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IDENTIFICATION AND ANALYSIS OF THE VARIABLES THAT IMPACT ON THE LEARNING OF MATHEMATICS IN NEW STUDENTS OF THE ITZ

IDENTIFICATION AND ANALYSIS OF THE VARIABLES THAT IMPACT ON THE LEARNING OF MATHEMATICS IN NEW STUDENTS OF THE ITZ

Palacios Contreras María Lidia[1], Barreto Cabrera Claudia[2] , Contreras Ochoa María del Socorro[3] , Díaz Domínguez Arturo Emmanuel[4] , Recillas Román Jesús[5]

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[1] National Technological Institute of Mexico/Zacatepec Technological Institute, maria.pc@zacatepec.tecnm.mx, https://orcid.org/0000-0003-2605-4077.
[2] National Technological Institute of Mexico/Zacatepec Technological Institute, claudia.bc@zacatepec.tecnm.mx, https://orcid.org/0009-0006-3417-5441.
[3] National Technological Institute of Mexico/Zacatepec Technological Institute, maria.co@zacatepec.tecnm.mx, https://orcid.org/0009-0008-9992-4962.
[4] National Technological Institute of Mexico/Zacatepec Technological Institute, arturo.dd@zacatepec.tecnm.mx, https://orcid.org/0009-0001-8142-0431.
[5] National Technological Institute of Mexico/Zacatepec Technological Institute, jesus.rr@zacatepec.tecnm.mx, https://orcid.org/0009-0002-7412-2767.

Abstract -- This research focuses on determining the variables that impact mathematics learning at the Zacatepec Institute of Technology (ITZ). New students enrolled in the Industrial Engineering Educational Program (PE) were considered, specifically those taking the Differential Calculus course. The methodology used was to apply the following three instruments: a diagnostic exam, questionnaires to repeat students about the knowledge learned in the semester they failed, and finally, a satisfaction survey. It was concluded that there are two relevant factors in student failure: their lack of study habits and the teaching style of each professor. Finally, there is a third factor that also influences student failure and dropout rates, which is the lack of sufficient financial resources to continue their studies without worries.

Keywords: Variable, Learning, Mathematics, Students.

Abstract -- This research focuses on determining the variables that impact the learning of mathematics at the Zacatepec Technological Institute (ITZ). New students of the Industrial Engineering educational program were considered, specifically those who were taking the subject of Differential Calculus. The methodology used was to apply the following three instruments: a diagnostic exam, questionnaires to repeating students about the knowledge learned in the semester they did not pass, and finally, a satisfaction survey. It is concluded that there are two relevant factors in student failure: the lack of study habits among students and the teaching style of each teacher. Finally, there is a third factor that also affects student failure and dropout rates, which is the lack of sufficient economic resources to continue their studies without worries.

Key words – Variable, Learning, Math, Students.

INTRODUCTION

Currently, the study and teaching of mathematics among students at all educational levels in Mexico has become a topic of great importance and concern for educational authorities.

Figures from the World Health Organization indicate that "one in seven young people aged 10 to 19 suffers from a mental disorder" [1]. Mental disorders have consequences throughout the life cycle, impacting the functioning of the individual in important areas such as school learning [2] and preparation for university life. Mental health is defined by the World Health Organization [1] as: "a state of well-being that allows individuals to function in daily life, cope with everyday stress, work productively, and make a meaningful contribution to their environment" (p. 1).

In addition, psychological (non-cognitive) variables can have predictive validity for future academic performance [3]. These refer to empirically validated constructs

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, such as commitment, study skills, motivation, self-concept, interpersonal skills, and personality traits [4][5].

In our teaching experience, we have observed that students' academic performance is a combination of various variables, both internal (personal, family, social, economic, prior knowledge, study habits, logical-mathematical skills) and external (curriculum design, teachers, facilities, climatic factors, the COVID-19 pandemic) and that it has been an indicator of student efficiency at various levels of our education system, whether public or private.

