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Artículos científicos

El efecto de la covid-19 en la impartición de cursos de matemáticas: evidencia experimental en una macrouniversidad de México

The effect of COVID-19 on the delivery of mathematics courses: experimental evidence in a macrouniversity in Mexico

O efeito do COVID-19 no ensino de cursos de matemática: evidências experimentais em uma macrouniversidade no México

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Resumen

Este artículo se centra en analizar los efectos que ha generado la pandemia por la covid-19 en la impartición de los cursos de matemáticas en la Universidad Autónoma de Nuevo León (UANL), máxima casa de estudios del norte de México. Para tal fin, se aplicó una encuesta en línea a 748 educandos de licenciatura en el segundo trimestre del año 2020. Con la información recabada se empleó un modelo Tobit censurado por la derecha, el cual permitió cuantificar el rendimiento académico de los estudiantes antes y durante el confinamiento en sus cursos o asignaturas de matemáticas en esta macrouniversidad. Entre los principales resultados se encuentra que la aplicación de *software* y plataformas digitales en la impartición de los cursos de matemáticas durante la contingencia sanitaria incrementa la eficiencia de los educandos en la solución y culminación de los ejercicios y los laboratorios, encargados por los docentes, en 23.2 %, mientras que el tiempo promedio para llevarlos a cabo es de 25.4 y 50.8 minutos, respectivamente.

Palabras clave: covid-19, *software* matemático, tobit.

Abstract

This article focuses on analyzing the effects that the COVID-19 pandemic has generated in the delivery of mathematics courses at the Autonomous University of Nuevo León (UANL), the highest house of studies in northern Mexico. To this end, an online survey is applied to 748 undergraduate students in the second quarter of 2020. With the information collected, a Tobit model censored by the right is used, which allows quantifying the academic performance of students before and during confinement in their math courses or subjects at this macro university. Among the main results is the application of software and digital platforms in the teaching of mathematics courses during the health contingency, increasing the efficiency of the students in the solution and completion of the exercises and the laboratories, commissioned by the teachers, in a 23.2%, while the average time to carry out a line of 25.4 and 50.8 minutes, respectively.

Keywords: covid-19, mathematical software, tobit.

Resumo

Este artigo se concentra na análise dos efeitos que a pandemia do COVID-19 gerou na realização de cursos de matemática na Universidade Autônoma de Nuevo León (UANL), a mais alta casa de estudos no norte do México. Para isso, é aplicada uma pesquisa on-line a 748 estudantes de graduação no segundo trimestre de 2020. Com as informações coletadas, é utilizado um modelo Tobit censurado à direita, que permite quantificar o desempenho acadêmico dos alunos antes e durante confinamento em seus cursos ou disciplinas de matemática nesta macro universidade. Entre os principais resultados está a aplicação de software e plataformas digitais no ensino de cursos de matemática durante a contingência em saúde, aumentando a eficiência dos alunos na solução e conclusão dos exercícios e laboratórios, encomendados pelos professores, em uma 23,2%, enquanto o tempo médio para realizar uma linha de 25,4 e 50,8 minutos, respectivamente.

Palavras-chave: covid-19, software matemático, tobit.

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Introduction

The covid-19 pandemic has negatively affected society and it seems that its effects will continue, at least, during the year 2022. According to data from Unesco (United Nations Educational, Scientific and Scientific Organization Culture, 2020), 188 countries -including Mexico- have implemented the closure of schools and universities in response to the pandemic, which means that more than 90% of students in the world are without attending face-to-face classes.

In this regard, Aquino and Medina (2020) explain that isolation and social immobilization as measures to reduce the spread of this disease have forced the temporary closure of educational institutions at all levels. In the same sense, Sanz, Sainz and Capilla (2020) point out that this unpredictable event brought with it the abrupt suspension of administrative, academic and research activities in all universities, which forced the implementation of digital strategies to continue with their teaching functions. and learning.

