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VISIÓN ELECTRÓNICA

A CURRENT VISION

Predictive model of risk management in the course of integral calculation of the Industrial Engineering Program for Universidad El Bosque in the process of student desertion

Modelo predictivo de gestión del riesgo en el curso de cálculo integral del Programa Ingeniería Industrial para la Universidad El Bosque en el proceso de la deserción estudiantil

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ABSTRACT

The research conducted evidences the creation of a predictive statistical model for student risk management, characterizing the students of Engineering of Universidad El Bosque, with the objective of predicting the probability of loss of the subject and desertion of the students of the course of Integral Calculus; This model required the construction of two forms which were filled out by the entire selected sample, for this the statistical technique used was Factor Analysis by Optimal Scaling, method which generated the vector of reduced dimensions collecting 80% of the most relevant information for the study, thus showing the variables with greater significance for the model. Among the most outstanding results of the research of the predictive model is the diagnosis of the student's risk status by cutting, both preventive and corrective strategies for academic improvement and mitigation of academic loss during integral calculus of engineering students at Universidad El Bosque.

RESUMEN

La investigación realizada evidencia la creación de un modelo estadístico predictivo para la gestión de riesgo estudiantil, caracterizando a los estudiantes de Ingeniería de la Universidad El Bosque, con el objetivo de predecir la probabilidad de pérdida de la asignatura y deserción de los estudiantes del curso de Cálculo Integral; dicho modelo requirió construir dos formularios los cuales fueron diligenciados por toda la muestra seleccionada, para ello la técnica estadística empleada fue Análisis Factorial por Escalonamiento Óptimo, método el cual generó el vector de dimensiones reducidos recogiendo el 80% de la información más relevante para el estudio, evidenciando así las variables con mayor significancia para el modelo. Dentro de los resultados que más se destacan de la investigación del modelo predictivo es el diagnóstico del estado de riesgo del estudiante por corte, las estrategias tanto preventivas como correctivas para el mejoramiento académico y mitigación de la pérdida académica en el curso de cálculo integral de los estudiantes de ingeniería de la Universidad El Bosque.

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1. Introduction

In the new era of knowledge, technological changes, and the generation of new paradigms of teaching and learning, converge with the coexistence of new generations, conditioned by cognitive, economic, academic and institutional processes, which eventually contribute positively or negatively to the decision to abandon or prolong university studies.

For the Ministry of National Education (MEN) as the governmental axis of the country, risk management refers to the principles and methodology for effective risk management, while risk management refers to the application of these principles and methodology to particular risks. Risk management comprises the set of control elements and their interrelationships, so that the institution can evaluate and intervene in those events, both internal and external, that may positively or negatively affect the achievement of its institutional objectives.

For the above the Universidad El Bosque with the formulation of the Development Plan 2016 -2021, within the Strategic Objective number 3 stipulates to train the student with excellence and relevance, highlights the importance of desertion and raises it as one of its goals that is "at the end of 2020 the population of new first semester students at risk of desertion due to academic performance may not exceed 10% of the total cohort.

1.1. Identification of determinant variables of university dropout.

Various attempts have been made to construct theoretical models on the phenomenon of university dropout. For the MEN in its paper "Student desertion in Colombian Higher Education: Follow-up methodology, diagnosis and elements for its prevention", 4 important factors are recognized that propel the student to abandon the career, in a specific period of time, in a first pillar and based on authors such as Spady (1970), Tinto (1975) and Bean (1980), the individual factors, such as psychological, social interaction, family environment, inappropriate attitudes towards learning, the low cognitive development of the student, originate a first initial moment that leads the student to become frustrated in the educational process [1-3].

In relation to academic factors, Tinto (1975), Spady (1970) and Escandell, Marrero and Castro (2002), highlight the pedagogical deficiencies, among them the

lack of clarity in the presentation of the subject, the scarce professional orientation, a loaded number of subjects, the lack of reflection on the subject and critical judgments; The lack of mastery of the subject taught, the lack of individualized attention to the students and the lack of teaching vocation in the last case, are characteristics that permeate the decision of the students to drop out of the academic program [1], [2], [4].

Adelman (1999) proposes a model based on the previous theories but adds the existence of institutional factors, which are of great importance in the educational process, here he frames support such as scholarships or forms of financing, academic support, psychological support and interaction with teachers and administrative staff, which show the social work of the Educational Institution in favor of the educational success of the student [5].

Finally, the socioeconomic factors, emphasize the student's work situation, the economic situation of the parents, the number of dependents, the educational level of the parents and the macroeconomic environment of the country, which are decisive elements at the time of remaining or abandoning university studies [6-8].

All these data show how dropping out of higher education is a multi-causal phenomenon as suggested by Yoder (2005), but whatever the origin, the high dropout rates are currently one of the alarming problems that must be addressed if the quality of university education is to be improved. This is the fundamental motivation for carrying out this research [9].

2. Methodology

This study has a quantitative approach of empirical-analytical type that allowed collecting data on trends, attitudes, and perceptions of students to stay or leave the subject of Integral Calculus in which they were enrolled. The research used a model as a theoretical framework, and purposive non-probabilistic sampling was used for the statistical analysis [10]. The identified population consisted of 34 students enrolled in Engineering in 2021-1, with an expected response rate of 98% who answered the instruments designed for the study.

The final sample consisted of 33 people, where 51% (17 people) of the sample was represented by the female gender while 49% (16 people) responded to the male gender. The age ranges of the participants were as follows: from 16 to 20 years old (27 students), between

the ages of 21 to 25 (6 students), between 26 and older (1 student).

2.1. Objectives

- To identify the factors related to the events of student desertion for the Industrial Engineering Program of the Universidad El Bosque in the subject of Integral Calculus.
- Characterize the profile of the student at risk of the subject of Integral Calculus in the Industrial Engineering program at the Universidad El Bosque.
- To develop a predictive model that incorporates relevant factors in student desertion, generating the indicator of risk of loss per student from the three dimensions of meaningful learning student-teacher-knowledge.

2.2. Design and Hypothesis

Taking into consideration the model that presents crucial factors that influence student dropout, and complementing additional elements raised in the literature [10], the following working hypothesis was designed:

What are the attrition factors with the highest correlation against the risk probabilities given by the predictive model of risk management in the subject of Integral Calculus?

H₀ = All attrition factors have a direct relationship with the probability of losing the course.

H₁ = Only academic factors have a direct relationship with the probability of losing the subject.

The design of the study under the protection of an analytical empirical methodological procedure, requires studying the total, or a sample extract, of a time cohort chosen in this case 2021-1. Secondly, after determining the values of the dependent variable (in our case it was students who lose, drop out and/or prolong their studies), the single group is divided according to these values, to establish comparative intergroup relationships with the independent variables.

The variables under study, some as causal factors and others as effects, were as follows:

- Dependent variable or criterion. It is presented as a quantitative variable with three levels: low risk, medium risk, high risk of dropping out of school. This is the condition on the basis of which it will allow comparison with the risk that students naturally intuit.
- Independent variables or determining factors. They are all presented as quantitative variables, with two response indicators: yes, more yes than no, more no than yes, and definitely no. These, in principle, are grouped around five factors: personal, economic, academic, and institutional, including teacher characteristics. These, in principle, are grouped around five factors: personal; economic; academic and institutional, including the characteristics of the teaching staff. In the results section you can see the relationship of each one of them.

