Revista Iberoamericana para la Investigación y el Desarrollo Educativo
ISSN 2007 - 7467

https://doi.org/10.23913/ride.v11i22.858

Artículos científicos

Estrategias para mejor la calidad educativa con base en el análisis de la trayectoria académica en el área de ingeniería

Strategies to improve educational quality based on the analysis of the academic trajectory in the engineering area

Estratégias de melhoria da qualidade educacional a partir da análise da trajetória acadêmica na área de engenharia

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Resumen

El objetivo de esta investigación fue analizar algunos indicadores de la trayectoria académica de alumnos de ingeniería en Computación (ICO) e ingeniaría en Sistemas y Comunicaciones (ISC) (cohorte 2014-2019) del Centro Universitario UAEM Valle de México. Para ello, se desarrolló un trabajo de tipo no experimental, en el cual se tomaron en cuenta los siguientes indicadores: número de alumnos que concluyeron su plan de estudios, grado de avance, deserción escolar, reprobación, tipo de examen (ordinario, extraordinario y título) mediante el cual los alumnos aprueban cuando están cursando por segunda vez una materia y escuela de donde procedían los estudiantes de ambas ingenierías. Los resultados más destacados

demuestran que la demanda de ambas ingenierías es equivalente, aunque en cuanto al sexo existe una preponderancia por parte de los hombres. Asimismo, se puede indicar que el grado de avance disminuye en el segundo y tercer semestre de ambas carreras, ya que los alumnos consideran que son los de mayor grado de dificultad. Para atender estas situaciones se recomiendan estrategias de atención que incluyan asesorías, tutorías, canalización psicológica, entre otras.

Palabras clave: deserción escolar, eficiencia, rendimiento escolar, repetición de curso.

Abstract

The objective of this research was to analyze some indicators of the academic trajectory of students of Computer Engineering (ICO) and Engineering in Systems and Communications (ISC) (2014-2019 cohort) of the UAEM Valle de México University Center. For this, a non-experimental type of work was developed, in which the following indicators were taken into account: number of students who completed their study plan, degree of progress, school dropout, failure, type of exam (ordinary, extraordinary and title) by which students pass when they are taking a subject for the second time and the school where the students of both engineering degrees came from. The most outstanding results show that the demand of both engineering is equivalent, although in terms of sex there is a preponderance on the part of men. Likewise, it can be indicated that the degree of progress decreases in the second and third semesters of both careers, since students consider that they are the ones with the highest degree of difficulty. To attend to these situations, attention strategies are recommended that include counseling, tutoring, psychological channeling, among others.

Keywords: school dropout, efficiency, school performance, grade repetition.

Resumo

O objetivo desta pesquisa foi analisar alguns indicadores da trajetória acadêmica de alunos de Engenharia de Computação (ICO) e Engenharia de Sistemas e Comunicações (ISC) (coorte 2014-2019) do Centro Universitário UAEM Valle de México. Para tal, foi desenvolvido um tipo de trabalho não experimental, no qual foram considerados os seguintes indicadores: número de alunos que concluíram o plano de estudos, grau de aproveitamento, evasão escolar, reprovação, tipo de exame (ordinário, extraordinário e título) pela qual os

alunos passam quando estão cursando uma matéria pela segunda vez e a escola de onde vieram os alunos dos dois cursos de engenharia. Os resultados mais marcantes mostram que a demanda de ambas as engenharias é equivalente, embora em termos de sexo haja uma preponderância por parte dos homens. Da mesma forma, pode-se indicar que o grau de progressão diminui no segundo e terceiro semestres de ambas as carreiras, uma vez que os alunos se consideram com maior grau de dificuldade. Para atender a essas situações, são recomendadas estratégias de atenção que incluem aconselhamento, tutoria, canalização psicológica, entre outras.

Palavras-chave: evasão escolar, eficiência, desempenho escolar, repetência.

