Acceso a tecnologías en el rendimiento universitario en tiempos del covid-19: análisis de asociación por clústeres

Access to technologies in university performance in times of covid-19: analysis of association by clusters

Acesso a tecnologias no desempenho universitário em tempos de covid-19: análise de associação por clusters

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Resumen

Ante los conflictos generados por el covid-19 en el ámbito educativo, las instituciones de educación superior se vieron en la necesidad de trasladar sus actividades al plano virtual, lo que modificó significativamente las formas de enseñanza y aprendizaje, y provocó nuevos retos y desafíos para el rendimiento académico de los estudiantes. En este contexto, el objetivo de la presente investigación fue analizar la asociación entre el rendimiento académico y el número de días de inactividad por covid-19. Para tal fin, se utilizó una metodología cuantitativa descriptiva de análisis no supervisado en una universidad pública de la Ciudad de México.

Entre los resultados obtenidos, se encontró que en su mayoría el promedio de calificaciones de los estudiantes fue de 7.9 y 8.5, con una media de 8.2. Asimismo, se decidió dividir a los alumnos en tres grupos (clústeres) según su rendimiento académico, y se encontró una asociación entre el rendimiento y el uso de las tecnologías de información (TI). En conclusión, se determinó que el uso de las TI está asociado con un mayor rendimiento académico de los estudiantes universitarios, a pesar de estudiar en un entorno afectado por la pandemia de covid-19. Por lo tanto, se considera importante garantizar el acceso de todos los estudiantes a estas herramientas mediante una buena conectividad a internet.

Palabras clave: rendimiento académico, covid-19, universidades públicas, herramientas tecnológicas, uso de TIC.

Abstract

Due to the COVID-19 pandemic, higher education institutions have had to shift their activities to the virtual realm, resulting in significant changes to teaching and learning methods and presenting new challenges for students' academic performance. This research aimed to examine the association between academic performance and the number of days of COVID-19-related inactivity. A descriptive quantitative methodology of unsupervised analysis was employed in a public university in Mexico City.

The results revealed that the majority of students had a grade point average between 7.9 and 8.5, with an average of 8.2. The students were also divided into three groups (clusters) based on their academic performance, and it was found that there was a correlation between performance and the use of information technologies (IT). In conclusion, it was determined that the use of IT was associated with higher academic performance among university

students, despite studying in an environment affected by the COVID-19 pandemic. Therefore, it is essential to ensure that all students have access to these tools by providing good internet connectivity.

Keywords: academic performance, COVID-19, public universities, technological tools, ICT use.

Resumo

Diante dos conflitos gerados pela covid-19 no campo educacional, as instituições de ensino superior se viram na necessidade de transferir suas atividades para o plano virtual, o que modificou significativamente as formas de ensinar e aprender, e trouxe novos desafios para o desempenho acadêmico dos alunos. Nesse contexto, o objetivo desta pesquisa foi analisar a associação entre o desempenho acadêmico e o número de dias de inatividade devido à covid-19. Para tanto, foi utilizada uma metodologia quantitativa descritiva de análise não supervisionada em uma universidade pública da Cidade do México.

Dentre os resultados obtidos, constatou-se que a maioria das notas médias dos alunos foram 7,9 e 8,5, com média de 8,2. Da mesma forma, decidiu-se dividir os alunos em três grupos (clusters) de acordo com seu desempenho acadêmico, e foi encontrada uma associação entre o desempenho e o uso de tecnologias de informação (TI). Em conclusão, foi determinado que o uso de TI está associado a um maior desempenho acadêmico de estudantes universitários, apesar de estudarem em um ambiente afetado pela pandemia de covid-19. Portanto, considera-se importante garantir o acesso de todos os alunos a essas ferramentas por meio de uma boa conectividade com a internet.

Palavras-chave: desempenho acadêmico, covid-19, universidades públicas, ferramentas tecnológicas, uso de TIC.

Introduction

The covid-19 pandemic has had a significant impact on higher education worldwide, forcing institutions to reconsider the use and capabilities of information technology (IT) (Gamage et al., 2020). In this context, measures have been taken to respond to the new conditions, taking advantage of the new resources to adapt to confinement and guarantee distance education through them (Tuyishimire et al., 2022). All of this is in line with

sustainable development goal number 4, which promotes quality and lifelong learning opportunities (United Nations, 2020), allowing for social and economic mobility.

The inclusion of IT has been accepted by university students, since they are digital natives (Youssef et al., 2022). This has allowed them to accept them responsibly (Limniou et al., 2021) and facilitated learning for those who are self-taught (Hidalgo, 2021). In fact, because every day there is an increase in the use of educational computer applications (Adeyeye et al., 2022) and students have access to more digital resources (Cobo-Rendon et al., 2021), some authors consider that technologies manage to increase the academic performance of university students (González et al., 2020).