In addition to this, over the years, the teaching of mathematics has always been a subject of study, due to the challenge that teachers face in order to achieve meaningful learning [6] or to enable students to acquire the necessary skills, and above all to convey to them the usefulness of this subject in their daily lives, regardless of other factors that will affect their learning. This is considered a matter of vital importance in order to make students aware of the fundamental nature of the study of mathematics in their academic and professional careers.

In the case of failure, reducing these rates is a task that requires the participation of everyone involved in the educational process: students, teachers, and educational authorities, as well as the development of strategies aimed at making students aware of their role and responsibility in their educational process, which encourage analysis of the problem and its prevention [7].

Likewise, identifying the reasons why students drop out allows teachers and educational administrators to propose actions aimed at improving student selection and increasing the percentage of students who remain in their programs and, therefore, the percentage of students who complete their studies [8].

In this context, strategies such as academic guidance for students, personalized support, and tutoring activities emerge as measures that could help address the problems of low academic performance, failure, and student dropout [9].

At the Zacatepec Institute of Technology, according to information obtained from new student admission exams, it can be observed that applicants to the Industrial Engineering Educational Program have had a decrease in their average achievement level, falling from 84 in 2018 to 70 in 2023. Meanwhile, the average high school graduation rate has fluctuated from 90 in 2018 to 80 for the August-December 2023 semester, based on information obtained from the certificates of graduates at that level who become applicants to the Zacatepec Institute of Technology. These data suggest a decline in the level of prior skills of students entering the Zacatepec Institute of Technology, which has an impact on the subject of Differential Calculus, one of the first subjects taken by students entering Industrial Engineering. This is confirmed by information provided by School Services regarding the failure rate for this subject, with 23% in the January-June 2022 period, 45% in August-December 2022, and 22% in January-June 2023.

The problem of failure is a difficult phenomenon to explain, as it depends on many variables of a diverse nature, and it is complex to determine precisely what level of impact it has on larger problems such as falling behind in school and dropping out. However, a very important step is to be able to identify these variables related to failure in order to understand their behavior, as well as the impact they have on it [10].

Based on the above, the objective of this research is to identify the variables or factors that affect mathematics learning in new students enrolled in the Industrial Engineering Educational Program (PE), with the purpose of obtaining information, analyzing the problems that exist, and facilitating decision-making by teachers and authorities at the Zacatepec Institute of Technology to improve the educational quality of that institution.

DEVELOPMENT

The methodology followed in this research consisted of three stages, which include: 1. diagnostic exam at the beginning of the course, 2. questionnaire during the course, and 3. satisfaction survey at the end of the course. These stages are described below:

1. Diagnostic exam

The diagnostic exam was administered to all new and repeat students enrolled in the January-June 2024 period and registered in the Differential Calculus course of the Industrial Engineering PE.

This exam consists of five exercises (see *Figure 1*) covering three of the basic branches of mathematics studied from the basic to intermediate levels.

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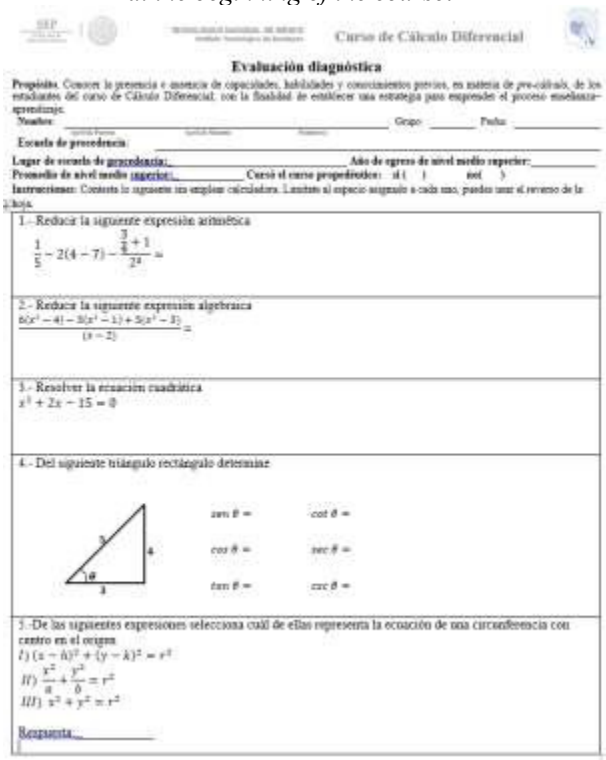
The first exercise relates to the branch of mathematics known as arithmetic (fundamental to the study of mathematics, as it deals with the study of numbers and basic operations with them, such as addition, subtraction, multiplication, and division). exercises two and three address problems in algebra (fundamental to the study of mathematics as it studies the structures and general rules that govern arithmetic operations), and exercises four and five are on trigonometry (fundamental to the study of trigonometric ratios).