2.3. Reliability of the Instrument.

An analysis was conducted for each variable using the statistical package SPSS Statistics 24 (Statistics Package for the Social Sciences) for its meaning in Spanish Statistical Package applied to the Social Sciences. To present the information related to each of the research questions, descriptive statistics, i.e., mean, and standard deviation among others, were performed. A multiple factor analysis was also performed to determine the main factors that influence each of the variables, i.e., personal or background, economic, academic interaction, institutional interaction, and classroom perception.

Analyzing the coefficient of internal consistency in the study, to indicate the reliability of the instrument the value of Cronbach's Alpha coefficient in the scale is 0.944 equivalent to 94.4% indicating a high correlation, a high level of stability in the answers, so the questionnaire presents indications of high reliability guarantees for the study.

2.4. Percentage Risk Equation

The mathematical model is responsible for estimating and predicting the trend of the student either to mention the high risk of loss or low risk during the subject of Integral Calculus, the index will change as the respective appropriate strategies are carried out to reduce the dropout due to cut off.

$$D_1 = \frac{0.6(I.A.R.PERFIL DEL ESTUDIANTE + I.A.R. ACTIVIDADES EN EL AULA + I.A.R EVALUACION DOCENTE)}{(CANTIDAD DE ITEMS)}$$

$$D_1 = \frac{0.6((\sum + \alpha + \mu + \delta) + (\beta + \lambda + \vartheta + \phi + \Upsilon) + (\omega + \sigma + \rho + \theta + S))}{\vartheta}$$

$$D_1 = \frac{0.6(9+8+5+6+7+9+10)}{42+5+4+30} = \frac{32,6}{110} = 0,29636$$

$$\{D_1 \geq 0.29636 \quad \text{posible desertor} \quad D_1 < 0.29636 \quad \text{posible no desertor}\}$$

Equation 1. Risk equation with teaching factor.

The construction of the equation depends on 110 coefficients, where they are broken down as follows: the first 16 items were aimed at identifying the personal data of the participating students, the next 14 items were aimed at identifying the economic data of the participating students, the consequent 6 items were aimed at identifying the student's stance on institutional characteristics, the next 10 items were aimed at identifying the academic data of the participating students, eventually the student's perception of the teacher is recognized through the first 12 self-evaluation items, the following 12 items aimed at evaluating the teacher in his or her Knowing, the Being in the classroom (18 items), and finally in his or her Teaching (19 items), 110 items designed to be answered using a Likert scale that varied with respect to the associated question.

In order to categorize the responses and subsequently interpret each item based on the predictive model built correlates the probability of losing or dropping out of the subject, the following scale was used statistically establishing the ranges between the following items to the response of the individual who is located in the characteristics of a dropout person giving a weight of 0.6 (High Risk of loss) while in the opposite case will have a reactive weight of 0.1 (Low Risk of loss).

2.5. Data collection procedure and instrument

The purpose of the research was to identify the factors that influence the student's decision. In such a way that a Google Forms instrument was constructed and administered to students via email through the Moodle

educational platform. The procedure used to collect the information that allowed answering the research questions was developed as follows:

1. A bibliographic review of the literature related to the variables under study was carried out at both national and European and American levels.
2. The model of student attrition was identified with greater appropriation, to group the variables that influence the student's decision in face-to-face and distance courses [10].
3. Based on the literature analyzed on the subject, the items were statistically assigned for each of the variables of the instrument, from which a first model of the questionnaire was elaborated. Eventually, the instrument was submitted to the assessment of judges with the collaboration of a group of experts (directors, coordinators, and deans of various faculties); the judges eliminated some items and reagents and identified other indicators that, based on their experience, they considered to influence the abandonment and prolongation of their students' studies.
4. In a second moment, the redesigned research instrument was submitted, reviewed, and approved under the criteria of coherence, relevance and pertinence of each of the items by the panel of experts, which consequently allowed the piloting with the experimental group through information and communication technologies (ICT).

5. The identified sample received via email and access to the courses in the Moodle educational platform, an informative message about the purpose of the study, the informed consent to participate in the study and the URL where the questionnaire was located. To ensure the participation of as many students as possible, a letter was included explaining the importance of the voluntary nature of their participation in the survey.

Therefore, the questionnaire was structured with information related to:

- Personal data.

- Socioeconomic data.
- Academic data.
- Institutional data, including the perception of teaching competencies through the course of class sessions, intuition of academic risk.

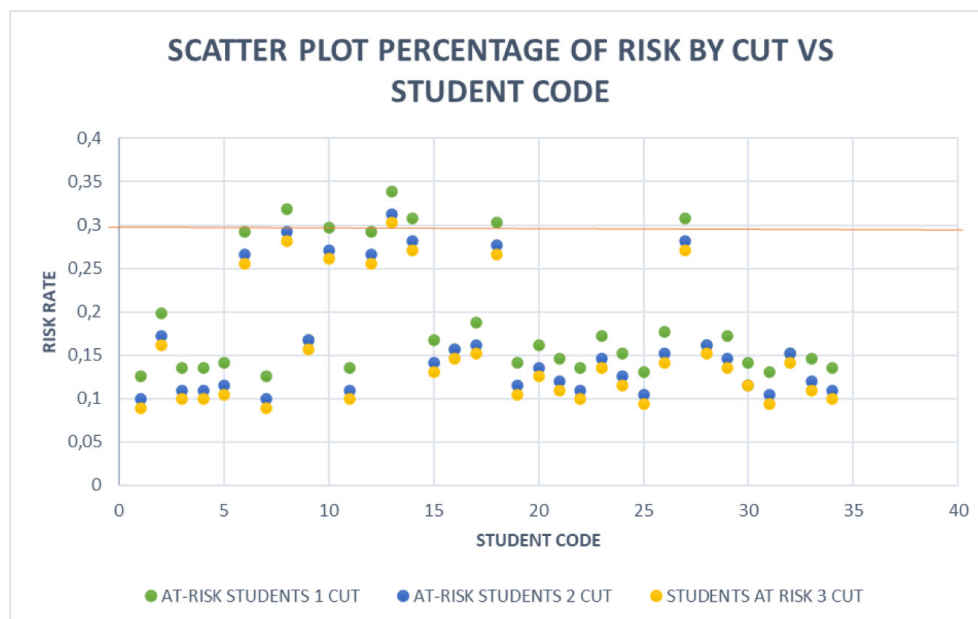
2.6. *Application of the model in Integral Calculus 2021-1*

The following will be observed the summary table of the risk of the three cuts in the subject of Integral Calculus 2021-1 of the Industrial Engineering program of the Universidad El Bosque.

Table 1. Table of risk coefficients per student in the 3 cuts.