Faced with this problem, the Autonomous University of Nuevo León (UANL) has opted for virtual distance education as an immediate response to covid-19 in order not to stop serving the university community and avoid missing the academic semester. Undoubtedly, the implementation of classes and virtual courses have represented a challenge for the authorities, administrators, teachers and students of the UANL due to certain limitations that have arisen, such as the availability of the internet, the difficulty in the use of virtual platforms, teacher training for digital courses, inappropriate environments for taking courses at home, saturation of technological support, among others.

But what about the teaching of mathematics courses? Should their teaching be similar to that of theoretical subjects? Based on these questions, this research aims to analyze the effect of confinement on the academic performance of students in their courses or subjects related to the area of mathematics, specifically in the culmination of the exercises and laboratories proposed by the teachers of the UANL[1].

This work starts from the premise that there is a positive relationship between the use of digital strategies, based on mathematical packages or software, and obtaining a better academic performance in subjects that contain mathematics, since it is considered that their use increases significantly learning and developing skills related to this type of course.

In this regard, Ruiz and Quintana (2016) argue that orthodox teaching in mathematics has been questioned in recent years in relation to quality and teaching because students reveal poor performance in solving and understanding real problems . It is not surprising from these shortcomings that problems of school delay, dropouts, failures, rejection of learning units, demotivation in the area, etc. originate. For this reason, this research seeks to more finely weave this topic, by making use of the virtual training given to UANL teachers in teaching techniques and tools for better use of the analytical programs of mathematics subjects in the online mode .

The hypothesis to be empirically tested is that the study or teaching of courses related to mathematics are more efficient and practical with the combination of digital platforms and the use of mathematical software. When quantifying the academic performance of students, this research focuses on the analysis of undergraduate students and the impacts that this digital change influences in the training, solution and completion of exercises and laboratories taught in class. For this, two particular hypotheses have been proposed. At the individual level, it is believed that the comprehension and understanding of the exercises proposed in the digital courses —in real time— positively impacts the completion and security of the students in solving problems in less time; while with the laboratories, a higher level of involvement with the use of mathematical software is expected and its culmination will be in a time and form consistent with the semester.

[1] The term exercises, in this work, refers to those mathematical problems or activities developed in real time within the subject or course, either before (face-to-face classes) or during the health contingency (virtual classes), while laboratories are the Tasks, exercises or mathematical problems that are left by the teachers for the solution at home, both taken for the semester from January to June 2020.

To achieve the objective of the research and respond to the hypotheses raised, an online questionnaire was implemented, from which a response was obtained from 748 students from different disciplines. A Tobit model censored by the right is applied, which allows explaining academic performance (understood in this article as the time it takes students to solve or complete the exercises and laboratories in minutes) based on the data collected before (first months of the semester, when students attended face-to-face classes) and during (last months of the semester, when students took virtual classes) the confinement in the macrouniversity.

The work is organized as follows: in the second section a brief theoretical review is developed; Section three describes the methodology and data collection; in the fourth the results are reported and, finally, some conclusions and recommendations are presented.

Literature review

Arteaga and Cruz (2018), Lamana and De la Peña (2018) and Medina, Fereira and Marzol (2018) point out that there are different causes that cause poor academic performance in the area of mathematics, among the most common are orthodox (or very obsolete) teaching strategies or techniques by teachers, which make students learn mechanically the concepts and formulas, which leads the student to worry only about passing the course or subject instead of acquiring an apprenticeship for their professional training.

For their part, Forés, Sánchez and Sancho (2014) argue that the main reason for students' disinterest in mathematics courses is the rudimentary teaching means or techniques that teachers use in teaching, as it is difficult for them to leave their area of learning. comfort or status quo. That is, they use the same methods for decades past, with which unpleasant results are generated for new generations of students.

