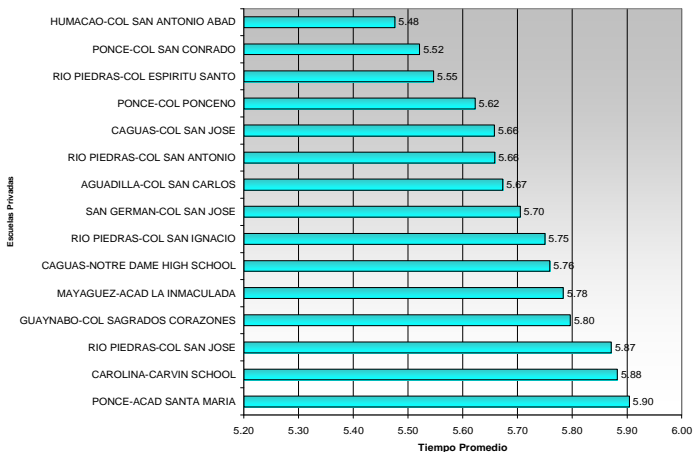


FIGURE 6

TOP 15 PRIVATE HIGH SCHOOLS WITH THE LOWEST AVERAGE TIME TO COMPLETE THE BACHELOR'S DEGREE IN ENGINEERING (1991-2006)

The top fifteen public high schools that showed the highest UPRM graduation grade point average (GPA) for students who entered the Faculty of Engineering and graduated from it (1991-2006) are shown in Figure 7. In first place is the UPR High School with an average GPA of 3.22. In second place is Lola Rodríguez de Tió School in San Germán with an average GPA of 3.13 and in third place is

Domingo Aponte Collazo School in Lares with an average GPA of 3.07. Among the 15 public high schools with the highest UPRM graduation GPA, two are from the metropolitan area of San Juan, eight are from the Western region, two are from the Southern region, two are from the Central region, and one from the Eastern region.

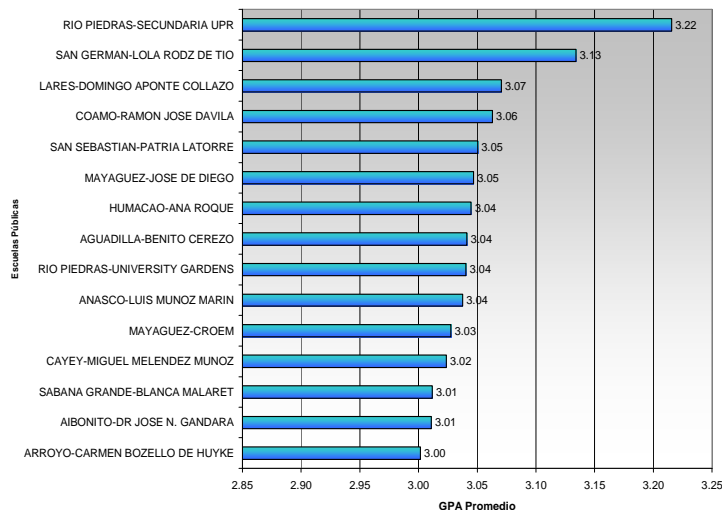


FIGURE 7

TOP FIFTEEN PUBLIC SCHOOLS WITH HIGHEST UPRM GRADUATION GRADE POINT AVERAGE (GPA) FOR STUDENTS FROM PUBLIC HIGH SCHOOLS WHO ENTERED THE FACULTY OF ENGINEERING (1991-2006)

The top seventeen private high schools that showed the highest UPRM graduation grade point average (GPA) for students who entered the Faculty of Engineering and graduated from it (1991-2006) are shown in Figure 8. The top private school in this category is Colegio Espíritu Santo in San Juan with an average GPA of 3.23. In second place for this category is Colegio San Carlos in Aguadilla tied with Immaculate Conception Academy in Mayagüez with an average UPRM graduation GPA of 3.21. Among the 17 private high schools with the highest UPRM graduation GPA, six are from the metropolitan area of San Juan, five are from the Western region, three are from the Southern region, two are from the Central region, and one from the Eastern region.

