Influence of Mathematics in The Desertion of Higher Education

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Abstract

In the present work the different models of university desertion are analyzed, identifying the factors that have influence in the continuation of the studies of the students. These factors are essentials to defining what will be understood by university desertion and to elaborate the profile of the deserter. In the case of the Universidad de Las Américas (Quito, Ecuador), the main factors that influence the desertion are corroborated with those that have been established according to the existing bibliography and a descriptive study of these data is carried out, in order to elaborate indicators that allow us to predict the behavior of the student population with a higher risk of dropping out. An analysis is made relating the area of Mathematics and the desertion, seeing how this area influences the possibility of a student dropping out.

Keywords: Student Desertion, Higher Education, University Abandonment, University Dropout, Mathematics Education.

2000 Mathematics Subject Classification: 97B99, 97D70.

1   Introduction

Desertion rates in education, particularly in higher education, have become a point of interest for academic research. The issue has grown to a point where several key stakeholders in the educational process have come together to establish policies to decrease attrition rates by improving support strategies throughout the student's academic experience. In doing so, they hope students are more likely to remain and successfully finish their studies.

A consensus on a definition for desertion is yet to be reached. Desertion rates can be defined as broadly as one might like and the approach to such definitions depend on the stakeholder's point of view and interest on the issue. Even though one might reach a consensus on a definition for the desertion phenomenon, issues on causality and which research approach is more appropriate will arise and, as such, will have to be resolved. To further complicate the issue, when researching desertion rates one has to take into account the national, local and institutional contexts since they have proven to have a significant impact on the issue.

Desertion rates in Latin-American universities are a growing phenomenon that has attracted interest from the academic community. One might say that such interest cannot only be attributed to the implications that desertion rates have for an individual's and institutional academic performances; but also because, it is of strategic interest to develop policies that effectively reduce desertion levels (see for example [1, 2, 3]).

In Ecuador, the issue has not been overlooked and some studies have been undertaken to study the causes and alternative solutions for such problem, [4]. The social and economic impact that desertion imposes is one of

the main reasons for gathering academic professionals from diverse areas of knowledge to address the problem from a multidisciplinary approach (social, psychological, academic, etc.).

Among the main reasons for deciding not to remain at university, the most important is academic performance, mainly within the first years of university. This phenomenon has received most attention in academic literature, as such; most policies have been developed to avoid desertion within the first couple of years of university. These policies have shown to have significant impact on reducing desertion rates.

Lack of knowledge and guidance when choosing a career can make the student feel discouraged, out of place and with no agency in his choice. Nevertheless, when the student has made an informed decision and is passionate about his career, frustration and discouragement have their root in other factors, where mathematics courses play an important role for these feelings.

The guidelines of Ecuador for higher education gives students up to three chance to pass a course. If a student cannot pass a course in his third attempt, the student cannot continue to study the career he chose. These guidelines have informed our definition for a deserter. For the purpose of this paper, a deserter is a student who has been unable to pass a course after the third attempt and, as such, will not finish his studies. Moreover, it is important to also study those trying a class for a second time, since the pressure of not doing well puts them at high risk of dropping out.

This paper studies the impact that mathematics course have on desertion rates. For this purpose, we first identify the main causes of desertion rates for Universidad de Las Americas (Quito, Ecuador), in doing so; we develop a behavioral profile for the deserter. To do this, we first review the current literature on desertion to find a model to explain the phenomenon and, confirm such relationships through a descriptive analysis for data available for students for UDLA, which are at high risk of dropping out, such as students trying to pass a course for the second and third times.

This work is organized as follows: section 2 organizes previous academic research on models to explain desertion rates, section 3 describes what we understand by desertion and how all the determinants interact to influence the phenomenon, in sections 4 and 5 we analyze in more detailed the determinants for desertion, in doing so, we can then study students at risk of deserting. Finally, section 6 evaluates the impact that mathematics course have on increasing or decreasing the desertion risk.

2   Models for University Dropouts

Dropout rates in higher education have become a point of interest for academic research, as shown in [4]. There are some definitions, causes and research methodologies. A concrete definition for attrition is yet to be proposed, as well as, a general and standardized description for the phenomenon. Even though, one might be able to reach a consensus on the definitions, one has to determine the causes and propose a road map for the rigorous study.