However, in these times of pandemic, online math teaching needs to be strengthened and improved. With the suspension of face-to-face classes, teachers must be creative to deliver meaningful and engaging learning for students. Although the latter are not physically available to carry out the procedures and solutions of exercises to mathematics problems, UANL teachers must take advantage of the changes that are being witnessed as a society in updating and training teaching in the area of mathematics to adapt to the health contingency of the covid-19; for example, the use of mathematical programs in combination with virtual platforms, which brings with it classes in the form of tutorials, considered until recently a taboo in the educational system, although at present most academic courses are being transferred to a online environment (Díaz, Vázquez, Olguín & Arau, 2018).

Likewise, Ferrando, Segura and Pla (2017) highlight that involving students and teachers in the face of a change or teaching-learning modality is challenging, but not impossible. It is enough to know the innovative teaching tools and methods in the field of mathematics to obtain positive and significant results in the development and training of students.

Therefore, the focus of this section is to show a frame of reference on the didactic models that understand the relationship that exists between teachers and students on communication and learning in these times of confinement. In this regard, Alvarado, Morales and Téllez (2016), Alvarado, Luyando and Picazzo (2015) and Pari (2014) point out that an educational system may be different depending on the conditions of the student's environment (infrastructure, teaching staff, teaching aids, integral development, among others). For this reason, any academic system must be able to have a balance between the academic environment (updating the teaching aids and curricular mesh of the subjects in a changing world) and the moral of the educators (adaptation of teaching and flexible evaluation towards learners).

Regarding the didactic models in the teaching and learning of mathematics, Mayorga and Madrid (2010) establish four models with which they indicate the actions planned by educators in order for students to achieve their training. The traditional didactic model explains the disciplinary or rigorous relationship between educators and their analytical program of the subject to be covered; In this model, students' ideas are not taken into account, since teachers must follow a strict schedule of activities and tests to obtain a final grade (homework, exercises, research, and exams). On the other hand, in the alternative didactic model, students' ideas are taken into account and redirected into methodologies or case studies based on real problems or the environment in which the students are immersed. The technological didactic model postulates the combination of experience by the teacher and the use of technological or digital tools in order to carry out a practical, applied and interesting course for students. Finally, the activist didactic model is based on the assimilation process that students obtain, based on content or experiences that the same students have learned, lived or developed in the labor market or in the environment in which they operate.

Consequently, the four models described show that teaching and learning, in the specific case of mathematics, are based on obtaining knowledge - regardless of whether it goes from the abstract to the specific or from the general to the particular - with the purpose of obtaining a reflective and critical thinking to impact on the integral formation of the students. In this way, it is believed that the technological didactic model is the most consistent with what happens in the UANL, since it is expected - given the contingency of covid-19 - that the mathematics courses will be updated and perfected with the application of software and technological platforms with the aim of involving and bringing students closer to mathematical knowledge.

Finally, the following section shows those empirical studies carried out on innovation and the application of technology in the teaching process in the area of mathematics. It is worth mentioning that of the works described below, few are related to the robust application of a Tobit model censored by the right because the corresponding literature refers to documentary, descriptive and correlational investigations of teaching-learning strategies in the subject matter. Hence the interest in making a contribution to this type of topic from a quantitative approach.

Importance of teaching-learning in mathematics with technological tools

The study of technological tools, computer methods and mathematical simulation through specialized software or packages is gaining very peculiar importance in educational systems. Meza and Cantarell (2002) and Gamboa (2007) point out that, as of the year 2000, the world is full of digital experiences and that technologies provide benefits and educational opportunities to people who wish to have a complete academic training. For their part, Haydel and Roeser (2002) argue that so-called millennial students demonstrate a clear preference for using mobile devices and information technologies in the classroom. Additionally, Molina (2017) and Fernández, Riveros and Montiel (2017) establish motivation as an essential factor for learning mathematics subjects, with the use of software as an indispensable resource in the area.