STUDENT NUMBER	AT-RISK STUDENTS 1 CUT	AT-RISK STUDENTS 2 CUT	STUDENTS AT RISK 3 CUT
1	0,125217391	0,099130435	0,088695652
2	0,19826087	0,172173913	0,16173913
3	0,135652174	0,109565217	0,099130435
4	0,135652174	0,109565217	0,099130435
5	0,140869565	0,114782609	0,104347826
6	0,292173913	0,266086957	0,255652174
7	0,125217391	0,099130435	0,088695652
8	0,31826087	0,292173913	0,28173913
9	0,166956522	0,166956522	0,156521739
10	0,297391304	0,271304348	0,260869565
11	0,135652174	0,109565217	0,099130435
12	0,292173913	0,266086957	0,255652174
13	0,339130435	0,313043478	0,302608696
14	0,307826087	0,28173913	0,271304348
15	0,166956522	0,140869565	0,130434783
16	0,156521739	0,156521739	0,146086957
17	0,187826087	0,16173913	0,151304348
18	0,302608696	0,276521739	0,266086957
19	0,140869565	0,114782609	0,104347826
20	0,16173913	0,135652174	0,125217391
21	0,146086957	0,12	0,109565217
22	0,135652174	0,109565217	0,099130435
23	0,172173913	0,146086957	0,135652174
24	0,151304348	0,125217391	0,114782609
25	0,130434783	0,104347826	0,093913043
26	0,177391304	0,151304348	0,140869565
27	0,307826087	0,28173913	0,271304348
28	0,16173913	0,16173913	0,151304348
29	0,172173913	0,146086957	0,135652174
30	0,140869565	0,114782609	0,114782609
31	0,130434783	0,104347826	0,093913043
32	0,151304348	0,151304348	0,140869565
33	0,146086957	0,12	0,109565217
34	0,135652174	0,109565217	0,099130435
Calculated threshold		0,29636913	

Source: own.

Figure 1. Dispersion of at-risk students by cut vs. student code.

Source: own.

The decrease of the academic loss for the course of Integral Calculus 2021-1, had a descending order starting with a percentage of loss for the first cut of 24% equivalent to 8 students out of a total of 33, so then the model generates the diagnosis of students who have a high risk of losing the course either by external variables to the classroom both personal, economic, and institutional or by internal factors in the teaching-learning process as are the teaching skills which are also subject to monitoring within the predictive model.

Eventually, when generating the diagnoses of the students after the first cut, strategies are generated in two categories, both preventive and corrective, registered in the Observatory of Student Success, which, if and only if they are carried out by the teacher in charge of the course, modifying to a certain extent his/her teaching work, generate improvements or decrease in the percentage of loss, as it was evidenced in this experimental group of Integral Calculus.

For the second cut the percentage of risk of loss was minimized to 6% equivalent to 2 students therefore a reduction of 18% of students in loss, eventually the model is applied for the third cut and finally the last preventive and corrective strategies put into action by the teacher are generated generating a final reduction to 3% therefore only 1 student at risk of loss, student

who was given tutorials in class in such a way that he was conditioned for before the final partial achieving acquire the minimum skills for the next course of Vector Calculus, ultimately a percentage of 90% risk mitigation in the course of Integral Calculus through the predictive model of risk management (see tables by cut).

Finally, a socialization was made to the students of greater risk of loss in the course on the accompaniment and the tutorials provided by the academic and the relevance of the strategies used, where it was evidenced under the concept of each of the students that they have seemed innovative, important and relevant the existence of the model and the application not only in this course of Integral Calculus but in others if possible.

Unlike the course of Integral Calculus 2016-2 directed by the same teacher only attacked the problem of low academic performance through a tutoring plan, which did not generate the expected results of minimizing the risk of loss yielding a total of 20% of the group of students who lost the subject and therefore should retake it.

3. Results

To answer this research hypothesis, using the optimal scaling technique for nonlinear canonical correlation, the following summary of the analysis is obtained.

Table 2. Summary of the optimal scaling analysis.

		Dimension		Sum
		1	2	
Losses	Set 1	,056	,094	,151
	Set 2	,115	,076	,192
	Set 3	,169	,497	,666
	Set 4	,196	,304	,500
	Set 5	,070	,141	,210
	Set 6	,210	,068	,278
	Set 7	,016	,108	,124
	Set 8	,020	,041	,062
	Media	,107	,166	,273
Eigenvalue		,893	,834	
Setting				1,727

Source: own.

In this analysis summary, OVERALS shows the fit and loss for each set in each dimension. The sum of the losses for dimension 1 and dimension 2 should match.

The average loss per dimension indicates a relatively minimal loss (0.273). The test fit represents an adequate value (1.727) and the eigenvalues (0.893 and 0.834) show a somewhat higher distribution of model variance explanation loadings in dimension 2 than in dimension 1.

Based on the non-linear canonical correlation analysis for non-parametric tests, only the factors with significance level according to the 2 dimensions of the model were related in this chapter of results. $p < 0.5$ according to the 2 dimensions of the model, in order to synthesize the most relevant parameters that explain the variance of the research data that influence the risk of loss or dropout of the Integral Calculus subject of the Industrial Engineering program.

3.1. Personal Factors

The first of the categories that, according to the model, affects the student's decision to stay or drop the subjects corresponds to personal or background factors.

Table 3. Adjustments by dimension versus personal factors.

Establish		Multiple adjustment Dimension			Simple adjustment Dimension			Simple loss Dimension		
		1	2	Sum	1	2	Sum	1	2	Sum
1	Respondent's age	,011	,029	,039	,011	,029	,039	,000	,000	,000
	Gender of respondent	,001	,456	,457	,001	,456	,457	,000	,000	,000
	Disability	,317	,138	,455	,311	,123	,434	,006	,015	,021
	Feeling demotivated all the time	,052	,000	,052	,052	,000	,052	,000	,000	,000
	Has emotional problems	,073	,537	,610	,068	,537	,605	,004	,001	,005
	Adaptation to virtual learning environments in Moodle	,187	,068	,255	,187	,068	,255	,000	,000	,000
	Ethnic Group	,215	,157	,371	,215	,157	,371	,000	,000	,000
	Taste for the course to be taken	,010	,181	,191	,010	,181	,191	,000	,000	,000
	Close death in the family	,001	,001	,001	,001	,001	,001	,000	,000	,000
	Use of hallucinogens or alcoholic beverages	,157	,970	1,127	,154	,969	1,123	,003	,000	,003
	Social Integration	,031	,039	,070	,031	,039	,070	,000	,000	,000
	Marital Status of Parents	,004	,154	,159	,004	,154	,159	,000	,000	,000
	Professional level of parents	,163	,062	,225	,163	,062	,225	,000	,000	,000
	Family Environment	,129	,871	1,000	,129	,871	1,000	,000	,000	,000

Source: own.

Among these are emotional problems (Adjustment of 0.537 in dimension 2), the use of hallucinogens (Adjustment of 0.970 in dimension 2) or alcoholic beverages and the family environment (Adjustment of 0.871 in dimension 2), factors of greater significance in the factor analysis that are explained below:

The question that was asked to the students related to the group of personal or background variables was

to indicate if they had emotional problems. The options presented were stress, indecision, lack of responsibility, laziness or none. A 47.1% reported having stress. While, both indecision or lack of academic responsibility 8.8% reported suffering from this issue, 11.8% of respondents referred to feeling laziness continuously and finally 23.5% reported not suffering from any emotional problem of any kind mentioned in the test. According to Sánchez Navarro (2009), one of the personal factors that most

affect the student process are the emotional problems that afflict the human being and attenuate the vision of the achievements or goals to be reached, a variable that stands out in the study of this group of students [11].