However, the World Bank found that online learning has not been entirely successful due to the need for effective teachers, appropriate technology, and engaged learners (Pintor, 2020). In addition, these unfavorable results are due to various social and economic factors that respond to the individual context, for example, the techno-stress of the students (Essel et al., 2021), which refers to the saturation of individual and educational activities at the level virtual; the new skills that teachers must acquire (Aristovnik et al., 2020; Lu et al., 2020), whose adaptation to the new teaching system was not easy for everyone; and the added difficulty of internet connectivity problems (Ilieva et al., 2021; Ruiz et al., 2021), as well as problems related to inequality in access to a study space. (Torres-Díaz *et al*., 2022).

Although in Mexico they have tried to reduce these inequalities of resources and the digital gap with the Aprende en Casa program for basic education, in higher education the universities only attended students who —in addition to living in low-income situations, that is, , without home internet access or electronic devices—had a minimum grade point average of 8. However, while this benefits some students with special needs, it does not cover all. A student who lives in a situation of low economic resources, and does not have access to the Internet or electronic devices to carry out their tasks, will hardly be able to achieve the academic performance that is reflected in an average of 8 on a scale of 5 to 10. .

The reflection on these problems, as well as the analysis of other research at a global level on the subject of covid-19, technology and academic performance make an analysis of the situation in Mexico essential to assess the knowledge of students (Sobral and De Oliveira, 2021), which also provides the latter with information on their final performance (Orsmond et al., 2000). However, in the country there are few investigations that evaluate the association between these points in higher education, despite the fact that social inequalities between students become more evident.

Therefore, the objective of this research is to analyze the association between academic performance and days of inactivity due to covid-19, the subjects in which a student enrolls, attendance at online classes while sick, access to IT, communication with these technologies, the teacher who teaches classes with IT and if he covered all the topics with technology. This association was used to find groups through the K-means method and analyze their relationship in the student's academic performance, which was measured as the grade point average in the January-June 2021 school period.

In this way, the following research question was raised: at the higher level can IT increase academic performance in times of the covid-19 pandemic? This question is answered with the results presented later in the graph of the three clusters that were found. Next, the scientific literature that justifies the investigation is presented.

Academic performance with digital tools in times of covid-19

Distance education through digital media has proven to be the only resource available as a substitute for traditional in-person learning methods due to the global lockdown generated by the covid-19 pandemic. For this reason, educational institutions around the world have invested heavily in distance learning, as this method has been shown to increase student academic performance (Alam et al., 2021). In this sense, it has been indicated that the higher the percentage of educational resources viewed through digital technologies, the higher the academic performance is obtained (Cobo-Rendon et al., 2021). Among these tools we can mention educational platforms such as Zoom and Moodle, which have had a positive impact on the academic performance of students in courses that involve practicals (Adeyeye et al., 2022).

However, it is important to consider that the adoption of digital tools due to the pandemic has had adverse effects (such as techno-stress), despite its advantages for both students and faculty (Essel et al., 2021). Indeed, the overload of activities in the virtual space, as well as the disappearance of the physical borders between work and home can negatively affect mental health and rest or leisure time.

Even so, during the confinement, new technologies and didactic platforms have allowed new methodologies to rise above the educational ecosystem as an adaptive process that began a couple of years ago to train future generations with skills for innovation and the creativity that are required in the workplace (Ruiz et al., 2021).

The pandemic has also presented factors that may be key in future education, since students have expressed that among all the digital resources they would like to keep after confinement are recorded classes (96%), video notes (74 %), online tutorials (51%) and the possibility of having classes at home (43%) (Ruiz et al., 2021). This shows that among the benefits offered by online education is the possibility of reviewing the activities that were not fully understood during real class time and accessing tutorials from home, which allows greater concentration by not having to to move around the city.

Inactive days due to covid-19

Some students have experienced days of inactive learning due to internet connectivity issues (Lahiri & Sinha, 2021). On the other hand, at a private university in Riyadh, Saudi Arabia, it was found that 37% of students missed classes for fear of contagion from covid-19, while 10% of students feared not being able to attend exams. if they contracted the virus (Rashid et al., 2022). Therefore, it is recommended to carry out studies on academic absenteeism in times of pandemic (Nathwani et al., 2021), since up to 44% of academic absenteeism due to covid-19 in universities has been reported (Gressman and Peck, 2020).

At the Autonomous University of Madrid (González et al., 2020), the effects of confinement due to covid-19 on the performance of university students were analyzed, for which they divided 458 students into two groups: one control and the other experimental. . The results showed that online education during the confinement had a positive and significant effect on the academic performance of the students, which can demonstrate that information technologies are useful and necessary in the learning process.