Given the diversity of technological tools, it is important to recognize which are the alternatives that are most adapted to the area of mathematics. In this regard, Falck, Kluttig and Peirano (2013) argue that educators must identify five factors when innovating a technological solution in the classroom. The first is related to individual competencies (necessary by teachers and students for the use of technologies); secondly, there are innovations to impart knowledge (they must be able to motivate and involve the participation of students in class); thirdly, it is necessary that the technological implementation is of the time or current (so that they provide real support to the student's environment); fourth, they must be accessible (so that students don't pay too much for their use); finally, it is necessary that the program or software has efficiency and quality in its estimates.

In the same sense, Almaguel, Álvarez, Pernía, Mota and Coello (2016), Avendaño, Rangel Ibarra and Chao González (2011) and Grisales (2018) highlight that the use of software in mathematics classes favors inductive processes and visualization of concepts in students; In addition, it allows one to compare problems and refute more practical and dynamic hypotheses, and it serves as motivation in learning mathematical content. In turn, Zermeño, Navarrete and Contreras (2020) add that programs or the use of technological tools allow students to efficiently develop their skills and efforts in solving problems related to mathematics subjects and their human development.

For their part, Acosta, Mejía and Rodríguez (2011), Fernández, Izquierdo and Lima (2000), Díaz and Hernández (2002), Morales, Valencia, Martínez and Mario (2013), Gómez, Aguileta, Gómez and Aguilar (2018) , Ruiz and Del Rivero (2019) and Salas (2018) establish that the use of software (Cabri-Geometric, Calculus, Derive, Eviews, FunReal, Mathematica, Modelus, SPSS, PSP, Stata, R, among others) helps students in concept formation, exercise and problem solving. Its application allows learners to be more proactive and participatory in understanding and understanding knowledge of quantitative methods.

However, authors such as Dede (2000) and Guédez (2005) indicate that it must be remembered that the constant use of technology is not the complete solution to all the problems or the contents of the subjects in mathematics, since the value or use of technological tools is a function of the design and programming of the learning units that educators develop in class.

All the investigations reviewed in this section, regardless of the tools or technological platforms that they analyze, agree that in the innovation and transformation that occurs in the classroom, it is necessary for teachers to consider adapting their didactic teaching model towards the students. In other words, educators must implement a traditional face-to-face dynamic, technologically enriched towards a digital didactic model.

In this literature review, there is no evidence of studies that have carried out an empirical analysis with a Tobit model censored by the right, among groups of students, to quantify the completion or completion of exercises and laboratories before a confinement stage. For this reason, this research aims to fill the gap in this type of analysis on this issue, given the situation that occurs in the UANL in the face of the health contingency of covid-19.

Methodology

To quantify the characterization and academic performance of university students in subjects related to the area of mathematics in the face of confinement at the UANL, an online survey was designed, available to all current students on university campuses during the second quarter of the year. 2020. For this, a non-probabilistic snowball sampling was carried out. In total, 748 surveys were collected in two degrees of training (undergraduate and engineering), who are virtually taking courses or subjects related to the field of mathematics in the semester between January and June 2020.

The questionnaire that was applied consisted of 21 questions, which were classified into three items available at https://www.observatoriocedeem.com.mx/encuesta/. The first item focused on the general characteristics of the students (age, gender, semester, career and faculty), while the second focused on the main problems faced by students in the face of the covid-19 contingency (educational, logistics , technological and socio-affective) and the third item considered the technological resources used during the confinement stage (communication and academic work).

Sample characteristics

This section shows the main descriptive statistics of the general characteristics of the students participating in this research. Table 1 shows a higher participation in male students (62.7%). In general, it is observed that the majority of the respondents reported that they were between 21 and 25 years old. Most of these subjects stated that their career was in the area of social sciences (70%), on average, they are at a higher level when they are in the seventh semester.