Fecha Recepción: Septiembre 2020 **Fecha Aceptación:** Febrero 2021

Introduction

Globalization, the use of ICTs and knowledge have imposed new challenges on higher education to transform society and promote development. These factors, in fact, have led to a reconsideration of whether the services they provide to the community are adequate, so it is necessary to analyze the quality of the training that students receive during their time at university.

The quality of higher education institutions (HEIs) depends on the relevance of the programs offered, which can be known through various indicators of the academic trajectory, such as lag, failure, terminal efficiency and dropout. These allow diagnosing and determining the impact of the education received by the students, as well as the efficiency of the institutions (González, 1999), which ultimately serves to develop and apply alternatives that allow strengthening the operation of the university.

Regarding school dropout, this constitutes, due to its magnitude, an important problem of the national education system. The high dropout rates that occur at all educational levels have a negative impact on the political, economic, social and cultural processes of national development.

In Latin America, social inequality is high and the dropout rate ranges between 40% and 70%, which contributes to expanding this situation. In this sense, students from the most vulnerable groups are often the ones who do not finish their studies (Salmi, 2016).

In the case of Mexico, some of the difficulties faced by higher education have to do with coverage, infrastructure, academic staff, curricular program, quality of professional and teacher training, scientific production, terminal efficiency , among others (Rugarcía, 1994).

In fact, some studies have made evident the need to know more about students, their expectations, their interests and motivations, as well as their problems and needs (Chaín-Revuelta, 1995; Reyes Pérez, 2006; Sánchez, 2006).

In this sense, within the 2013-2018 Education Sector Plan of the federal government (in chapter 1, related to the Diagnosis of higher education and training for work) it is pointed out that the abandonment of studies in higher education is one of the challenges of the educational system. One of the criteria for evaluating the quality of an HEI is terminal efficiency by generational cohort, an indicator that can be measured by the failure, dropout and lag rates.

Due to the above, in the seventies of the last century, within the educational research of Mexico, studies focused on the academic trajectory, pedagogical relationships, interaction and daily experiences in the educational process emerged (De Allende and Gómez, 1989), which gave rise to a new educational trend. Of them, the studies of school trajectory focused on revealing the different problems that the student faces throughout his academic life. Its analysis provides information to design actions aimed at achieving a better student journey in the educational institution.

The first works on academic trajectories in Mexico were carried out in the eighties with descriptive designs, which attracted the attention of educational policy designers and HEI managers. This gave way to topics such as dropout, dropout, and terminal efficiency starting to position themselves on the research agenda.

In the first inquiries, the dimensions of the object of study began to be identified. In this way, an institutional type emerged, related to the internal efficiency of the system, terminal efficiency, performance and institutional evaluation processes linked to the performance of students. At the same time, another dimension focused on individual and group behavior reflected in school failure, success, dropout, lag, dropout, repetition, among others. This implied knowing basic questions that would help explain student attitudes in relation to their location and origin; for example, identify where they came from, their most common study habits, etc.

Now, due to the context in which some of these studies arose (Bartolucci, 1994, 1998; Calatayud and Merino, 1984; Camarena, Chávez and Gómez, 1985; Covo, 1988; Gómez, 1990; Noriega, 1989; Tinto, 1993), the definition of the indicators was established according to academic, administrative and normative guidelines of the institutions themselves.

From a quantitative point of view, monitoring the academic trajectory of students entering the university allows us to know, among other things, the behavior of enrollment throughout the semesters and identify possible action strategies based on academic support provided by the institution, as shown below.

For example, at the Autonomous University of Tamaulipas (UAT) a big data analytical model was implemented, which considers that school dropout is a multifactorial problem that cannot be addressed with the analysis of limited information. This model makes it possible to cross and integrate data from different associations, organizations and external institutions with data from the institutional information systems themselves in order to identify the causes and factors that influence university dropout. (UAT, 2016).