In the last decades, several conceptual models have been developed to explain attrition rates. In [5] authors introduce five approaches to categorize them. Depending on the author's approach, they include variables of various sorts–individual, institutional, familial. These models are summarized in the figure 1.
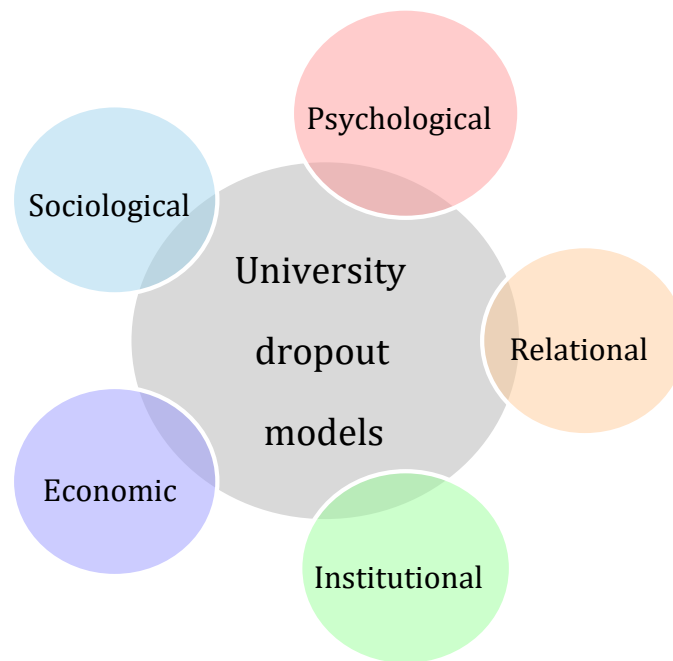
Figure 1: Models for university dropouts.

2.1   Psychological Models

From a psychological stand point, a student's personality traits increases or decreases his likelihood to dropout. One first model which might give some insight into such difference is the "Theory of Reasoned Action", [6], where the "intention to take action" is determined by two factors: "attitude towards taking action" and the "subjective norm". The subjective norm explains how an individual behaves in and with society. Behavioral patterns are influenced by society. The decision to drop out or continue to studying is influenced by several stimuli: previous behaviors, previous attitudes towards dropping out and subjective norms about this actions. Thus, dropping out results from a weakening of the initial intention to study, whereas remaining in school results from a strengthening of the initial intention. Author in [7] reinforces the theory that dropout and completion rates are heavily influenced by students' perceptions and how they view their lives once in university. Thus, this analysis directly influences their decision to remain or drop out.

Based on previous research, autor in [8] created a more detailed framework that informed a more general theory of "achievement behaviours", [9]. This model includes additional characteristics such as perseverance, choice and performance. The model posits that previous academic performance determines future academic performance. Previous academic performance informs the student's perceived academic ability, his perception on topic difficulty, goals, values and expectations of success. Family support and encouragement also have an influence on student's perceived academic ability and goals. Ethington found that the goal's reach has a direct impact on student's values. Additional, a student's expectations of success are strongly correlated to his perceived academic ability and perception on topic difficulty. Thus, the probability of completing university is influenced by the student's values and expectations of success.

Authors in [10] have proposed a more contemporary model. This model is based on the psychological processes related academic and social integration. The basic framework for the model are four psychological theories:

   a)   Theory of attitude and behaviour, which comes from the basic structure of the model.

   b)   Theory of replicated behaviour, for which the ability to enter and adapt to a new environment is paramount.

c)   Theory of self–efficacy, individual's own perception on his ability to accomplish specific tasks.

d)   Theory of attribution, where an individual has strong self control.

For these authors, the role of the educational institution is important and it can be enhanced by providing quality teaching services, learning communities for first year students, career guidance seminars and mentoring programs to bolster student success rates.

2.2   Sociological Models

These models focus their attention on how external factors affect the individual's decision to remain at university. The origins of this theory can be traced back to the theory of suicide in [11]. This theory determines that suicide is the result of an individual breaking with his social system, given his inability to feel part of it. Following the same theory, in [12] assert that dropping out results from student not being able to fit into the educational environment. Moreover, the author posits that the family environment is one of the main sources of influence, expectations and demands that directly affect the degree of integration to university. According to the same theory, the family environment is correlated to academic performance and policy coherence. Furthermore, the former underscores academic performance. Additionally, policy coherence acts upon on academic and intellectual performance, support networks among students and social integration. Likewise, this support network has an effect on social integration. The latter, weighs positively on student's integration to the university and contributes to reaffirming his commitment to the institution.

In the same work, posits that there is higher probability of dropping out when the several elements that influence a student's decision move in opposite directions, which results in unsatisfactory academic performance, low social integration level, and as a matter of fact, feeling unfulfilled and not committed to the university. Otherwise, if the influence move in the desirable direction and depending on a student's starting point, the student is more likely to achieve academic and social success. In this case, success is determined by the accomplishment of the student's own expectations in combination with the institutional expectations, which is positively correlated to the institution's retention rates.

Using a study case with American colleges, the author found six variables which together determine the likelihood to dropout: academic integration, social integration, socioeconomic status, gender, quality of the career and grade average.

2.3   Economic Models

According to [13, 14, 15, 16] there are two models:

2.3.1   Cost–Benefit Models

When the student believes that the social and economic returns to study are greater than the alternative, for example, working instead of studying, then he can be more motivate to stay at university. An important element at this point is the student capacity to finance his studies.