Regarding the types of problems that students face from the virtual modality, the most frequent are socio-affective (50.9%) due to the emotional impact that the confinement stage brings, plus the excess academic load that brings frustration , anxiety, demotivation and fatigue in students; followed by logistics (31.6%), which refer to the circumstances associated with the administration of class times and inadequate physical space within the home to attend mathematics courses; then the technological ones (13.6%), as many students argue that they do not have internet access at home or that they lack the equipment to operate the software and platforms requested by the macro-university courses; lastly, the educational ones (3.9%), which impacts on the fulfillment of the academic activities entrusted by teachers such as exercises and laboratories in the digital tools or platform.

Similarly, it can be observed that regarding the technological resources most used by students to work virtually in this contingency were virtual platforms (56.8%), specifically Teams and Zoom; then communication (43.2%) such as WhatsApp and email. It should be added that 53.6% of the students indicated that they prefer face-to-face classes. However, they establish that a combination (eg, classroom teaching plus the use of software or digital tools) would be optimal for their professional training.

Tabla 1: Descriptivos de las variables sociodemográficas y explicativas

Componente		Estadísticos			
		Frecuencia	Porcentaje	Media	Desviación típica
Género	(1) Hombre	469	62.7	0.63	0.484
	(0) Mujer	279	37.3		
	Total	748	100.0		
Edad	(1) Menos de 20 años	180	24.1	1.98	0.761
	(2) De 21 a 25 años	450	60.2		
	(3) De 26 a 30 años	73	9.8		
	(4) Más de 31 años	45	6.0		
	Total	748	100.0		
Área	(1) Ciencias sociales	523	69.9	1.36	0.586
	(2) Ingenierías	184	24.6		
	(3) Física y matemáticas	41	5.5		
	Total	748	100.0		
Semestre	(1) De 1 a 3 semestres	163	21.8	2.45	0.883
	(2) De 4 a 6 semestres	122	16.3		
	(3) De 7 a 9 semestres	427	57.1		
	(4) Más de 10 semestres	36	4.8		
	Total	748	100.0		
Problemas	(1) Educativos	29	3.9	3.12	0.984
	(2) Logísticos	236	31.6		
	(3) Tecnológicos	102	13.6		
	(4) Socioafectivos	381	50.9		
	Total	748	100.0		
Recursos	(1) Comunicación	323	43.2	1.57	0.496
	(2) Trabajo académico	425	56.8		
	Total	748	100.0		
Modalidad	(1) Presencial	401	53.6	1.76	0.878

	(2) Virtual	128	17.1		
	(3) Mixta	219	29.3		
	Total	748	100.0		

Fuente: Elaboración propia

Specification of the empirical model

As mentioned in the introduction, the objective of this research is to quantify the academic performance of students before and during the health contingency of covid-19. To achieve the above, the responses of the students were classified into two groups, so that each group answered the average time it takes to solve the exercises and laboratories before and during confinement. The answers that each student answered about the time it took to finish their exercises in class (either in person or online) serves to construct the variable minutes-exercises, while the records that take to finish a task or problem are called minutes- laboratories. At the same time, this procedure identifies the students who, at the time of the application of the survey, had not completed their exercises and laboratories entrusted to them by the teachers, which means that they are facing a case of data censored by the right. Therefore, it is chosen to create a variable of censorship (censorship) that is worth 1 for the censored data and 0 for the uncensored data.

To carry out the aforementioned econometric exercise, a Tobit model censored by the right (also known as higher or higher censorship) is applied, which allows obtaining estimates when the dependent variable (censorship) is not observed for a part of the students , that is, it is zero for a part of the study subjects. The above can be represented through a Tobit model:

$$Y^{*} = X\beta + \mu \; \mu|X, c_{\sim}N(0, \sigma^{2}) \; Y = \min\,(Y^{*}, c) \; (1)$$

Which can also be written:

$$Y_i = \{^{c \; si \; Y_i^{*} \geq c}_{Y_i^{*} \; si \; Y_i^{*} < c} \; (2)$$

Given equation 2, it is established that Y * is less than the value of c, but it is not known how much it is; therefore, the Tobit model is considered with caesura on the right. However, to calculate the parameter estimates, maximum likelihood (MV) must be applied, since in uncensored observations Y = Y *, the density of Y is the same as that of Y *. But for censored observations we have:

$$P(Y = c|X) = P(Y^{*} \geq c|X) = P(u \geq c - X\beta|X = 1 - \emptyset[(c - X\beta)/\sigma] \; (3)$$