In the case of the degree in Psychology from the National Autonomous University of Mexico (UNAM), it is considered that the problems of lag and dropout are complex and have multifactorial causes, so that the alternatives to reduce these indices and improve the quality of the Education requires the joint and coordinated participation of the sectors involved in the educational process: students, administrators and teachers. In this IES it is considered essential to identify the advantages and limitations of the Institutional Tutoring Program, which needs to have a mechanism to monitor and evaluate the effects and impact of the program on academic performance. Another proposal in the aforementioned house of studies is to continue with the activities of the Center for Attention and Monitoring of Academic Development (CASDA) to support and guide students regarding the development of study strategies, reading comprehension and other issues associated with academic performance (UNAM, 2015).

In this way, by detecting students with levels of risk of dropping out, efforts will be able to prioritize attention, in a corrective manner, helping those who are at high levels of school risk; as in a preventive way supporting students without risk to remain at this level.

In accordance with the previous ideas, the Autonomous University of the State of Mexico (UAEM) proposes the following in the Master Plan for Institutional Development (PRDI):

> The Autonomous University of the State of Mexico, like other institutions of higher education, has established quality standards and the means to achieve them. It is expected that these mechanisms will allow, among other achievements, to reduce school dropout and failure, to increase terminal

> efficiency, which will result in the training of competent, creative and innovative professionals (UAEM, 2017a, p. 65).
>
> When talking about quality in the training of our students, it is essential to analyze the indicators that account for it. One of these indicators is the failure rate in professional studies; This allows to deduce the efficiency of the educational process (achievement) and induces to look for contextual references (social and economic, basically) of the students who enter this scheme of failure and possible failures in the teaching-learning process (UAEM, 2017a, p. 66).

Based on the previous precepts, the UAEM in 2004 implemented the Institutional Model of Curricular Innovation (MIIC), which is based on flexibility and teaching based on competencies and on the student. The MIIC lays the foundations for the training of professionals to respond and permanently adjust to social demands and scientific, humanistic and technological advances, and promote the balanced articulation of knowledge (knowledge), know-how (procedures), knowing how to be (values), that promote critical thinking and develop the ability to solve problems both in the disciplinary theoretical context and in the social context (real field, insertion of the profession), with an interdisciplinary and transdisciplinary vision (Moreno, Medina, Espinoza and Miranda, 2005).

Likewise, it is inserted into the General Development Plan of the University, since the problem of failure is closely linked with dropout, that is, the percentage of students who fail to acquire the minimum knowledge necessary to accredit the subject taken within the plans set for it.

Currently, according to official figures, more than 30% of upper secondary students have difficulties in successfully acquiring knowledge and skills in different subjects, especially in disciplines such as mathematics, physics, chemistry, English and biology. For this reason, the Education Sector Program has set, by 2021, the goal of reducing the failure rate from 30% to 18% at this educational level, with special emphasis on the indicated areas (UAEM, 2009).

Finally, it is possible to point out what is indicated within the Development Plan of the Valle de México University Center (PDCUVM), where “to support students who present lag, 18 remedial courses and academic mentoring were implemented, in case of failure, special groups and intensive courses" (UAEM, 2017b, p. 21).

Academic trajectory

The academic trajectory refers to the quantification of the school behavior of a group of students with similar characteristics (cohort) during their educational journey or stay (that is, from admission to completion of credits and the academic-administrative requirements that define the curriculum) (Ponce de León, 2003). This construct also includes the set of factors and data that affect and account for the school behavior of students during their stay at the university (Fernández, Peña & Vera, 2006).

Chaín-Revuelta (1995) explains that school trajectories require differentiating a set of issues ranging from internal efficiency, terminal efficiency and performance to the academic behaviors of students during their school life (such as academic achievement, failure, success, achievement, approval, disapproval, repetition, and abandonment). The school trajectory, therefore, constitutes a set of factors and data that affect and show the school behavior of students during their stay at university (Cuevas, 2001). These factors can be psychological and sociological (qualitative), or they can provide accurate data on the academic results of students (quantitative).

Considering the previous definitions, it can be affirmed that the academic trajectory is linked to the journey of a group of students in a study plan, which generate important information for the decision-making of educational institutions.