Another question that was asked to the students related to the personal variables was to indicate if they actively consumed hallucinogens or alcoholic beverages. The options presented were cigarette, beer, schnapps, or none. A total of 2.9% reported smoking cigarettes. Meanwhile 20.6% reported drinking beer, 11.8% of the respondents referred to drinking aguardiente and finally 64.7% reported no hallucinogenic consumption or drink mentioned in the test. According to Spady (1970), consuming alcohol could be one of the relevant factors to take into account that hinder the student's attachment to the university, finally causing the desertion, as for this sample of students statistically is one of the causative factors for potential student desertion [1].

Finally, as part of the personal or background variables with the highest correlation with the risk management model, the participants were asked about the type of family environment in their homes. Some 5.9% of the students indicated that their family environment suffered

from problems of family disunity, 20.6% responded that they had slight problems in the family environment and finally 73.5% reported that their family environment was united. According to the MEN (2009) mentions that many individuals face barriers such as the absence of a favorable family environment that make it difficult for them to achieve their goals, a variable that is evident from the psychological point of view of the student [12].

3.2. Economic Factors

For the second category of variables, items related to the situation of the students were considered on the following aspects: socioeconomic stratum, dependents, salary income, family economic support, has EPS, ARP or social security, and topics associated with digital culture such as access to a computer with internet connection or time spent connected to the social network, among others. For this variable it is recalled that only the questions with a significance level greater than 0.5 in the associated dimension were related in these aspects of results to synthesize the most relevant economic factors of the research that influence the risk of loss or abandonment of the subject of Integral Calculus of the Industrial Engineering program.

Table 4. Adjustments by dimension versus economic factors.

Establish		Multiple adjustment Dimension			Simple adjustment Dimension			Simple loss Dimension		
		1	2	Sum	1	2	Sum	1	2	Sum
2	Socioeconomic Stratum	,840	,022	,862	,840	,017	,857	,000	,005	,005
	Head of Household	,004	,017	,021	,004	,017	,021	,000	,000	,000
	Persons in Charge	,229	,184	,413	,228	,184	,412	,001	,001	,001
	Currently working	,009	,297	,307	,009	,297	,307	,000	,000	,000
	Salary income	,343	,202	,545	,343	,202	,545	,000	,000	,000
	Family Financial Support	,080	,045	,125	,080	,045	,125	,000	,000	,000
	Business financial support	,412	,118	,530	,411	,115	,526	,001	,003	,004
	Type of training of your co-workers	,001	,003	,004	,001	,003	,004	,000	,000	,000
	Are you a member of a cooperative?	,044	,036	,080	,044	,036	,080	,000	,000	,000
	Do you have EPS, ARP or Social Security?	,000	,000	,000	,000	,000	,000	,000	,000	,000
	Own a smart cell phone with internet	,082	,027	,109	,082	,027	,109	,000	,000	,000
	How long you stay connected to the network	,338	,008	,346	,338	,008	,346	,000	,000	,000
	How long you stay connected to social networks	,212	,002	,214	,212	,002	,214	,000	,000	,000
	Time compatibility between work and study	,001	,124	,125	,001	,124	,124	,001	,000	,001

Source: own.

Within these possible factors, the most significant was the socioeconomic stratum, whose descriptive statistics are mentioned below:

The most relevant distribution that correlates directly with the risk indexes of loss of the subject was associated with the socioeconomic stratum, question to which students mostly responded to be in middle strata 3 and 4 associated percentage 35.3% and 44.1% respectively, followed by strata 2, 1, 5 and 6 equivalents to 5.9%, 2.9%, 8.8% and 2.9% respectively. Vásquez and Rodríguez (2007) and the MEN (2009) as external causes that should be taken into account and have a considerable impact on dropout are the low economic

resources of the student, i.e. the impossibility of acquiring all the necessary elements to access the learning goal, permeating all the subjects of the current semester [12], [13].

3.3. Institutional Factors

For the third category of variables, questions related to the students' perception of the following aspects were considered: reasons for choosing the university, academic support, problems with teachers and administrators, professional advice when choosing a career, and philosophical or normative aspects of the university.

Table 5. Adjustments by dimension to the institutional factors.

Establish		Multiple adjustment Dimension			Simple adjustment Dimension			Simple loss Dimension		
		1	2	Sum	1	2	Sum	1	2	Sum
3	Did you choose Universidad El Bosque for its high-quality accreditation?	,333	,133	,466	,328	,117	,445	,006	,016	,021
	Previous problems with teachers and administrators	,207	,230	,437	,207	,230	,437	,000	,000	,000
	The course syllabus is considered adequate	,184	,113	,298	,184	,113	,298	,000	,000	,000
	Had professional advice when choosing the course	,056	,054	,109	,056	,054	,109	,000	,000	,000
	Has problems with regulatory aspects of the University.	,040	,044	,084	,040	,044	,084	,000	,000	,000

Source: own.

For this variable there are no relevant factors for the research that influence the risk of loss or abandonment of the Integral Calculus subject of the Industrial Engineering program.

Table 6. Adjustments by dimension to the academic factors.

Establish		Multiple adjustment Dimension			Simple adjustment Dimension			Simple loss Dimension		
		1	2	Sum	1	2	Sum	1	2	Sum
4	Repetition in other courses	,009	,013	,022	,009	,013	,022	,000	,000	,000
	Icfes or ECAES Results	,013	,011	,024	,013	,011	,024	,000	,000	,000
	Choosing the right course	,167	,103	,270	,167	,103	,270	,000	,000	,000
	It has a space for self-study.	,001	,041	,042	,001	,041	,042	,000	,000	,000
	How much time do you have per day to study independently?	,008	,762	,771	,008	,762	,771	,000	,000	,000
	A possible study schedule could be daytime or evening.	,057	,323	,380	,057	,323	,380	,000	,000	,000
	Could carry out work or projects collaboratively	,114	,022	,136	,114	,022	,136	,000	,000	,000
	Academic performance in previous virtual courses	,316	,097	,413	,299	,093	,393	,017	,004	,020

Source: own.

3.4. Academic factors

For the fourth category of variables, items related to students' perception of the following aspects were

considered: receiving academic counseling services, academic support in terms of course quality, study habits in terms of study skills and abilities, state test results, and course availability in terms of selection.

The most relevant distribution that correlates directly with the risk indexes of loss of the subject was associated with the time to study autonomously, question to which the students 58.8% responded to have less than 2 hours a day to study, while 38.2% of students mentioned having more than 2 hours a day to study, one student said he had no time to study. According to Díaz (2009) the effort in autonomous learning by the student is vital in the time where he is not accompanied by the teacher, to enhance the concepts seen in class and get to have a more structured criterion of the subject, a habit that if it is not present, makes the learning less lasting in the student [14].

3.5. Teacher competence factors

For the fifth category of variables were considered reagents related to the perception of students on the following aspects given in the classroom; evaluating

the teaching competencies according to the pentagon of the Ministry of National Education (MEN, 2013) and in the teacher evaluations that Universities (OXFORD, HARVARD, BOLONIA, ALMERIA, GRONINGEN) of high International Ranking throughout the world that have worked to determine the fundamental factors of teacher management in the classroom as among them the BEING, KNOWING and DOING [15].