2.3.2   Targeted Financial Aid

The objective is to create financial aid packages–total or partial–whose size constitute an incentive to stay at university, in particular, for those students who are at greater risk of dropping out. Thus, discount packages, scholarships and low interest loans can help students pay for their studies, and in turn, become more committed to the university. In [17, 18] we can see that financial aid, especially in the form of scholarships, increase the probability of remaining at school, considerably. The authors show that there is a positive correlation between attrition rates and, the size and duration of the financial aid. These become more important when the student faces financial challenges, which increase their risk of dropping out.

2.4   Institutional Models

In [19], a study shows that institutional models that explain attrition rates are centered around what the university has and which services can offer to the students. According to [5], these models focused on variables that describe quality at university, such as, quality of teaching and students' experiences in the classroom. In these models, the authors include health benefits, opportunities for other activities, academic support, bibliographic resources, labs and student–teacher ratios.

2.5   Relational Models

Tinto in [20] is one of the leading authors in the field. His work expands on Spady's model [12] by adding the exchange theory from Nye [21]. The exchange theory is based on the idea that human beings avoid any behaviour that implies costs and look for rewards in all their relationships, interactions and emotional states. According to Tinto, students act according to the exchange theory building a social network and academic support system. These integration areas manifest themselves in terms of goals and commitment to the institution. If the student believes that the gains from staying at school are greater than the costs, then he has a greater chance at staying and finishing his studies. Besides, if he has alternatives which offer him a better cost–benefit trade off, the student will be tempted, and it is more likely that drop out. From another point of view, attrition can be seen as the result of the interaction between the force in the academic and social systems at university.

As the student goes further along in the higher education system, there are several variables which further reinforce his commitment to the institution he chose. These characteristics are related to family history, such as socioeconomic status and family culture, as well as, personal values, attributes and, past academic performance. These aspects come together and inform a student's initial commitment to the institution, as well as, increasing his probability to successfully finish his studies. Academic integration, academic performance and intellectual development all play equally important parts in determining success. Moreover, social integration encompasses development, frequency of positive interactions with peers and professors and, the opportunity to take part in non–academic activities. Furthermore, commitment to the institution is influenced by social integration. The more the student is committed to finishing his studies and to the institution, the less likely he is to dropout.

According to Tinto, dropping out can be temporary or permanent, with respect to the time the student has been away. The author posits that dropping out is temporary when the student decides to come back, as long as he does not have substantial obstacles to come back. Otherwise, he is less likely to come back when there are important obstacles that prevent him from coming back. In [22, 23, 24], authors add to Tinto's model characteristics from labour organizations models, adapting variables that refer to the organizational environment by others more suitable to the educational environment, where student satisfaction is akin to employees satisfaction with work (see figure 2).
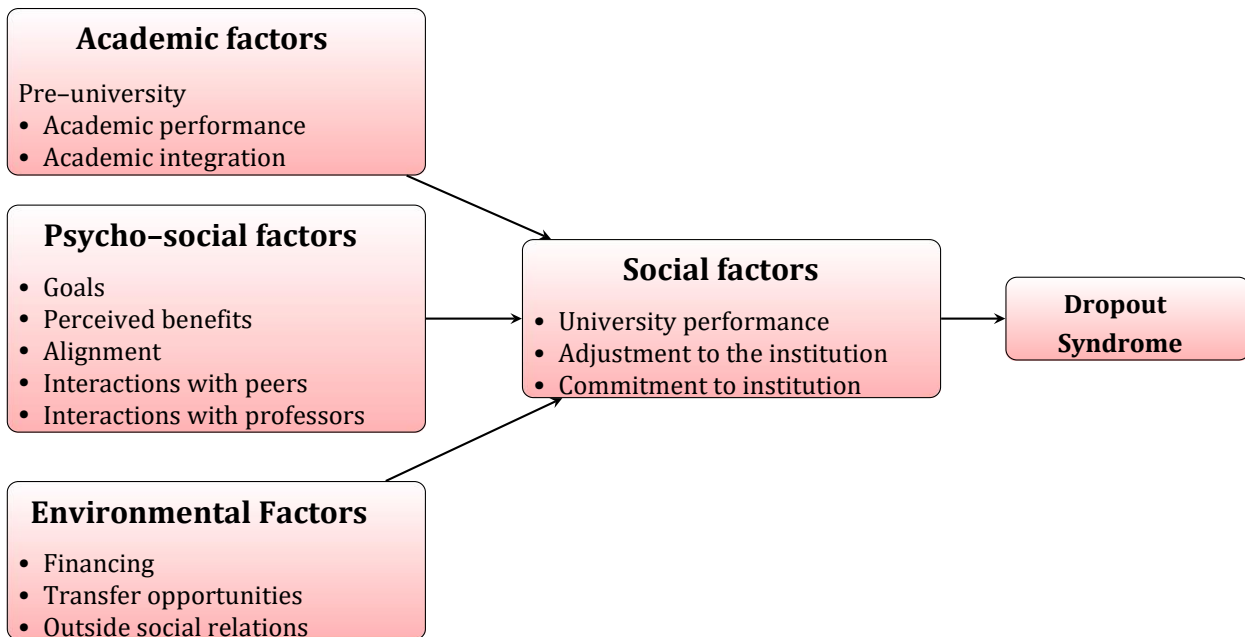
Figure 2: Bean's models [22, 23, 24].