Subsequently, the logarithm of the likelihood function is calculated and the estimation is carried out by MV in order that the β_j are interpreted as a classical regression model; For this, the expression of the logarithm of the likelihood function for a sample size such as the one in the present study is the following (Pérez, 2005):

$$\text{Ln}MV = \sum_{i=1}^{c}\left(1 - \emptyset\left(\frac{X_i\beta}{\sigma}\right)\right) + \sum_{i=c+1}^{n}\emptyset\left(\frac{Y_i - X_i\beta}{\sigma}\right) \quad (4)$$

Results

Table 2 presents the results of the model applied to the research while contrasting the estimates of the Tobit model with other models of normal and logistic distribution. In order to verify if the proposed model presents a better fit, according to the data collected in the study, where the first and second columns show the estimates, assuming a normal distribution; the third and fourth columns present the results of the application of a logistic model; and columns five and six show the estimates from the Tobit model.

Tabla 2, Estimaciones del modelo Tobit en contraste con otros

Minutos	Normal		Logístico		Tobit	
	Ejercicios (1)	Laboratorios (2)	Ejercicios (3)	Laboratorios (4)	Ejercicios (5)	Laboratorios (6)
Constante	22.839	45.678	23.002	46.004	24.591	49.183
Modalidad	0.761* (.431)	1.294 (.801)	0.724* (.395)	1.261* (.719)	0.816** (.416)	1.632* (.852)
Log Likelihood	-1831.5	-2213.4	-1832.2	-2214.1	-1880.9	-2262.8
Schwarz	5.055	6.077	4.925	5.946	4.923	5.944
Hannan-Quin	5.044	6.065	4.914	5.935	4.912	5.933
Right censored	197		197		197	
Uncensored obs	551		551		551	
Observaciones	748		748		748	

Los asteriscos (**) indican significancia estadística de 5 %, y (*) de 10 %.
El error estándar se encuentra entre paréntesis
Fuente: Elaboración propia

In relation to the academic performance of the students - understood in this article as the time it takes for the students to solve or complete the exercises in class (either face-to-face or virtual) and the laboratories assigned to perform at home, measured in minutes—, in columns five and six statistical significance is obtained in the estimated parameters, which means that for a student in the virtual group (virtual mode), the solution and completion time of the exercises carried out digitally in class with software and technology platform support is 25,407 minutes. While the development of laboratories - without the help of the teacher - at home takes an average of 50,815 minutes for students[2].

On the other hand, the students in the face-to-face group (face-to-face mode) take 26,223 minutes to complete the solution of the exercises, and the completion of the labs —to be done at home— takes an average of 52,447 minutes. In other words, it is appreciated that the teaching-learning process in mathematics courses or subjects in virtual modality groups are more effective than face-to-face classes, since the students subject to study complete their exercises and laboratories in less time with respect to to the group of face-to-face classes.

In the same way, the normal and logistic models result with good significant representation for the estimated parameters. It is also observed that the differences with the Tobit model are very small. Also, the information criteria values are acceptable and consistent with each other. That is, if a comparison is made between the three models (normal, logistic and Tobit) it can be seen that the Tobit censored by the right is the most appropriate, since it presents the lowest values of information criteria (Schwarz and Hannan-Quinn) and the greater the value of the likelihood function (Log Likelihood).

Discussion of results

According to the results of this research, it can be argued that the proposed model allows quantifying the academic performance of students with respect to the satisfactory completion of exercises and laboratories, specifically, in the virtual mode, since the application of tools, software and technological platforms improved the performance in the solution and the development of academic activities. These findings coincide with those presented in Cuicas, Debel, Casadei and Álvarez (2007) regarding that virtual distance education improves the teaching-learning process as long as the skills and experience of the teacher are optimal and have support, resources and pedagogical training to better transmit knowledge to students.