This is also seen in an increase in the use of language learning applications, virtual training, video conferencing tools and online learning programs since covid-19 (Adeyeye et al., 2022). Although all this arose to a large extent due to the confinement and the increase in time in people's routine, it also shows the interest of people in learning and how easy it is to use information technologies.

In Nigeria, at least 91% of students were affected by the closure of higher education institutions. Even so, despite the difficulties of students to adapt to the new modality, 73.9% of them considered that online learning platforms are more convenient than conventional learning, since it allows them to attend classes from home and control course materials (Adeyeye *et al*., 2022).

In general, students did not experience significant problems adapting to digital transformations due to their commitment to information technologies in their university and personal lives. However, the covid-19 pandemic forced to change habits and take advantage of the experience to develop self-regulation approaches and strategies that can affect both teaching and learning, which can be reflected at the end of the confinement (Limniou et al., 2021).

On the other hand, at the University of Southeast China, 39,854 students were surveyed to measure the effectiveness of online education. The results showed that although covid-19 had a severe impact on normal educational progress, universities took advantage of such a moment to detect deficiencies and accelerate the reform of online education through IT. (Sun *et al*., 2020).

IT access

The use of IT as tools for learning and quality education is essential and useful, as they meet the demand of users. However, access to connectivity can hinder the learning process and academic performance when used for educational purposes. During the covid-19 pandemic, the Internet connection has become a social conflict throughout the world, since the lack of a good connection prevents continuing adequately with work routines and other activities that have been transferred to the virtual plane from of confinement, including online education.

Students at a university in China reported the quality of internet connectivity (32.4%), the lack of a study hall (20.5%), the lack of interest from professors in teaching online (18.1%), and the lack of an adequate communication device (8.1%) are the main problems they face (Ilieva et al., 2021). In addition, students living in rural areas more frequently experience a slow internet connection, and low economic status becomes a barrier to having an adequate physical environment for good academic performance.

Ruiz et al. (2021) agree that both students and teachers faced logistical problems after lockdown, such as bandwidth, servers, infrastructure to teach online, and access to hotspots. In addition, each teacher had to adapt their subject to the new online education system, which could have caused a disparity in their rate of adaptation to the new circumstances.

Therefore, it is necessary to guarantee universal access to the Internet to allow the constant use of IT and, therefore, the use of it in the education and learning processes. It is crucial to address the most urgent need to provide connectivity in rural communities.

Communication with IT

The current student population is made up of "digital natives" who have grown up with new technologies. For these students, the use of IT is common, and academic performance improves with innovative and collaborative use of IT, as long as the users aim to improve their learning. For example, self-taught students benefit from the advantages of online tools, although others may find it difficult to adapt, which may be due to two main factors: little access to these tools or lack of interest in using them for these purposes (Hidalgo et al., 2021; Youssef et al., 2022).

In fact, although the use of IT in university learning processes has generated different benefits for both students and teachers, its use has also been observed to reduce participation in collaborative learning, interaction between students and teachers, and debate. bidirectional. This is due to the constant interaction between screens and therefore the communication limit between peers. For this reason, it is important to analyze aspects of IT communication between teachers and students (Álvarez-Risco et al., 2021).

Research by Haider and Al-Salman (2020) found that in a Jordanian university during the covid-19 pandemic, out of 775 students, 59.5% indicated that face-to-face interaction significantly contributes to improving their academic performance, while that 55.5% mentioned that the volume of tasks through e-learning generated confusion, frustration and poor performance. This shows that despite the benefits of these tools in the learning process, some IT still have communication gaps between peers.

Continuing with the communication aspects, it is observed that the student-student dialogue and the course design are predictive factors of the perceived learning results, while the teacher-student dialogue is a determining factor in the student's initiative. This exposes the personal interaction in the exchange of ideas as fundamental in the learning process. (Tsang *et al.*, 2021).

Teachers who use IT

With a sample of 30,383 students from 62 countries, Aristovnik et al. (2020) found in their study that during the lockdown and transition to online learning, students were satisfied with the support provided by their universities' faculty and public relations staff. However, poor information technology skills and increased workload, mainly in financially challenged students, prevented them from perceiving their own performance (Aristovnik et al., 2020). These data show that, as mentioned before, despite the benefits offered by

technological tools, they cannot be fully exploited when there are inequalities in access and knowledge.

In the face of lockdown, university professors had to quickly switch from face-to-face teaching to online teaching to ensure academic continuity. In such a scenario, the institutions should have favored this modality with the incorporation of virtual tools and learning management systems. However, for these tools to play a positive role in teaching, both students and teachers had to acquire new skills in the use of technological resources (Cobo-Rendon et al., 2021). However, this was not the same for everyone, since depending on the social, economic and emotional context of each person, some were able to learn these skills better than others.