Further research, [25] shows that non cognitive factors, such as personal characteristics (attitudes, aspirations, motivations, interests), environmental and organizational also have an important effect on attrition, particularly on voluntary drop out. There are other approaches which explain attrition, which are not as popular as the ones mentioned above that are equally important to explain attrition, such as, in [26, 27]. These models proposed five key characteristics to consider:

- Personal: skills, performance, personality, aspirations.

- Structural to the institution: admission, students, selection.

- Institutional environment.

- Interactions: frequency and quality of interactions with peers and professors.

- Effort: quality of student's effort.

3 Desertion

3.1   Definition

According to Tinto in [28], the deserter is that individual who, being a student of a higher education institution, does not present academic activity during three consecutive academic semesters. In other studies, the first dropout refers to that desertion in which it is unknown whether the individual will resume his studies later. In [2], González et al. argues that the desertion can be defined as the process of abandonment, voluntary or forced in which a student enrolls, by the positive or negative influence of internal or external circumstances to him or her. Himmel in [29] refers to the desertion as the premature abandonment of a program of studies before reaching the degree, and considers a time long enough to rule out the possibility of the student rejoining. In his work distinguishes the desertion between voluntary (resignation on the part of the student or uninformed abandonment to the institution of superior education) and involuntary (institutional decision, based on its current regulations, which forces the student to withdraw from studies). In this last case, the desertion can be justified in an insufficient academic performance or caused by disciplinary reasons of diverse kinds. In the figure 3 you can see the position of Himmel.
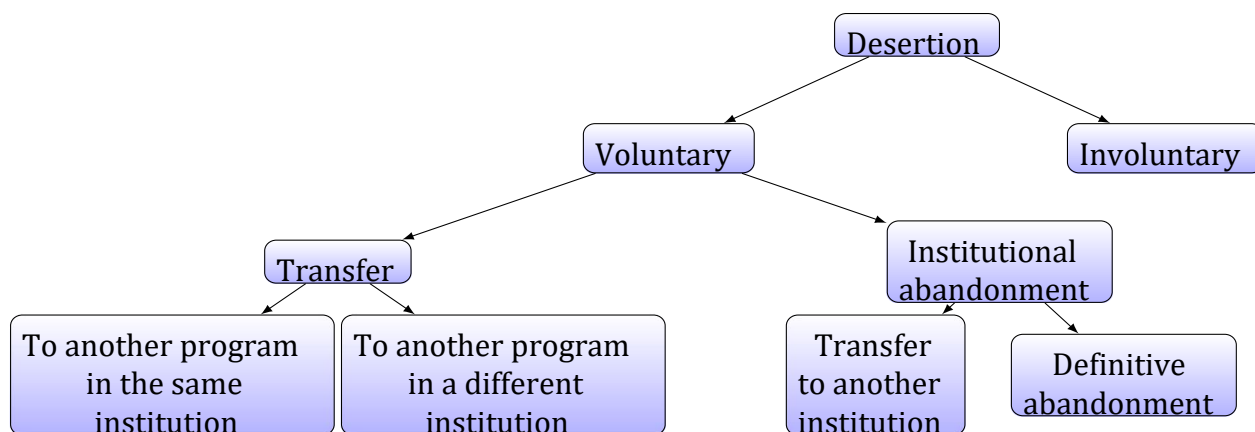
Figure 3: Desertion scheme [29].

In a explanatory model of desertion in the retention analysis [30], define the "drop out rate" as "1−retention rate", i. e., students who having enrolled in a year, do not enroll the following year.

3.2   Factors of University Desertion

In Latin America, the studies are oriented to explain the desertion based mostly on the models presented above. For example, the works [2, 29] focus the phenomenon through the concept explaining the desertion from the theory. The same happens with the descriptive analysis of desertion. Studies are carried out on desertors in the search for common patterns in behavior, which provide information in terms of selection of explanatory variables in relation to the approaches proposed by Tinto [28] and Spady [12].

At the international level, there are works that explain and even predict the university dropout from statistical models, based on the theories raised by classical authors and with results from the selection of arbitrary variables due to various reasons such as the availability of data, the level of analysis (country, city, university, etc.) and the definition of retention.

Then, in the table 1, we present a summary of the determinants of university dropout found in the literature, according to the interpretations of Díaz [1] and Lopera [31], and that they are frequently used in empirical analysis.