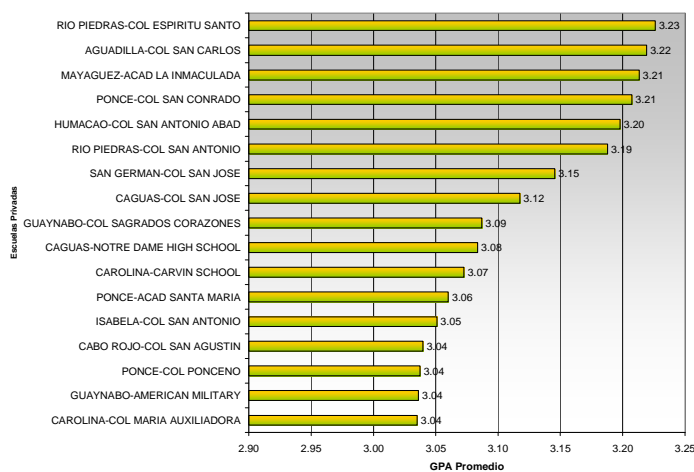


FIGURE 8

TOP SEVENTEEN PRIVATE SCHOOLS WITH HIGHEST UPRM GRADUATION GRADE POINT AVERAGE (GPA) FOR STUDENTS FROM PRIVATE HIGH SCHOOLS WHO ENTERED THE FACULTY OF ENGINEERING (1991-2006)

The top fifteen public high schools with the highest UPRM graduation rates for students who entered the Schools of Engineering in the cohorts of 1991-1997 are shown in Figure 9. The first public high school in this category is Patria Latorre School in San Sebastián with a graduation rate of 83.56%. In second place is the UPR High School in San Juan with a graduation rate of 82.46%. In third place is Efraín Sánchez Hidalgo School in Moca with a graduation rate of 80%. Among the top fifteen public high schools with highest graduation rates, two are from the metropolitan area of San Juan, nine are from the Western region, one is from the Southern region, two are from the Central region, and one from the Eastern region.

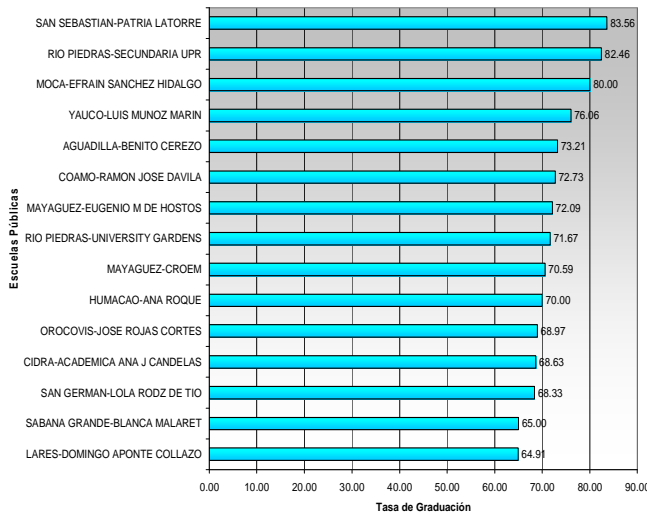


FIGURE 9

TOP FIFTEEN PUBLIC HIGH SCHOOLS WITH THE HIGHEST UPRM GRADUATION RATES FOR STUDENTS WHO ENTERED THE SCHOOL OF ENGINEERING IN THE COHORTS OF 1991-1997

The top fourteen private high schools with the highest UPRM graduation rates for students who entered the Schools of Engineering in the cohorts of 1991-1997 are shown in Figure 10. In first place in this category is Colegio San Conrado in Ponce with a graduation rate of 93.02%. In second place is Immaculate Conception Academy in Mayagüez with a graduation rate of 90.18% and in third place is Santa María Academy in Ponce with a graduation rate of 82.50%. Among these fourteen private schools with highest UPRM graduation rates, seven are from the metropolitan area of San Juan, one is from the Western region, two are from the Southern region, one is from the Central region, and one from the Eastern region.

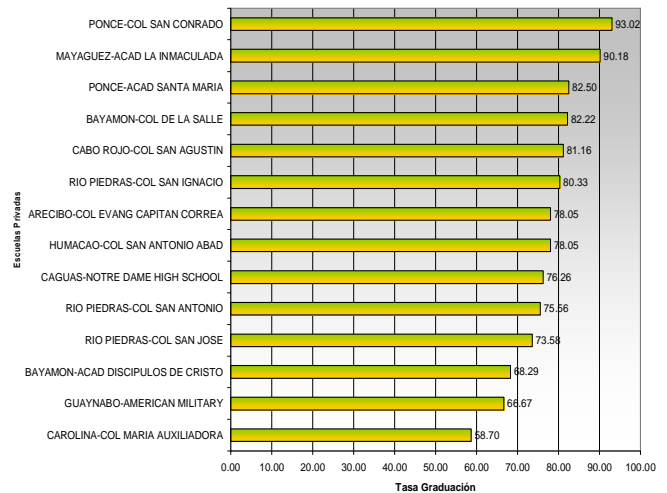


FIGURE 10

TOP FOURTEEN PRIVATE HIGH SCHOOLS WITH THE HIGHEST UPRM GRADUATION RATES FOR STUDENTS WHO ENTERED THE SCHOOL OF ENGINEERING IN THE COHORTS OF 1991-1997