Regarding the acceptance of IT during confinement by teachers, it was found that in a Chilean university, 38 of 251 teachers had low technological acceptance, the majority being men. In addition, these teachers were found to have shorter connection times compared to teachers with high technological acceptance (Cobo-Rendon et al., 2021). Although this is not a large sample, it can explain that the use and benefit of IT is related to the knowledge of use and access to it. In other words, if a person does not have easy access to the internet or does not have enough skills to use the tool, it will be more difficult for them to adapt to online education, so they will give priority to the traditional system.

With the current combination of the two modes of learning (face-to-face and online), it is necessary for teachers to acquire easy-to-use tools that allow them to monitor the learning process and detect students at risk from an early stage. This translates into low dropout rates (7%) and high student satisfaction with the teaching-learning process (4.56 out of 5) (Sáiz-Manzanares et al., 2021).

On the other hand, it should be noted that e-learning has limitations in that both teachers and students must have skills, knowledge and experience in technology, as well as pedagogical skills to complete the course (Lu et al., 2020). Lack of IT skills can lead to poor academic performance and lack of motivation to learn. Therefore, the construction of online courses that meet the needs of students in limited conditions represents a challenge for universities (Lu et al., 2020), since this implies that teachers cover these skills and offer a suitable course for online learning, as well as each student's access to these tools.

In Mexico, some universities have offered economic and material support (delivery of tablets) to pay for the Internet connection, but this effort cannot be considered sufficient

if it is only offered in some schools and under some selection conditions to receive said support.

Topics with IT

During the covid-19 pandemic, IT-based materials have been used in higher education to transfer knowledge, so universities should continue to experiment with off-the-shelf technologies, such as various message boards and chat features, which which offers great benefit and can lead to a more self-sufficient workforce with variable levels of higher productivity and adaptation to change (Linnes et al., 2022).

It is essential to note that fewer digital materials to cover the topics of a course is an obstacle for students to achieve effective learning (Noor et al., 2020). In addition, digital materials are more flexible, since students can consult them from anywhere in the world (Haugom, 2022).

In this context, the following question arises: is there a significant association between academic performance, days of inactivity due to covid-19, access to IT, communication with IT, teachers using IT and topics covered with YOU?

To answer this question, this hypothesis is posed: access to IT, communication with IT and the topics covered with IT generate higher academic performance, measured by the average grades of students who use IT, despite that students have presented inactive days or absence from their classes due to covid-19 infections.

Method

This research was carried out at a public university in Mexico City, where a population of 13,500 students was studied. A random sample of 440 students enrolled in the school period from January to June 2021 was selected. The study was quantitative and descriptive, with unsupervised analysis, since a dependent variable was not used, but clusters were created through association.

Participants

The study participants were university students from a public school of the National Polytechnic Institute in Mexico City, who were randomly and voluntarily selected. The students belonged to five different study programs (Industrial Administration, Transportation

Engineering, Computer Engineering, Industrial Engineering and Computer Science). Some had suffered from covid-19 and had been absent or inactive in the academic environment. These university students can choose the number of subjects to which they enroll (from 1 to 10 subjects), since they can take a minimum or maximum load. The students also came from different regions of Mexico, where internet access featured different types of bandwidth, and some students resided in rural communities without internet access.

Research instrument

An online semi-structured survey was used, through Google forms, in which the following data was requested: 1) academic information such as the semester they were enrolled in, number of subjects they were taking, number of subjects failed, average general grades, among other questions, 2) information related to covid-19, such as infections, type of vaccine, days of academic inactivity due to virus infection, 3) access to technology by students, both hardware and software, 4) communication through IT, and 5) the support of teachers in teaching classes with digital technologies.

Previously, a pilot test was carried out with 10 students, and a reliability test of the scale was carried out through Cronbach's alpha coefficient. From the questions posed in the instrument, the variables presented in Table 1 were selected.

Table 1. Description of variables used in the study

Variable	Description
Academic performance	It is the average grade obtained by a student in the school period of the January-June 2021 semester.
Inactive days	Frequency of days in which the student was inactive due to covid-19, which had a scale 1) from 1 to 5 days, 2) from 6 to 10 days, 3) from 11 to 15 days, 4) from 16 to 20 days, 5) from 21 to 30 days, 6) more than 30 days.
Subjects	Subjects in which the student was enrolled. It is worth mentioning that a student may be enrolled in subjects from different semesters and from different academic programs.
Classes with covid-19	The student answered the frequency with which he attended classes while sick with covid-19: 1) partially, 2) yes
Access IT	Question formed through a construct that included hardware aspects: broad internet bandwidth, limited internet data use via mobile phone, computer, cell phone, tablet, shared computer.
Communication IT	Number of digital means that were used to communicate academically with teachers and classmates, such as email, WhatsApp, video calls, and internal messaging of the educational platform.
Professors IT	Number of digital media used by teachers to communicate with their students in an emerging way given the covid-19 pandemic, from digital presentations, video links, video calls, among others.
Topics IT	Percentages of topics covered by the teacher digitally that the students took.