Individual	Institutional
Age	Academic regulations
Gender	Financing
Civil status	University resources
Family group	Interaction with teachers
Social integration	Interaction with other students
Time incompatibility	Educational quality

Academic	Socioeconomic
Type of secondary education	Social stratum
Professional orientation	Employment situation
Academic performance	Parent education
Study methods	Employment status of the student
Admission test	Dependents
Satisfaction with the program	Familiar surroundings
Academic charge	Macroeconomic environment
Repeat	

Table 1: Factors of university desertion.

4   Main Characteristics of Dropouts

In the following sections, the main characteristics of dropouts at university and types are analyzed and described. This analysis is compared to other contemporary international research ([32, 33, 3]). Results are similar to those found in the relevant literature, which implies that preventative measures could be taken in order to reduce the number of dropouts, as proposed by other authors.

4.1   Demographic Information

This section analyses variables, which described the dropouts' most salient characteristics with particular interest to influences from their social context.

We can observe in the official bulletins of the institution that even though female population is greater than male, males' dropout rates are higher. Moreover, despite most students being between 20 and 21 years of age, people who are 30 years or older have higher dropout rates than the rest of the student body, followed by students between 18 and 19 years of age (figure 4). It has been shown that students' home location ([34]) has an impact on his likelihood of dropping out. The further the residence from the university, the more likely the student is to dropout. Moreover, widows and widowers are more likely to drop out ([35]) whereas, unmarried students are the least likely to drop out.
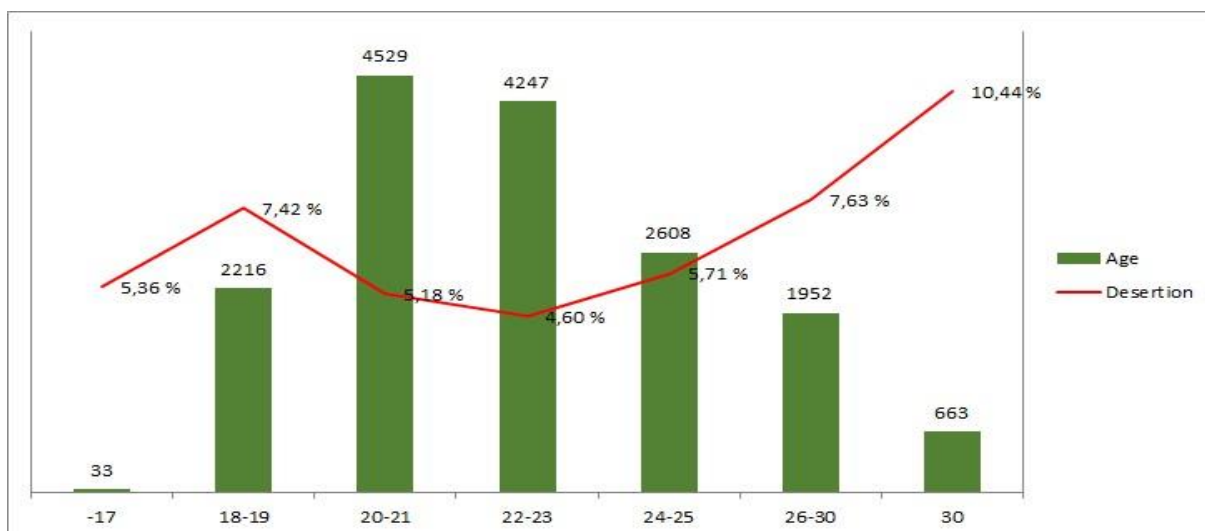
Figure 4: Students ages vs. drop out rates.

4.2   Background of Students

It has been shown that there is a link between family income and likelihood to drop out of school, Hazar [35], which in turn is related to the type high school the student graduated comes from (private or public). We identify five income groups and from the second group (income between $501,00 and $1.000,00) on wards one can clearly see a decreasing tendency on dropout rates. This pattern has been seen before in Nora [36], where a study was carried out with students from Mexican origin in a public school in Texas.

The students that come from public high schools are more likely to drop out, which is consistent with results in Sánchez et al. ([3]).

Thus, both in high school and higher education economic stability plays an important role.

4.3   University Life

A link has been established ([37]) between a student's development at the educational institution and its environment and the student's likelihood to drop out of school. Some relevant characteristics are described in more detail below.