School performance

For Galán (1985, cited by Romero, 2006) school performance is the degree of educational success or failure set based on the achievement of academic goals, in terms of learning objectives achieved and individual or group grades obtained. In other words, academic performance can be defined as the average of the grades that students obtain at the end of the school term, and is an important factor in the analysis of the quality of an institution, since it offers an approximation to the educational reality .

For this reason, Chaín-Revuelta (1995) suggests that studies of school trajectories become an excellent platform for the implementation of improvements in terms of objectives, strategies and curricular changes that allow addressing dropout and lag, problems of great international scope (Martínez-Rizo, 2001).

School dropout

School dropout refers to a situation in which the student is repeatedly absent from classes until, finally, they leave the educational system. There are various causes for which the students drop out, among which are economic and family problems, academic and social situations, etc.

Methodology

The present research was non-experimental and was developed by cohorts, that is, a group of students who enter a professional career in the same year (Cancela, Cea, Galindo y Valilla, 2016).

Method and participants

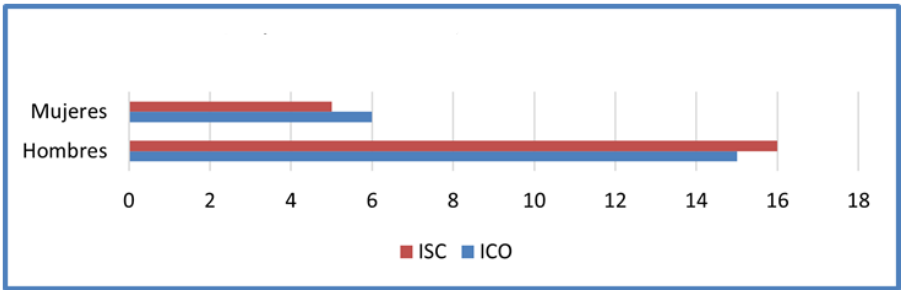
The procedure that was carried out was the analysis of the database of the Department of School Control of the University Center, from which the following study criteria were considered, validated by said instance: year in which they entered and graduated, subjects with higher failure rate (these data provide students' lag), semester in which these subjects are taught (to specify where there is the greatest complication for students) and type of exam to accredit each subject.

In the study, 153 academic trajectories were analyzed —provided by the Department of School Control of the UAEM Valle de México University Center— corresponding to 76 Computer Engineering students (ICO) and 77 Systems and Communications Engineering students (ISC), which belong to the generational cohort 2014-2019. Of the total, 26.4% are women and 73.6% men. Their age ranges ranged from 17 to 22 years.

Results

With the data provided by the Department of School Control of the UAEM Valle de México University Center, it was obtained that in both careers 21 students completed their study plan (27.6% and 27.2%, respectively): 15 men (71.4%) and 6 women (28.6%) in Computer Engineering (ICO), and 16 men (76.1%) and 5 women (23.8%) in Systems and Communications Engineering (ISC), (Figure 1).

Figura 1. Alumnos que concluyeron el plan de estudios



Fuente: Elaboración propia

Degree of progress

The degree of progress is defined as the number of students who are enrolled in each semester. Both engineering programs comprise 10 semesters (table 1).

Tabla 1. Porcentaje de grados de avance

	1.°	**2.°**	**3.°**	**4.°**	**5.°**	**6.°**	**7.°**	**8.°**	**9.°**	**10.°**
ICO	96.2	83.6	89.3	91.7	92.3	95.4	95.3	97.2	97.5	98.3
ISC	97.1	85.3	88.7	93.4	93.6	95.1	96.2	96.6	98.2	98.7