Source: Self made

Analysis of data

The data was collected from the Google platform through a form and stored in a comma-separated flat file. Subsequently, they were analyzed using algorithms created in the Python Jupyter Notebook software (Anaconda3). Descriptive analysis using unsupervised learning was carried out to represent new knowledge without modeling a specific outcome, to identify inherent clustering within the data (Ebrahimi et al., 2022) and to look for hidden patterns (Koren et al. , 2020) due to the lack of a dependent variable. Therefore, a cluster analysis algorithm was developed by clustering association, based on distances between

groups, using the K-means method. In addition, to find the association, the dimensionality of the data was reduced by means of a principal component analysis that represented a wide probability of the data and two principal components were elaborated.

Unsupervised analysis approach

Regarding the unsupervised analysis approach, unsupervised machine learning algorithms from Python libraries were used, namely: 1) import pandas as pd, 2) import matplotlib.pyplot as plt, 3) import seaborn as sb, 4)) from sklearn.preprocessing import StandardScaler, 5) from sklearn.decomposition import PCA, 6) import numpy as np, 7) from sklearn.cluster import KMeans. Inertia and silhouette tests were performed to determine the number of clusters that would not represent losses.

Also, the K-means clustering algorithm was carried out, since it is an unsupervised learning algorithm that provides an easy way to classify a data set into a certain number of groups. That is, a data set such as X1, X2, X3,..., Xn are grouped into K groups, where each observation is assigned to a group whose mean value is closest to a centroid (Gonzáles Argote and Ticona Gonzáles, 2019). Furthermore, it is a modern machine learning model for grouping individuals based on related scores (Tuyishimire et al., 2022). It also offers a feasible solution to the problem of identifying groups of students with similar attitudes toward distance learning and academic achievement. (Ilieva *et al*., 2021; Sáiz-Manzanares *et al*., 2021).

Results

Figure 1 presents a graph that shows the academic performance of the students, in which it can be seen that the majority are between a grade point average of 7.9 and 8.5, with a mean of 8.2, in addition to some minor outliers. to 7.1 and greater than 9.3. Consequently, in the following sections the relationship between academic performance and the other variables studied will be discussed.

Figure 1. Graph of academic performance of the students surveyed
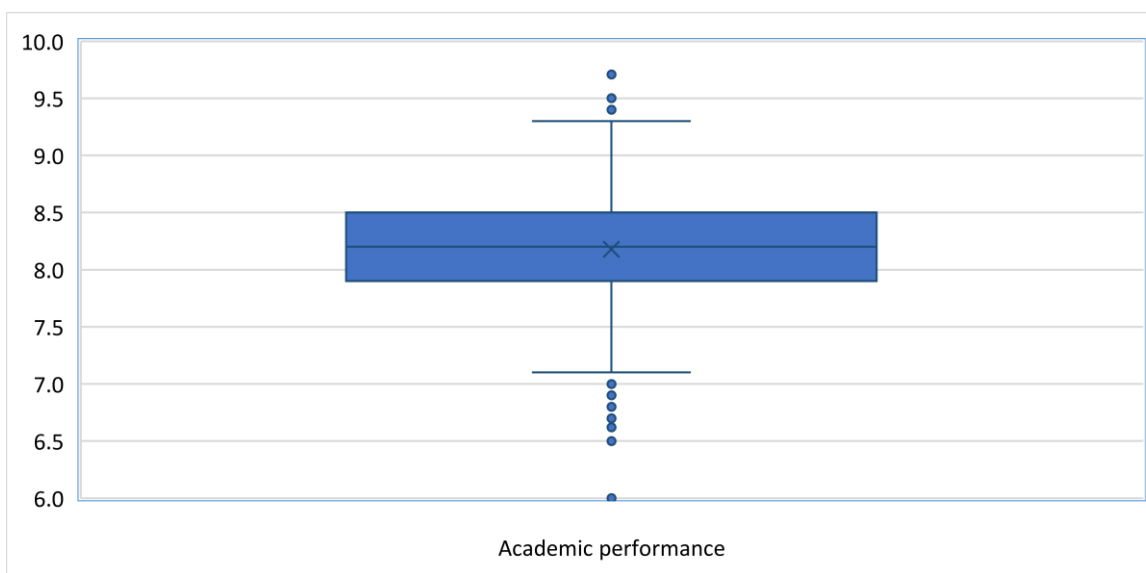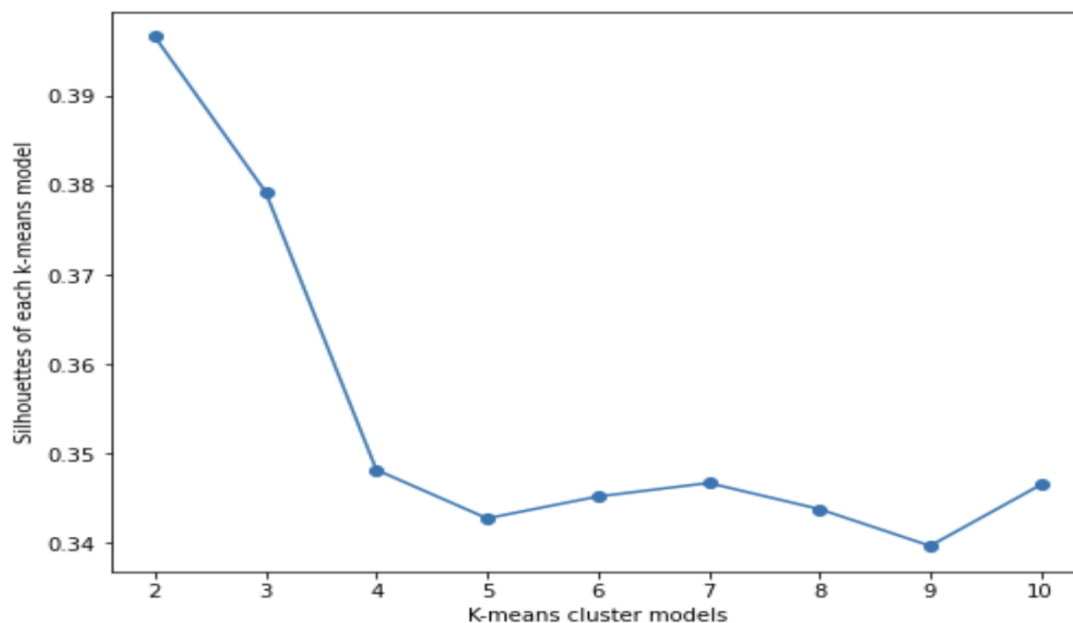