The university has two sessions: daytime and evening classes. Even though there are more students in the daytime session, there is a higher drop out rate for students enrolled in the evening session. Looking at drop out and pass rates together, students who pass between 20–30% of course are more likely to drop out (figure 5).
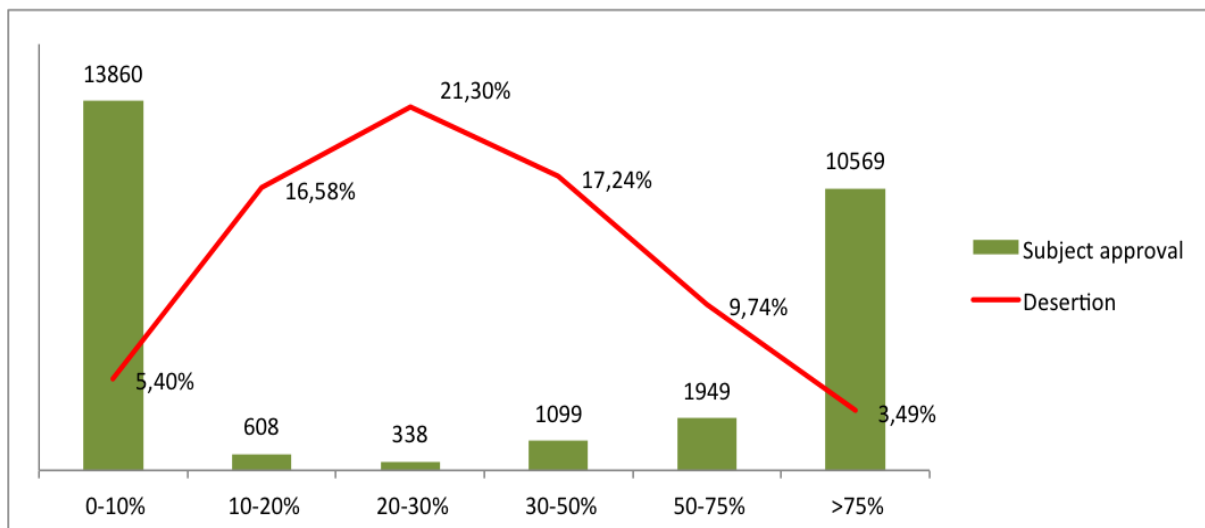
Figure 5: Pass rates vs. drop out rates.

Finally, it is important to point out the observed linked between class attendance and drop out rates. Figure 6 illustrates such relationship. Students who goes to class regularly is less likely to drop out. From out data, 20.50% of dropouts missed between 51 and 75% of lessons.
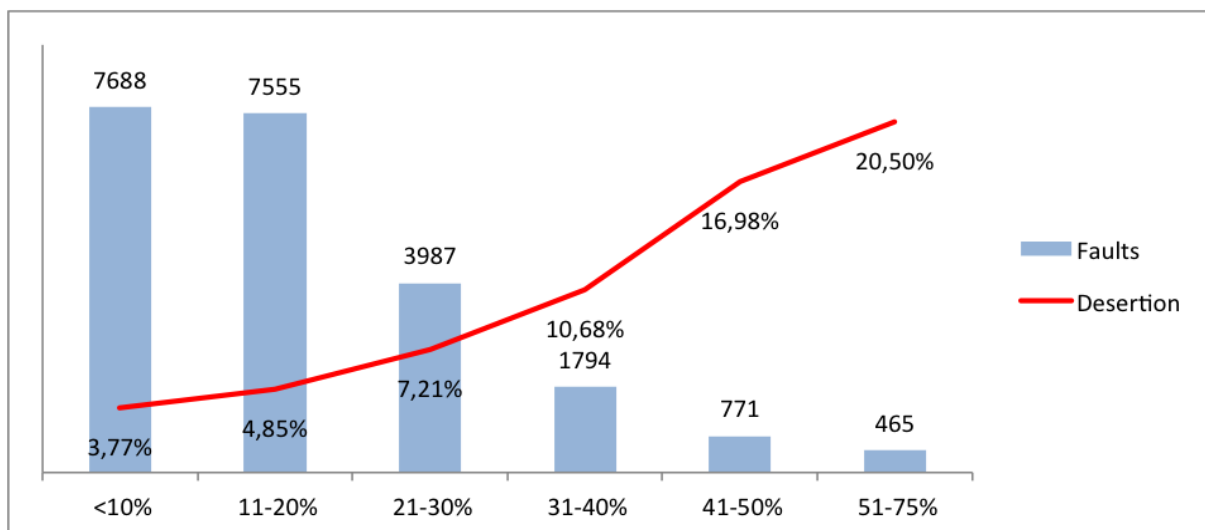

Figure 6: Faults rates vs. drop out rates.

5   Descriptive Analysis of Students At Risk of Drop Out

This section details the descriptive analysis carried out on the data on the history of the students at Universidad de Las Américas (Quito, Ecuador) who are in the second and third registers. This analysis seeks to identify causes that influence university students to drop out of school.

The data analyzed here was facilitated by the Intelligence Area of the Information, through the Menu of Reports of Academic Management (Tracking) of the university, which forms a large database on the various academic aspects of the institution. The first step was to analyze the data corresponding to the students of second and third grades, since these are the population that present the highest risk of dropping out due to academic causes. Figure 7 shows the percentage of students in second and third grades, with respect to the total number of students enrolled per period.