3.6. Perception of teaching knowledge

Teachers must know their subject matter, appropriate the domains of their discipline, understand that the training process does not end, and must use cognitive strategies to receive the new information that their profession provides them with day by day and be open to resolving the unknowns that may appear throughout their professional life [16].

Table 7. Adjustments by dimension regarding the perception of teaching knowledge in the classroom.

Establish		Multiple adjustment Dimension			Simple adjustment Dimension			Simple loss Dimension		
		1	2	Sum	1	2	Sum	1	2	Sum
6	Has the teacher followed the course syllabus? UNIBO ^a	,639	,012	,652	,639	,011	,650	,000	,001	,001
	Are the teacher's explanations clear? UNIBO ^a	,021	,086	,107	,020	,086	,106	,001	,000	,001
	Are supplementary teaching activities (exercises, workshops, seminars, etc.) useful for the learning process? UNIBO ^a	,053	,203	,255	,051	,202	,253	,001	,001	,002
	The tests and quizzes tested what I memorized and not what I understood. OXFORD ^a	,005	,020	,025	,001	,020	,021	,004	,000	,004
	The volume of work in this module is too much to understand thoroughly. OXFORD ^a	,329	,011	,340	,328	,006	,334	,000	,005	,005
	The tests/exams were totally different from the results and lectures. OXFORD ^a	,442	,005	,446	,432	,001	,432	,010	,004	,014
	The exam questions were clearly worded. GRONINGEN ^a	,173	,008	,181	,171	,006	,176	,002	,002	,004
	My teacher clearly explains difficult things. HARVARD ^a	,942	,201	1,142	,941	,199	1,141	,000	,001	,002
	My teacher has several good ways of explaining each topic he covers in class. HARVARD ^a	,090	,487	,577	,090	,487	,577	,000	,000	,000
	Lessons in this class are often difficult for the teacher to make clear. HARVARD ^a	,083	,020	,103	,083	,018	,101	,000	,002	,003
	Does the teacher assess the subject adequately? ^a	,637	,117	,754	,637	,117	,754	,000	,000	,000
	Does my teacher give timely feedback on assessments? ^a	,137	,357	,494	,134	,356	,490	,003	,001	,004
	Is the teacher able to arouse the students' interest in the subject of the course? UNIBO ^a	,652	,061	,713	,651	,051	,702	,001	,010	,011

Source: own.

According to Harvard University it is of vital importance to recognize the student's perception of whether the teacher is capable of transmitting or explaining complex subjects in the light of the moment, without improvising and perhaps not giving the concrete information that is required, this as the first factor with a coefficient of 0.942 in dimension 1.

For this item, 64.7% of the students state that the teacher does explain difficult topics clearly, while 6 students (35.3%) mention the opposite. In the section of Interest and satisfaction of the teaching evaluation of the University of Bologna, there is special importance in asking about the teacher's initiative to arouse the interest of students in the subject of the subject, a fundamental element in the classroom hand in hand with the disciplinary knowledge, this as the second factor with coefficient 0.652. For this subject of Integral Calculus, the students have responded in the following way: 14 people Definitely Yes (41.2%), 14 students More Yes than No (41.2%), 3 students answered More No than Yes equivalent to (8.8%) and 3 students answered Definitely No (8.8%).

3.7. Assessment of the teaching profession

The dimension of Knowing-Being corresponds to the sum of essence, personality, and knowledge, which allow the teacher to interact successfully with the people around him/her, to exchange knowledge, practices and attitudes that favor the construction of a multidimensional subject and an adequate environment for the exercise of his/her knowledge and his/her work [16].

According to the questionnaire of student experience of the University of Oxford already mentioned previously the factor enthusiasm stimulated by the teacher inside the classroom, it is of importance to know the opinion of the student, for which we have the following answers of the subject of Integral Calculus: 17 people answered the option Definitely Yes (50%), 12 students answered More Yes than No (35.3%), 3 students answered More No than Yes equivalent to (8.8%) and 2 students answered Definitely No (5.9%).

Table 8. Adjustments by dimension regarding the perception of being a teacher in the classroom.

Establish		Multiple adjustment Dimension			Simple adjustment Dimension			Simple loss Dimension		
		1	2	Sum	1	2	Sum	1	2	Sum
7	Is the teacher available to clarify issues and offer explanations? UNIBO ^a	,100	,185	,285	,099	,185	,284	,000	,000	,001
	The teacher of this module motivated me to do my best work. OXFORD ^a	,368	,047	,415	,368	,046	,414	,000	,001	,001
	My teacher has stimulated my enthusiasm to continue learning. OXFORD ^a	1,538	,225	1,763	1,538	,225	1,763	,000	,000	,000
	The teacher of this module is very good at explaining things. OXFORD ^a	,233	,013	,245	,233	,013	,245	,000	,000	,000
	Overall, I am satisfied with the quality of my teacher's support. OXFORD ^a	,760	,761	1,521	,760	,760	1,520	,001	,000	,001
	My teacher is kind to me when I ask questions. HARVARD ^a	,877	,168	1,045	,877	,168	1,045	,000	,000	,000
	My teacher pushes everyone to work hard. HARVARD ^a	,018	,009	,027	,018	,009	,027	,000	,000	,000
	In this class, we learn how to correct our mistakes. HARVARD ^a	,104	,068	,172	,104	,068	,172	,001	,000	,001
	My teacher makes me want to go to college. HARVARD ^a	,955	,986	1,940	,954	,984	1,939	,000	,002	,002
	My teacher in this class makes me feel that he/she really cares about me. HARVARD ^a	,121	,007	,128	,121	,006	,127	,000	,001	,001
	My teacher gives us time to explain our ideas. HARVARD ^a	1,251	,204	1,455	1,250	,199	1,449	,001	,005	,006
	My teacher knows when the class understands, and when we do not. HARVARD ^a	,201	,161	,362	,201	,159	,360	,000	,002	,002
	My teacher wants me to explain my answers - why I think what I think. HARVARD ^a	,004	,035	,039	,003	,035	,038	,001	,000	,001
	If I'm sad or angry, my teacher helps me feel better. HARVARD ^a	1,050	,078	1,128	1,049	,076	1,125	,001	,002	,003
	My teacher in this class still doesn't know me very well. HARVARD ^a	,360	,014	,374	,360	,000	,360	,000	,013	,013
	Expresses positive expectations of students. MEN ^a	,074	,888	,962	,074	,888	,962	,000	,000	,000
	Is respected by all students in the course. MEN ^a	,398	,182	,580	,398	,182	,580	,000	,000	,000
My lecturer gives the objectives, contents and rules of the subject?	,907	,059	,966	,907	,059	,966	,000	,000	,000	

Source: own.

Eventually to the question that was asked to the students related to the quality of the teacher's support, an important factor according to the University of Oxford, answers were presented for the group of Integral Calculus as; Definitely Yes, more Yes than No, more No than Yes, and Definitely No. 20.6% reported that the class was not satisfied with the accompaniment or support by the teacher, while 79.4% reported that they are satisfied with the accompaniment of the teacher in the subject.