Source: Own elaboration

From the analyzed data, a principal component analysis was carried out, from which the inertia and silhouette graphs were obtained, presented in figures 2 and 3, respectively. Looking at both graphs, it was decided to generate three clusters. Subsequently, the grouping of the three clusters was carried out based on the two main components, which is shown in Figure 4.

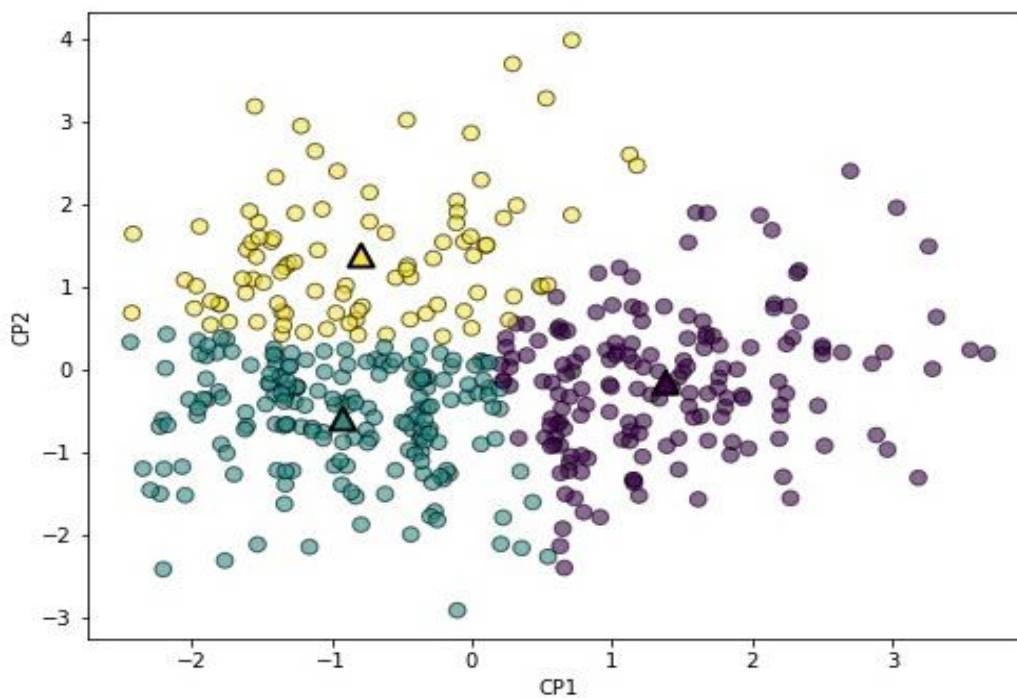**Figure 2.** Inertia graph of the K-means cluster models
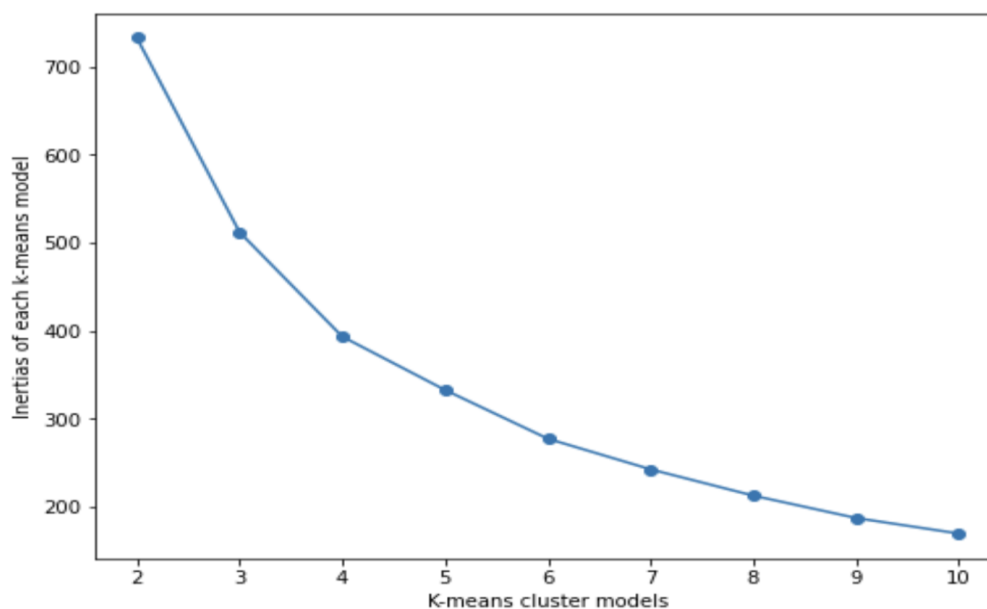
Source: Own elaboration