In the Institutional Statistics Bulletins we can find a variety of historical graphs corresponding to the last five years, both in the evolution of the total number of enrolled students, as well as in the cases of second and third registers segmented into different categories, such as, for example, gender or study modality. In the present work some of the graphs that serve in the later analyze are presented.
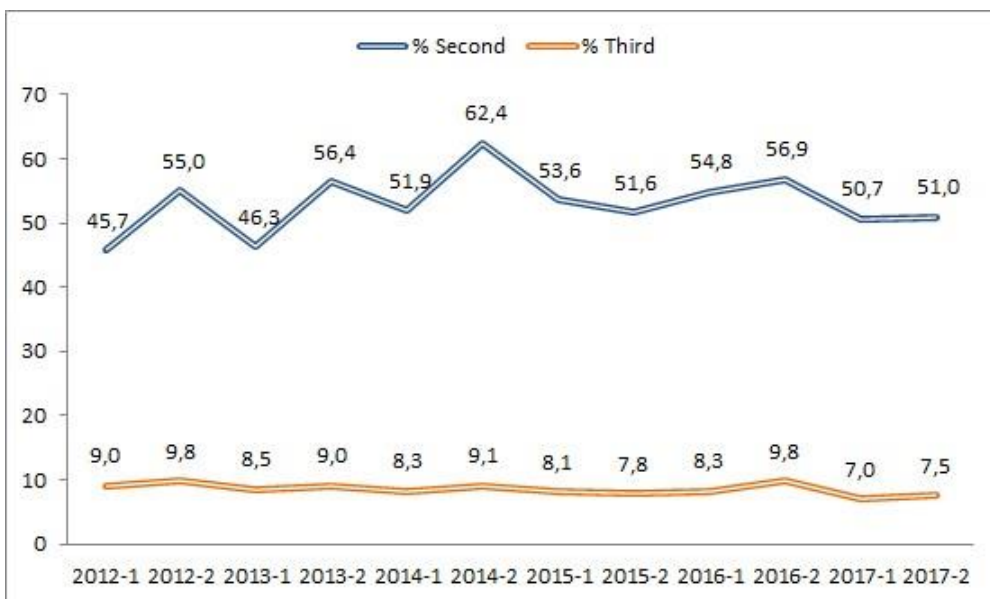

Figure 7: Evolution of second and third register.

Within the data analyzed, apart from the typical variables (age, gender, student's origin) there are variables of great interest, such as careers, subjects, grades, among other. To study the correlations and the behavior of these variables are fundamental to construct statistical indicators that allow us not only to represent the behavioral pattern, but to predict the risk of drop out.

5.1 Students in Second and Third Enrollment

In table 2 we observe that the second and third enrollments by age have decreased considerably, this is due to the institutional policies adopted and the activities implemented by the school of Mathematics of the institution.

The distribution of students in second and third enrollment, according to genre has remained practically unchanged in the last five years, being in an approximate proportion of 60% male and 40% female in both cases.

As for the place of origin of the students, the distribution of students in second and third enrolment has remained practically invariably in the last five years, so it can be concluded a priori that the variable of origin does not influence of great way in academic performance.

Academic period	Second enrollment	Third enrollment
2012–1	26.93	27.80
2012–2	26.39	27.55
2013–1	26.12	26.68

2013–2	25.35	26.65
2014–1	25.24	25.87
2014–2	24.76	25.74
2015–1	24.47	25.19
2015–2	24.20	25.43
2016–1	23.59	24.41
2016–2	22.98	24.35
2017–1	22.81	23.94
2017–2	22.54	23.43

Table 2: Second and third enrollments.

The average age of students who are in second and third enrolments has declined considerably in the last five years, from 22 years to 26 years in the case of second register and 23 years to 27 years, in the case of third register. This makes sense, given that the total population of enrolled every year is younger.

With respect to stratum and type of school, data indicate that the majority of the students of second and third enrolment come from medium strata (high and low) and from of private schools.

Finally, reviewing the average of grades, we found a great difference in the averages of grades between second and third enrolments, in general, the students in second register have a worse performance that the ones of third register. This can be explained by the fact that the students in third enrollment are "forced to" approve the course that are taken. However, the bad performance for students of second register can be a decisive factor for desertion, so is fundamental to comprise this variable in its entire dimension.

6   Mathematics and Desertion: Hypothesis Contrast

Several databases are available at Universidad de Las Américas. It was used the information about students enrolled in any subject in the area of Mathematics in the semester 2016–20 and those that contained information about students enrolled in general, in the period 2017–10. The purpose of the study with these databases is to obtain the students enrolled in the 2016–20 period in some subject of Mathematics that did not enroll in the 2017–10 period.

According to institutional data, 625 students were not enrolled in the 2017–10 period of the 5,114 students who did in the 2016–20 period, that is the 12.22%. This percentage corresponds to students that in this period had took some subject related with Mathematics. We can observe that they did not obtained more than three points over ten, being the range between 1.75 and 3.25. This definitely is an indicator that although the desertion, as we have seen, is a problem in which converge several factors, definitely the academic factor is fundamental in the decision to drop out the studies, and the data showed give us account that in some concrete cases, the Mathematics have a predominant role in the desertion.