With respect to the optimal scaling the following item is directly related to dimension 1, question to which the 24 students (70.6%) categorized that the teacher was kind to them at the time of answering questions inside and outside the classroom. These were the most relevant factors that affect the student's continuity, factors of the Self that the teacher should work on to improve the climate in the classroom and subsequently help the student in his or her training process.

3.8. Evaluation of teaching

On the other hand, the Know-how concerns those capacities of the teacher oriented to action, to the correct and effective use and application of the acquired knowledge that help the professional to have an optimal performance of his or her work. A professional's knowledge is very important, but even more important is the use he or she makes of it, to the extent that it contributes to the

construction of his or her own quality of life and that of the group with which he or she works [16].

The most relevant distribution that correlates directly with dimension 2 of risk of losing the subject, a question that according to the Oxford U. teaching evaluation is important and was associated with the results of information about the student's progress through the subject, question which students in its large magnitude of students 88.2%, highlighted if they were provided with useful information about progress, while 11.8% of students chose to mention that they were not given useful information about their progress within the subject.

Eventually, another of the most significant questions asked to the students was related to the integration of work groups in balance, an important factor according to the University of Groningen in its teaching evaluation entitled "De kwaliteit gewogen", exactly half of the experimental group 17 students (50%) reported that the teacher did not integrate work groups in balance, which implies that there were marked differences in some work groups and not in others, while the other half reported that the teacher was satisfied with the integration of the groups in the way they were working. According to Harvard University, the error is a new learning opportunity, therefore it is important to recognize if for the teacher it is also a new learning opportunity, therefore the student's perception would give the index of this factor.

Table 9. Adjustments by dimension regarding the perception of teaching in the classroom.

Establish		Multiple adjustment Dimension		Sum	Simple adjustment Dimension		Sum	Simple loss Dimension		Sum
		1	2		1	2		1	2	
		9	My lecturer usually gives me useful feedback on my progress. OXFORD ^a	,2129	,607	2,736	2,129	,607	2,736	,000
	My lecturer made a real effort to understand the difficulties I had. OXFORD ^a	,387	,178	,565	,387	,178	,564	,000	,001	,001
	The teacher worked hard to make this topic interesting and applicable. OXFORD ^a	,980	1,840	2,820	,980	1,840	2,820	,000	,000	,000
	My lecturer spent a lot of time commenting (orally/written) on my work. OXFORD ^a	1,123	,165	1,288	1,123	,164	1,287	,000	,000	,000
	The teacher allowed space for questions, answers and comments from the students. GRONINGEN ^a	,283	,128	,411	,283	,128	,411	,000	,000	,000
	The teacher proposes and integrates work groups in balance. GRONINGEN ^a	,506	,510	1,016	,506	,510	1,016	,000	,000	,000
	In our class, mistakes are okay if you tried your best. HARVARD ^a	,253	,682	,935	,253	,681	,934	,001	,000	,001
	Our class stays busy and doesn't waste time. HARVARD ^a	,277	,014	,291	,277	,014	,291	,000	,000	,000
	Homework helps me learn. HARVARD ^a	,194	,425	,619	,194	,425	,618	,000	,000	,000
	My teacher tells us what we are learning and why. HARVARD ^a	,527	1,107	1,633	,525	1,106	1,632	,001	,000	,001
	My teacher asks questions and checks to make sure we are following when he/she is teaching. HARVARD ^a	,121	1,434	1,555	,120	1,434	1,555	,000	,000	,000
	When my teacher marks my work, he/she writes on my papers to help and I understand how to do it better. HARVARD ^a	,134	3,604	3,738	,133	3,604	3,738	,000	,000	,000

Source: own.

Based on the previous premise for this item, 67.6% of the students state that the teacher does value the mistakes, while 11 students (32.4%) mention that the teacher does not value these mistakes as an opportunity for new learning.

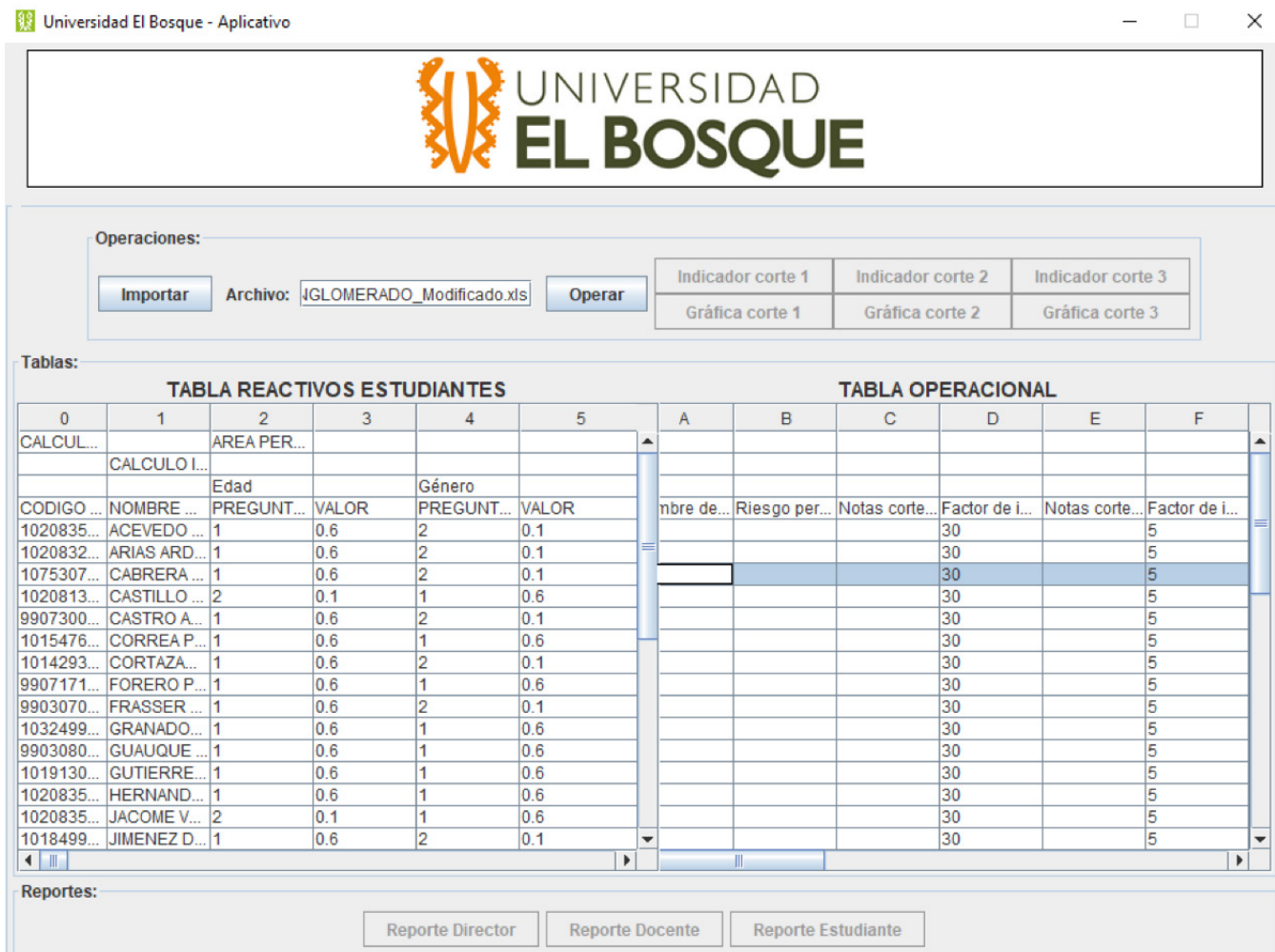
The last of the most important aspects that correlates directly with the risk of losing the subject was associated with the dynamism of the class, a question to which most students (23 equivalent 67.6%) responded that the class is active and dynamic, on the contrary 11 students (32.4%) mentioned that the class

is not dynamic and very passive. According to MEN (2009) teacher evaluation should be able to examine whether the teacher conducts dynamic or active classes to generate interaction between teacher-student, student-student, for the comprehensive construction of knowledge [12].