Figure 3. Silhouette plot of the K-means cluster models

Source: Own elaboration

Figure 4. Principal Component Clusters

Source: Own elaboration

Figure 5 shows the results of the association of variables, where they were grouped
as follows: 1) cluster 0: students with good academic performance (166 students); 2) cluster

1: students with excellent academic performance (182 students); and 3) cluster 2: students with low academic performance (93 students).

Figure 5. Association of three groups by academic performance
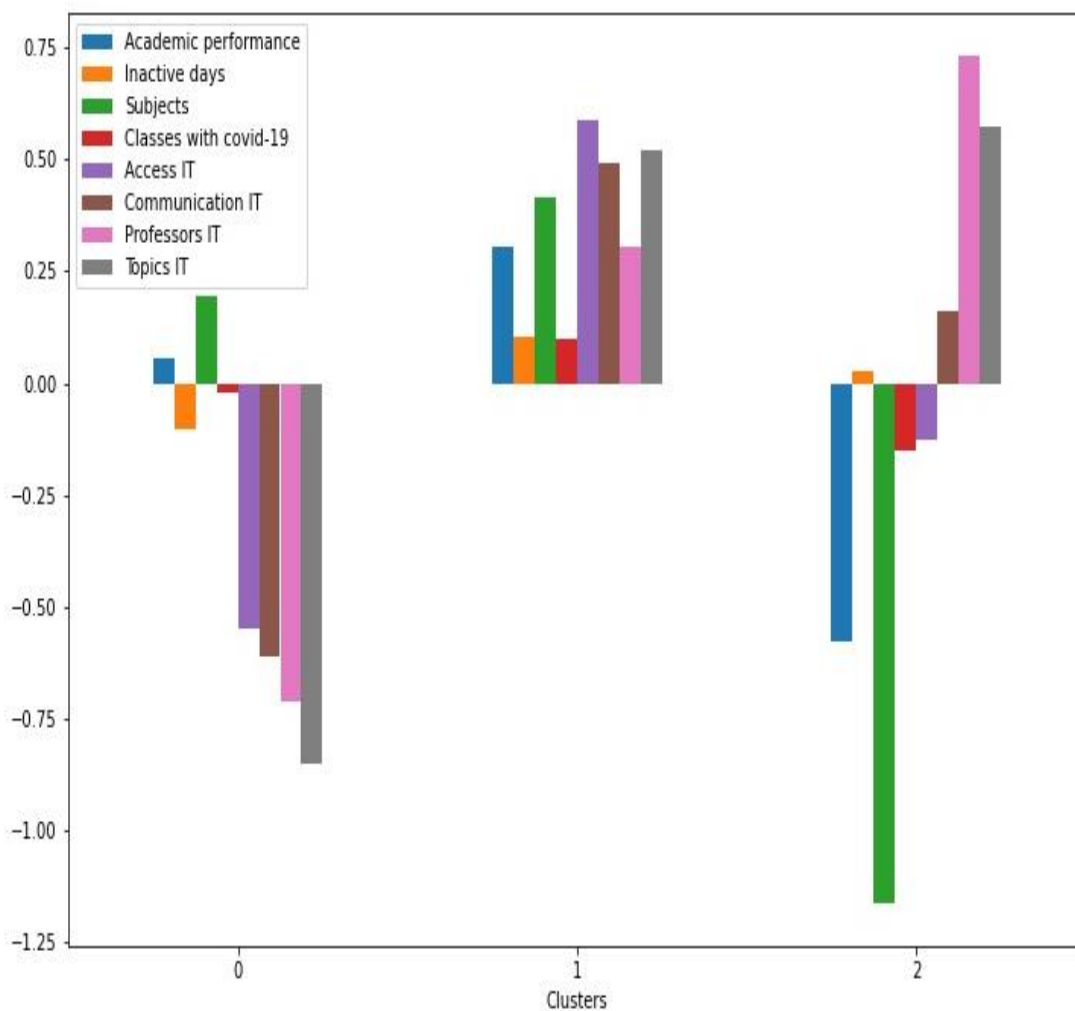
Source: Own elaboration