The foregoing denotes that it is possible to integrate mathematics courses or subjects to digital work through intelligent software and platforms that motivate and facilitate students in their academic training; As Oteiza and Silva (2001) point out, by focusing the use of computer packages

[2] In order that the reader can make their own inferences, given the results obtained in this research, the procedure for the virtual modality of the group of students in the preparation of exercises is exemplified: 24.591 + 0.816(1) = 25.4 minutes.

towards teaching in quantitative disciplines, their effectiveness increases. However, Hodges, Moore, Lockee, Trust and Bond (2020) point out that it is not the same to respond to a global catastrophe by showing solidarity and enthusiasm than incorporating activities to which one was not accustomed to daily life, which leaves future lines of research in this study phenomenon.

It is important to emphasize that this work aims to contribute from the academic point of view to studies and analyzes focused on the process of teaching and assimilation in mathematics. It is evidenced with a cross-sectional sample that for the surveyed students the virtual modality is effective in mathematics courses. On this occasion, an investigation is carried out that seeks to prove, through an econometric exercise, the average performance of students at the end of their exercises and laboratories in classes when using technological tools, where their efficiency in learning and completion in times on exercises and labs completed in a timely manner.

Other interesting findings in this document were the identification of the main problems faced by students in confinement by covid-19 (in order of importance were socio-affective, technological, logistical and educational), as well as observing the main technological resources they use. (Teams and Zoom). These results coincide with Tyng, Amin, Saad and Malik (2017) and Zubieta, Bautista and Quijano (2012) in establishing that technological tools seek to share information and knowledge to interact with students, and that the comprehension and understanding of the subjects are effective and considered an alternative for a promising future in educational systems.

Conclusions

This research shows that university students who take a mathematics course or subject, in the semester between January and June 2020 of the UANL, responded and adapted positively to software and digital platforms. In general, it is found that students decreased their delivery and completion time in the exercises and laboratories required in mathematics courses.

By using the Tobit model censored by the right, the answers given by the students are controlled by time group in the solution of the exercises and the laboratories, before and during the confinement in the macrouniversity, which gives as main result that the students During the confinement they were those who fulfilled and satisfactorily concluded the activities assigned in the courses and subjects related to the area of mathematics.

Finally, with respect to the descriptive analysis, it is found that the variables related to the problems faced by students in this contingency are stress, anxiety and frustration due to the excess work they present in the semester, while in technological resources They stated that they use the Teams and WhatsApp platforms more to communicate with teachers.

Based on the findings in this work, it is considered pertinent to consider the following academic recommendations to enrich the knowledge in the teaching process in students about the use of software and digital platforms in mathematics courses and subjects as a cognitive tool, as well as to improve the understanding and teaching of the subject in mathematics in students: joint training between teachers and students to carry out actions that guarantee the teaching-learning process for all.

To achieve the above, it is necessary to reach agreements with academic bodies of the same institution so that they share their research experience applied to real case studies for the interest of the students. Likewise, institutional support must commit to acquiring software licenses or mathematical packages, as well as conducting constant training courses in tools, software and digital platforms for all the actors involved in the efficient teaching of mathematics.

Future lines of research

As future work, it is pertinent to continue and follow up in the immediate subsequent period (semesters of 2022) with the aim of quantifying the differences in the teaching of mathematics courses after COVID-19. This is due to the fact that in the confinement period (since March 2020) teachers and students have received training aimed at creating virtual environments and software object of learning in the matter that have been significant and productive in their academic training. In this sense, for future work it is recommended to extend the study to other learning units and universities, separately or simultaneously. Similarly, it is suggested to broaden the dimension of this topic, including an increase in the number of participants and faculties or departments of the university. The implication of the study phenomenon in graduate students should also be considered.

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