3.9. Software

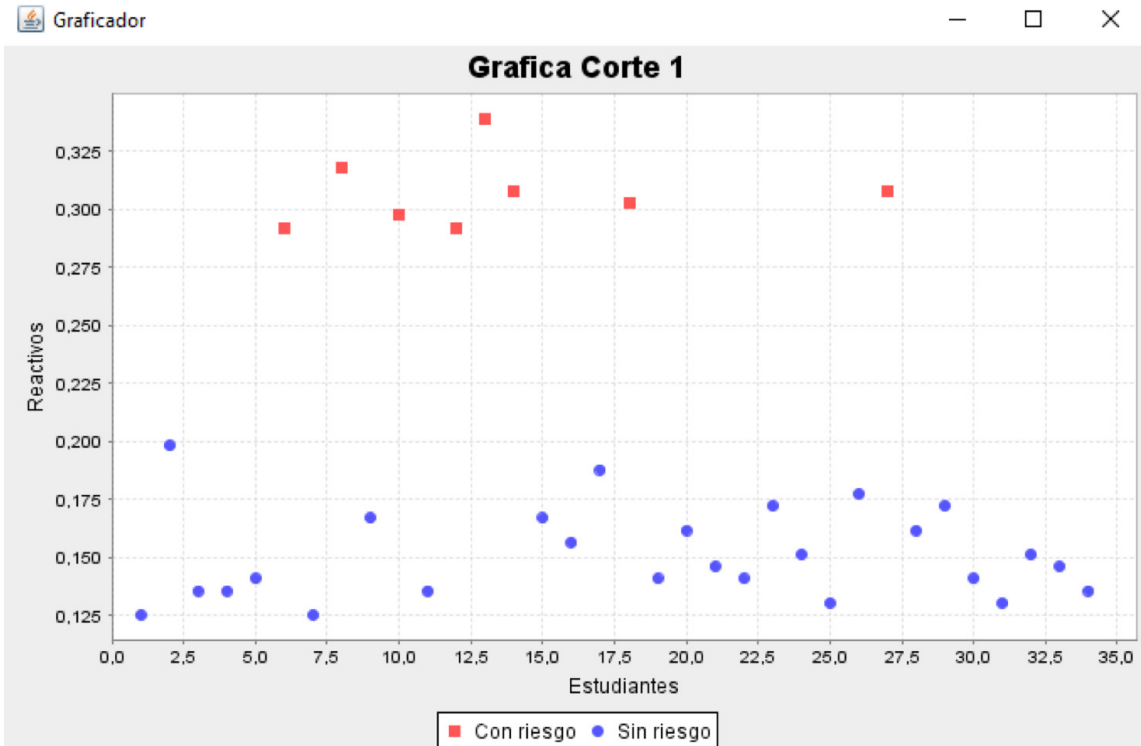
To systematize the model and put it into production for the final client, a software was designed in JAVA, the figures 2-6 are the general graphic interface:

Figure 2. Interface



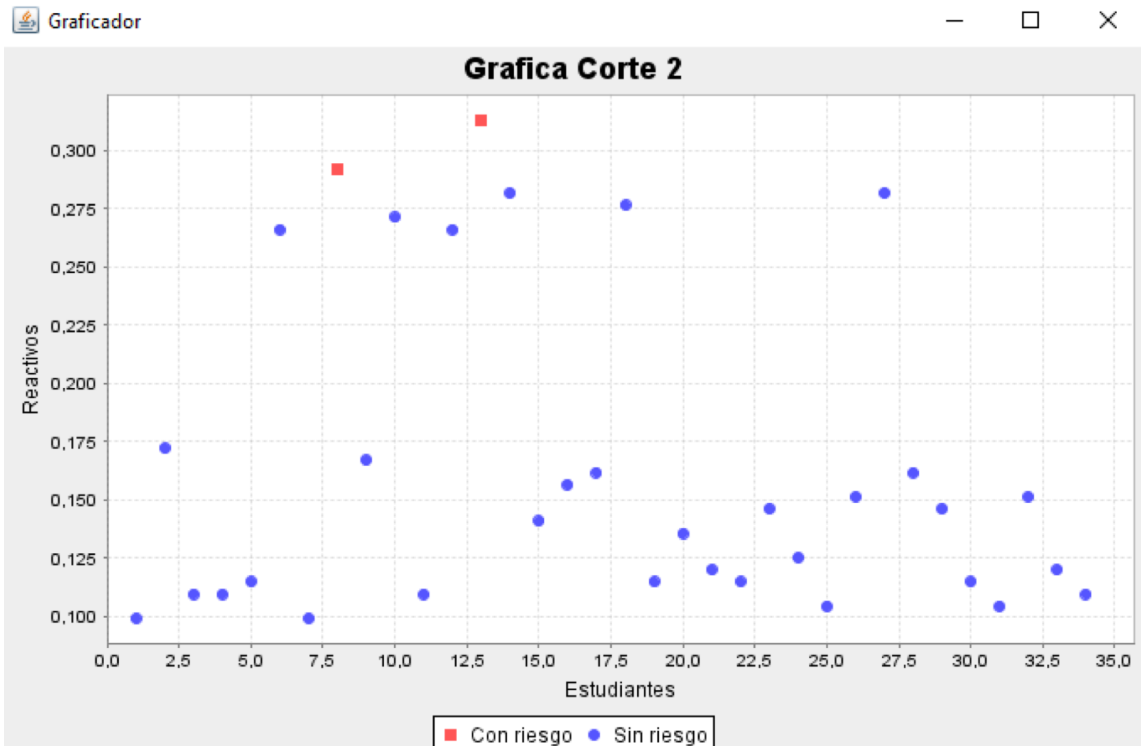
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Figure 3. Graphic 1.