The previous six charts are related to time to graduate, graduation grade point average and graduation rate. These three indicators will be combined in the next section to develop a performance index (PI) that will allow ratings of these high schools.

PERFORMANCE INDEX USING QUADRATIC LOSS FUNCTION

The concept of quadratic loss function has been proposed by Phadke [2] to approximate quality losses. One can develop a performance index (PI) to compare high schools through the execution of their students at the high level institutions. The quadratic loss function is given by

$$\text{Loss}(y) = k (y - T)^2 \quad (1)$$

where k is a proportionality constant and T is the target value for the y characteristic. Usually in quality control applications a tolerance Δ is defined such that if the y characteristic is within $T \pm \Delta$ (two sided tolerance) the characteristic is acceptable. The quadratic loss function in (1) penalizes the behaviors that deviate from the target T . A challenge with (1) is the definition of constant k . Artiles-León [3] defined this value to assure that the loss function is insensitive to the system of units used to measure the quality characteristic y . For the two sided tolerance problem this definition becomes:

$$k = \left(\frac{2}{2\Delta} \right)^2 \quad (2)$$

Using k in (2) results in a “standardized” loss function. Since the standardized version of the loss function is dimensionless if several quality characteristics are considered their correspondent loss functions can be added.

In our case study, the quality characteristics or critical indicators that we are considering are: the average

time to degree, the average graduation GPA and graduation rates for the high schools under consideration. These characteristics are not suited for the two sided tolerance approach. The first one, average time to degree, can be described better as a smaller-the-better characteristic, while the other two average GPA, and graduation rate of a higher-the-better characteristic form. Expanding the standardized concepts to one-sided tolerance characteristics the following two equations can be derived for smaller-the-better (3) and higher-the-better (4).

$$S_{Loss}(y) = \frac{y^2}{\Delta^2} \quad (3)$$

$$S_{Loss}(y) = \frac{\Delta^2}{y^2} \quad (4)$$

A total standardized loss (*TSLoss*) for our case study can be defined as:

$$TS_{Loss} = \frac{y_1^2}{\Delta_1^2} + \frac{\Delta_2^2}{y_2^2} + \frac{\Delta_3^2}{y_3^2} \quad (5)$$

where y_i , and Δ_i corresponds to the characteristic and tolerance for the critical indicators.

The *TSLoss* in (5) could be generalized to m characteristics and can combine one and two sided tolerance characteristics. *TLoss* can be viewed as a performance indicator for high schools as represented by their students execution. The lower performance index the better the students performance at the university, the better the high school. Applying (5) to institutional research data for high schools that provide the largest number of students to our engineering college for the last 10 years the following estimates in Table 1 are obtained.

TABLE 1
RATINGS OF HIGH SCHOOLS BASED
ON PERFORMANCE OF INDEX

High School	Performance Index
Colegio San Conrado, Ponce	3.250182
Academia de la Inmaculada Concepción, Mayagüez	3.376351
Secundaria UPR, Río Piedras	3.569336
Colegio San Antonio Abad, Humacao	3.737924
Patria Latorre, San Sebastian	3.74815
Academia Santa María, Ponce	3.796827
Colegio San Antonio, Río Piedras	3.893357
Notre Dame High School, Caguas	3.995966
Ramón José Dávila, Coamo	4.195212
Benito Cerezo, Aguadilla	4.237077
University Gardens, Río Piedras	4.326681
Ana Roque, Humacao	4.376365
Lola Rodríguez de Tió, San Germán	4.440817
Domingo Aponte Collazo, Lares	4.711063

FINDINGS AND CONCLUSIONS

FUTURE WORK

The suggested performance index, based on the *TSLoss*, should include additional critical indicators. We suggest

exploring the following indicators, average GPA math courses, average GPA science courses, average GPA language courses, attempted credits, among others. A limitation of the described performance index is that it does not take into account the correlations among the critical indicators variables considered. Future work should consider techniques such as the *Mahalanobis Distance* to incorporate such relationships.

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