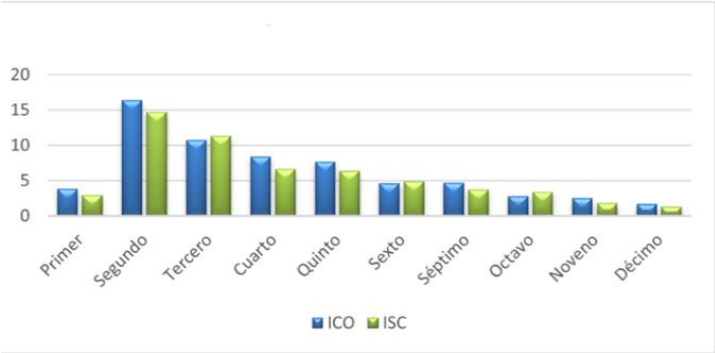
Fuente: Elaboración propia

As can be seen in table 1, the degree of progress per semester of the students remains at a high level for both careers, although a decrease is perceived in the second and third. In this regard, it can be indicated that these would be the most difficult moments to face in the races because the adaptation process must be consolidated. In fact, when asking the graduates about this situation, the majority considered the degree of complexity of the subjects, the lack of knowledge or personal problems.

Desertion

Another indicator considered in the study of the students' trajectories was dropout, which refers to the abandonment of the subjects or career in which the students were enrolled (figure 2).

Figura 2. Deserción



Fuente: Elaboración propia

Figure 2 shows that the dropout levels are presented with greater emphasis in the second and third semesters. Some of the most frequent causes for making this decision are the lack of identification with the career, financial, personal and academic problems, and specifically the number of failed evaluations during their stay at the institution (Vázquez Lozada, 2016).

Reprobation

Failure is the number or percentage of students who have not obtained the necessary knowledge in a certain subject, which is why they are forced to take it (National Institute of Statistics and Geography [Inegi], 2006). According to the data provided by the School Control Department, the subjects with the highest failure rate in Computer Engineering (ICO) and Systems and Communications Engineering (ISC) are shown in table 2.

Tabla 2. Materias con mayor índice de reprobación

Área	Materia	Semestre
Ingeniería en Sistemas y Comunicaciones		
Ciencias básicas y matemáticas	Álgebra y geometría analítica	Primero
	Álgebra lineal	Segundo
	Cálculo diferencial e integral	Segundo
	Ecuaciones diferenciales	Tercero
	Lógica matemática	Tercero
	Cálculo vectorial	Cuarto
Área	**Materia**	**Semestre**
Ingeniería en Computación		
Matemáticas	Álgebra superior	Primero
	Cálculo I	Primero
	Geometría analítica	Primero
	Física	Segundo
	Álgebra lineal	Segundo
	Cálculo II	Segundo
	Cálculo III	Tercero
	Ecuaciones diferenciales	Tercero
	Análisis de Fourier	Cuarto

Fuente: Elaboración propia

Considering the above, the subjects with the highest failure rate are in the area of basic sciences and mathematics, located in the first three semesters of both careers, which is related to the dropout detected in those semesters. Some of the causes of this situation are not having basic knowledge, the degree of complexity of the subject and finally the teacher.

On the other hand, Table 3 shows the type of exam (ordinary, extraordinary and title) by which students pass when they are taking the subject for the second time. In addition, it shows the percentage of students who pass each type of exam and the range of grades they obtain, which is low, despite taking it a second time.

Tabla 3. Tipo de examen mediante el cual los alumnos aprueban en un segundo curso

		Tipo de examen			
Área	**Materia**	**Ordinario %**	**Extraordinario %**	**Título %**	**Rango de calificación**
Ingeniería en Sistemas y Comunicaciones					
Ciencias básicas y matemáticas	Álgebra y geometría analítica	10	50	30	6-8
	Álgebra lineal	25	30	45	6-8
	Cálculo diferencial e integral	45	40	15	6-8
	Ecuaciones diferenciales	50	45	5	6-8
	Lógica matemática	15	35	50	6-8
	Cálculo vectorial	20	45	35	6-8
Área	**Materia**				
Ingeniería en Computación					
Matemáticas	Álgebra superior	35	50	15	6-8
	Cálculo I	25	45	30	6-8
	Geometría analítica	40	35	25	6-8
	Física	55	35	10	6-8
	Álgebra lineal	45	30	25	6-8
	Cálculo II	20	55	25	6-8
	Cálculo III	15	65	20	6-8
	Ecuaciones Diferenciales	45	30	25	6-8
	Análisis de Fourier	40	20	40	6-8

Fuente: Elaboración propia

Finally, the information provided by the School Control Department also allowed us to know the school from which the students of both engineering degrees came (table 4), a fact that could be significant, since some contact could be established with the authorities of those institutions to show them the areas of opportunity in the area of mathematics.