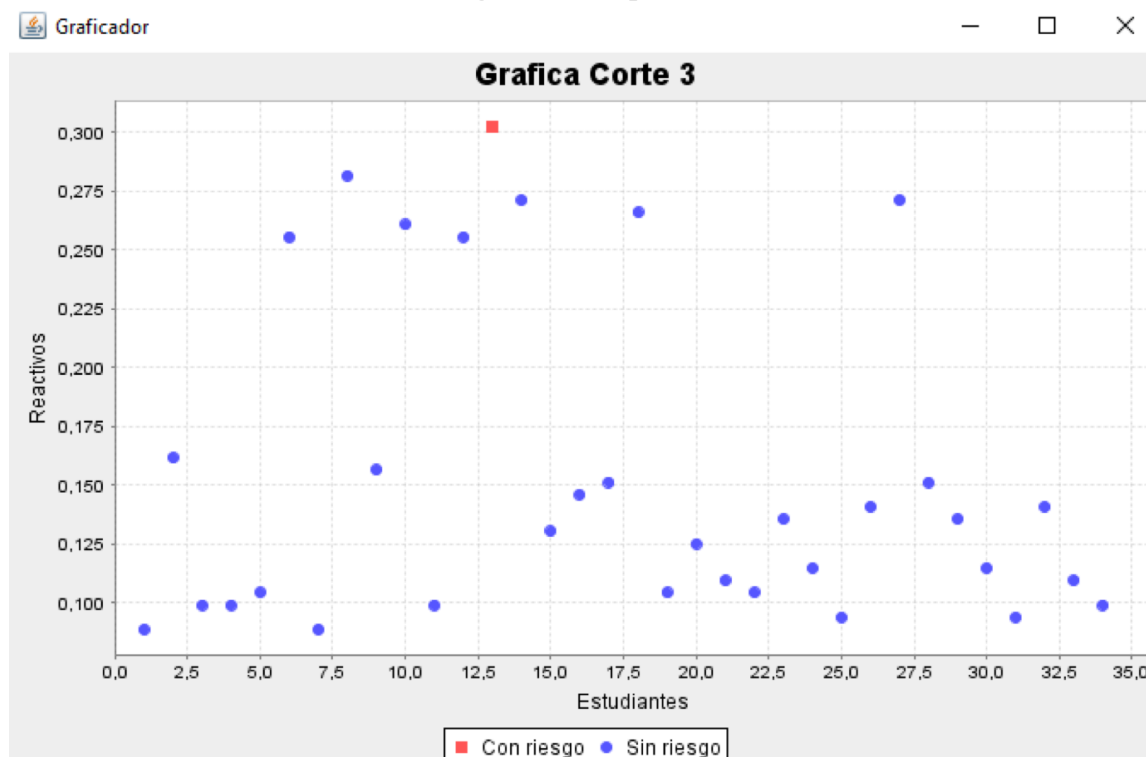
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Figure 4. Graphic 2.



Source: own.

Figure 5. Graphic 3.



Source: own.

Figure 6. Interface student.

The screenshot shows the interface of the "SISTEMA DE SEGUIMIENTO Y ACOMPAÑAMIENTO AL ESTUDIANTE (SAE)" at Universidad El Bosque. The header includes the university logo and name. Below the header, it states "ÉXITO ESTUDIANTIL - DIVISIÓN DE EDUCACIÓN VIRTUAL Y A DISTANCIA" and "REPORTE VARIABLES DE RIESGO Y SUGERENCIA DE ESTRATEGIAS". The main content area reports: "El estudiante no tiene una alta probabilidad de riesgo de pérdida del curso de CALCULO INTEGRAL. Sus parámetros son:". Below this, it lists "PERFIL DEL ESTUDIANTE Y NOTA DEL CORTE 3" with 18 numbered variables and their values. At the bottom right, it says "Generado: 10-25-2021".

Source: own.

With the following modules:

- Importing data through files with .xlsx extension
- Data Table Display
- Operational module and data processing
- Cut chart generator (risk status with color)
- Generator of indicators of at-risk students based on their characteristics.
- Generation of reports for director, teacher and students in pdf format.

4. Conclusions

This is the first study carried out with this statistical technique for the creation of a predictive model on the factors that influence the decision of students in face-to-face or distance mode to remain or drop out of the courses, as well as in the institution investigated. The results motivate to generate improvement strategies within the faculty on issues related to the aspects pointed out by the students as elements that affect their decision to abandon the career. The aspects that influence the abandonment of the courses involve the interaction of the faculty and the teaching competences. The research shows that the student requires greater accompaniment and technical support in their efforts to achieve their academic goals, strategies for self-learning more effectively.

Within the personal factors with more influence in the two dimensions given by the factorial analysis technique for the desertion of the subject of integral calculus were the emotional aspects (61%), the consumption of hallucinogens and/or alcoholic beverages (100%), the family environment (100%), the socioeconomic stratum (86%) and the time of autonomous study (77%), variables that generated corrective strategies from the support of the financial and psychological programs of the University, in order to improve the quality and performance of the student and retention of the same. Simultaneously, the model provides the factors that most affect the student's performance from the teaching competences in the classroom, for their significance the following stand out: the teacher does not explain difficult things clearly (100%), is not able to arouse students' interest (71%), does not stimulate enthusiasm to continue learning (100%), there is no quality support (100%), the teacher is not kind when asked questions (100%), the

teacher does not provide useful information about the progress of the students (100%), does not propose or integrate work groups in balance (100%) and does not carry out active and/or dynamic classes (92%), these variables generate preventive strategies to be applied by the teacher in order to reduce the risk of loss of the subject or desertion.

It is noteworthy to mention the creation and reliability (94.7% by Cronbach's Alpha) of the instruments that allowed characterizing the student and being a fundamental input for the design of the model, so that by building this instrument with the most significant variables in the process of desertion based on the literature examined, this becomes a tool applicable to any population, of course the role of the items should be reevaluated to the extent that there are more cases of desertion and allows feedback to the model, thus minimizing the decline of the quadratic gradient of the model and immediate updating of the same. [17]

As an additional value this predictive model of risk management allows graphically record the behavior of the permanence and desertion of students belonging to each program in each of the periods in which they are enrolled in the subject of integral calculus additionally generate reports for department directors and deans of faculty, according to the states of progress that have students during his career and through the courses, semester to semester.

5. Discussion and future work

The results obtained in this study indicate that there are implications in teacher management for the researched institution which are intended to achieve better retention and avoid student attrition, if implemented. Yoder (2005) noted that if student needs are identified and support is ensured in administrative, academic, and technical structures, 100% retention in programs can be achieved. Some of the recommendations, supported by Yoder (2005) are included below: Promote a greater teacher presence in external class tutorials, evaluate the competencies of the professors who will teach the courses so that they have a genuine commitment according to the expectations of the students in the teaching-learning process [9]. Ensure that teachers are trained in the use of technology, consider in the design of the courses, more rigorous parameters to ensure the following: adequate dosage of information, readings and activities, so that the student does not feel overloaded; include audio-visual resources, that is, sound and image so that the student

does not feel alone; try as much as possible, to ensure student training in the use of the virtual library and other teaching support services and encourage the social aspect among students of the subject, key elements that should be taken into account to reduce student risk [18].

To make known in the student lists of each teacher of the industrial engineering program at the Universidad El Bosque in the subject of integral calculus, the results of risk management through this model, to make an academic treatment and institutional counseling, to minimize the desertion of students, identified in areas of low and high risk of desertion. Didactic experiences using technology can be used for this, [19], [20-27].

As a last recommendation it is suggested to form a team of software designers to build an institutional application based on the mathematical model described in this thesis in order to provide the Universidad El Bosque a Critical Monitoring Room (Crisis Room) that allows in real time to observe monthly or weekly the progress of students of all the different on-site or virtual programs of the University, in order to monitor, control and act, in order to reduce risks and increase the retention rate of students in this prestigious University.

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