Discussion

Figure 5 shows the zero point, which represents the average of each variable. This indicates that the bars above zero are the data above the average and the bars below zero are below the average. Cluster 0, made up of students with good academic performance, presents an academic performance slightly above the normal average and a positive association with the number of subjects they enrolled in.

However, these students are below the average in terms of inactive days due to covid-19, classes with covid-19 and everything related to IT, that is, they have a lower average access to IT, less average communication with IT, lower average number of professors who use IT and lower average access to topics developed with IT. Due to this, its average could not be higher and was slightly above the normal average, which coincides with what was said by Ilieva et al. (2021) and Ruiz et al. (2021). When there are problems of access to IT, such as Internet connectivity, classes cannot be carried out online, so it does not make sense for the teacher to have all the subject material digitally.

On the other hand, cluster 1 —made up of students with excellent academic performance— presented the highest academic performance with the use of IT, despite the fact that the students were enrolled in a greater number of subjects than the normal average and attended classes with covid-19 disease. This group had greater access to IT, communication with IT, and teachers covered the topics with IT, which demonstrates an association between IT and academic performance in situations with covid-19. In the public university of study, access to IT is an important factor in achieving higher academic performance. However, it is important that students take responsibility for taking their classes online (Limniou et al., 2021), which may not be possible at other educational levels.

In cluster 2, students had a below-average GPA and, although they had some inactive days due to COVID-19 and were enrolled in subjects below the average for students, they did not have access to IT. Despite teachers using IT and covering topics with IT, the lack of access to IT prevented an increase in academic performance, which may be due to the digital divide in terms of digital infrastructure negatively impacting on learning Educative development (Torres-Díaz *et al*., 2022).

Conclusions

The results indicate that, although the general grade point average is 7.9 and 8.5, with an average of 8.2, the outliers observed in clusters 1 and 2 reveal a direct relationship between the use of IT and academic performance in related situations. with covid-19. Cluster 1 presents an above-average academic performance, despite having enrolled in more subjects and having attended classes despite the illness.

On the other hand, cluster 2 includes students who performed below average, despite enrolling in fewer subjects and having days off due to illness.

It should be noted that both clusters had a teacher who used IT to teach their classes, but the difference between them is that cluster 1 had greater access to these technological tools and a teacher who used them more effectively, while cluster 2 did not have such wide access.

These results show that the association between the use of IT and academic performance is fundamental during the learning processes, since it allows students to expand and improve their knowledge. However, social and economic inequalities can affect access to these tools, making it necessary to guarantee equal access to the Internet and IT for all students and teachers. In this way, it will be possible to offer an equitable and quality education that allows to take full advantage of all the tools that IT offers to improve academic performance.

In conclusion, the use of IT is clearly associated with higher academic performance in university students, even in situations of illness such as covid-19. To achieve an equitable and quality education it is necessary that students have access to information technologies, good internet connectivity, communication tools such as WhatsApp and educational platforms, and that teachers have access to IT and use it effectively in teaching the subjects they teach online.

Future lines of research

The results obtained in this research are of great importance for studies on education and inequality in higher education institutions in relation to access to information technologies. In addition, these data can be very useful for qualitative studies on the acceptance or rejection of the use of IT in learning processes.

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