Tabla 4. Escuelas de procedencia de los alumnos de ICO e ISC

Ingeniería en Sistemas y Comunicaciones	• Centro de Estudios Tecnológicos Industrial y de Servicios nro. 35 • Colegio de Estudios Científicos y Tecnológicos del Estado de México, plantel Nicolás Romero • Escuela Preparatoria Oficial nro. 148 • Escuela Preparatoria Oficial nro. 87 • Colegio de Bachilleres nro. 5
Ingeniería en Computación	• Colegio de Bachilleres nro. 5 • Colegio de estudios Científicos y Tecnológicos del Estado de México, plantel Nicolás Romero • Escuela Preparatoria Oficial nro. 87 • CBTS Atizapán de Zaragoza • Centro de Estudios Tecnológicos Industrial y de Servicios nro. 35 • Nueva Escuela Tecnológica Nicolás Romero.

Fuente: Elaboración propia

Discussion

The results show that the demand for both engineering is equivalent, although in terms of sex there is a preponderance of men. Likewise, it can be indicated that the degree of progress decreases in the second and third semesters of both careers, since students consider that they are the ones with the highest degree of difficulty. This situation is generated because students lack solid foundations to face the subjects belonging to the basic sciences, which causes the levels of failure and lag to increase, since some of these subjects have seriation. In fact, Programming is one of the subjects that is most difficult for them, which has a greater serialization.

On the other hand, not identifying with the career, as well as economic, personal and academic problems are the causes of dropping out of studies. Likewise, the school of origin of the students of both engineering degrees could be considered as important information to communicate to their respective authorities the areas of opportunity in which they can support their students.

Conclusions

The study and monitoring of academic trajectories in higher education institutions constitutes an essential source of information to improve educational quality. This is because by analyzing the trajectories, the risk levels in which the students are can be identified, which could serve to create support strategies. In this sense, the proposed solutions are explained below:

Academic mentoring

This strategy consists of offering disciplinary advice through outstanding students, specifically in subjects that represent academic risk, as well as recommending learning and study strategies to improve school achievement through student-student interaction.

Consulting

The consultancies can be offered by a different teacher than the one who teaches the subject. These would try to support students in a problem situation and solve academic doubts. Students would request advice through their tutor, directly with the tutoring coordinator or with the teacher.

Tutorials

The tutorials would be personalized attention strategies to reduce dropout rates and contribute to the comprehensive training of the student. In this sense, it is proposed that the tutors fulfill their different administrative and academic activities to support the students in their passage through the educational program.

Psychological channeling

Sometimes the poor academic performance of the students is due not only to the misunderstanding of the subject matters, but also to personal problems, for which they require psychological attention. Therefore, the tutor must put the student in contact with the relevant authority.

Reading comprehension

Text comprehension is essential for learning because most of the information received comes from written sources. Therefore, the application of didactic strategies in this area would contribute to reducing failure rates.

Teaching update

Teacher updating is an important factor in developing useful attitudes and skills to enhance students' abilities to solve problems.

In short, it can be concluded that the school trajectory indicators offer mechanisms that serve to propose strategies that could be implemented to serve students throughout their academic career.

Future jobs

Some lines of research that could be developed in future work are the following:

- Update the Academic Tutoring Information System to have an academic information management tool that systematizes, monitors and evaluates the tutorial activity. This would be useful for the student to have contact with her tutor, while the latter would serve to support the student in a timely manner through the analysis of their academic record.
- Integrate into the School Control System a section that allows career coordinators to obtain information on the trajectory of students in a simple and graphic way. In this way, the subjects taken, the second courses, the subjects failed, the pending subjects, the degree of progress, the status of the students, etc. could be identified.

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