In Figure 8, we can see the students enrolled in the 2016–20 period who were not enrolled in 2017–10 with respect to Mathematics subjects.
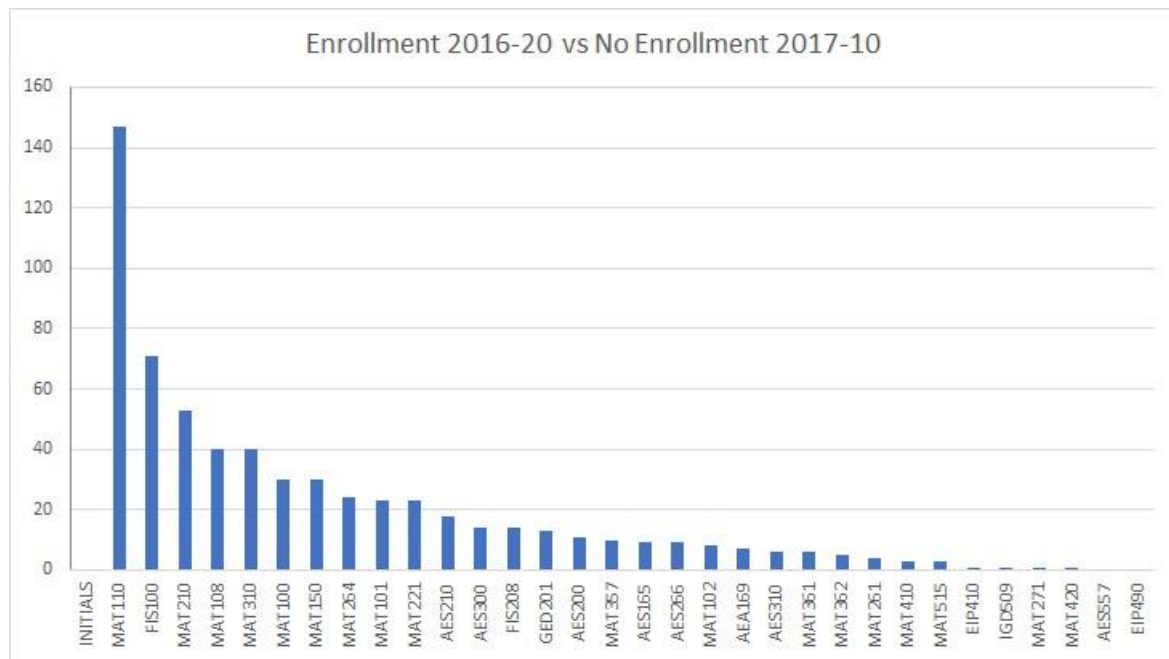
Figure 8: Number of non–enrolled students in the 2017–10 period who were enrolled in the 2016–20 period by subject of Mathematics.

The top ten subjects where students are not enrollment are subjects of the first semesters of a degree in general, where more desertion of this type occurs as in other previous works.

We proceeded to perform the Chi–square test using *Minitab 17.2.1* software to study the dependence between the variables: to have completed or not a subject of mathematics in the semester 2016–20 (variable *A*) and the decision to enroll for the next period 2017–10 (variable *B*).

Null hypothesis H_0: *A* and *B* are independent variables.

Alternative hypothesis H_1: *A* and *B* are dependent variables.

Test statistic: Pearson Chi–Square = 180,000; *DF* = 24; *p*–value= 0.000.

Decision: As the *p*–value < α = 0.05, the null hypothesis H_0 is rejected, and it is concluded that there is dependence between the mentioned variables.

Through the data, there is a relationship between the fact of having a subject in the area of Mathematics in the period 2016–20 and the student has not been enrolled in the period 2017–10.

Other of the appearances to stand out in that the desertion, although it is the result of several factors interacting as it is stablished in Bean's model, is strongly tied to factors of academic type, for example in the chart of the figure 5 it is compared the percentage of approval of matters and the desertion, although certainly there are students that desert even having approved in good percentage of the academic workload. We can see that the majority of the deserters approve less than 60% of the academic workload. In the same way, in the chart of the figure 6 we see how rank of assistance to class is in inverse proportion to the desertion, what corroborates us once again that the academic factor is central in the problem of the desertion.

The main goal which we pretend take in a deeper study, has to deal with the creation of a model that allow us to identify the patterns of behavior of the population in risk of desertion, no only recognize when a student has greater risk to abandon the studies, based in the diverse factors of risks, but to understand the process in early

stages, identify the path that follows the population that does not culminate his studies and establish measures that can warn that it arrive to a point of no return.

Conflicts of Interest

Authos declare that there are not conflicts of interest.

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