This assessment was carried out with the intention of determining the students' prior knowledge in order to identify any deficiencies they may have at the beginning of the course.

Figure 1. *Diagnostic test administered to new students at the beginning of the course*.



Curso de Cálculo Diferencial

Evaluación diagnóstica

Propósito. Conocer la presencia o ausencia de capacidades, habilidades y conocimientos previos, en materia de pre-cálculo, de los estudiantes del curso de Cálculo Diferencial, con la finalidad de establecer una estrategia para reforzarlos el proceso enseñanza-aprendizaje.

Nombre: _____ Grupo: _____ Fecha: _____

Escuela de procedencia: _____

Lugar de escuela de procedencia: _____ **Año de egreso de nivel medio superior:** _____

Promedio de nivel medio superior: _____ **Cursó el curso propedéutico:** si ( ) no ( )

Instrucciones: Contesta lo siguiente sin emplear calculadora. Localiza el espacio asignado a cada uno, puedes usar el reverso de la hoja.

1.- Reducir la siguiente expresión aritmética

$$\frac{1}{5} - 2(4-7) - \frac{\frac{3}{4}+1}{2^4} =$$

2.- Reducir la siguiente expresión algebraica

$$\frac{6(x^2-4)-3(x^2-1)+5(x^2-3)}{(x-2)} =$$

3.- Resolver la ecuación cuadrática

$x^2 + 2x - 15 = 0$

4.- Del siguiente triángulo rectángulo determinar

$\sin\theta =$ $\cot\theta =$

$\cos\theta =$ $\sec\theta =$

$\tan\theta =$ $\csc\theta =$

5.-De las siguientes expresiones selecciona cuál de ellas representa la ecuación de una circunferencia con centro en el origen

$I)\ (x-h)^2 + (y-k)^2 = r^2$

$II)\ \frac{x^2}{a} + \frac{y^2}{b} = r^2$

$III)\ x^2 + y^2 = r^2$

Respuesta: _____

Source: *Own creation*.

2. Questionnaire

After administering the diagnostic exam, we began developing methods for data analysis and collection, now taking into account a sample of 35 students from the groups enrolled in the January-June 2024 period, including students who had not passed the course in the August-December 2023 period.

It should be noted that two questionnaires were presented, one of which provides information on the August-December 2023 semester and repeat students, and the other provides information on students in the normal course for the January-June 2024 period. The questionnaire was administered in person during the course to the students mentioned above.

These questionnaires consist of 10 multiple-choice questions (see Figure 2) that address topics that allow us to understand the teaching method and the socioeconomic and emotional aspects in both cases.

Figure 2. *Questionnaire for identifying variables that impact mathematics learning*.

TECNOLÓGICO NACIONAL DE MÉXICO

IDENTIFICACIÓN DE LAS VARIABLES QUE IMPACTAN EN EL APRENDIZAJE DE LAS MATEMÁTICAS EN ESTUDIANTES, DEL PROGRAMA EDUCATIVO DE INGENIERÍA INDUSTRIAL

El objetivo de este cuestionario es conocer la manera en la que se imparten las clases de Cálculo Diferencial, los ambientes de aprendizaje y cómo te sientes en las clases. Las respuestas nos servirán para proponer estrategias de mejora que permitan aumentar el índice de aprobación en esta materia. Agradecemos tu tiempo.

INSTRUCCIONES: Elija la respuesta que consideres mejor (Favor de contestar con la mayor veracidad posible)

1. ¿La clase de Cálculo Diferencial, la recibe en un aula de forma presencial?
   a) Sí b) No, es virtual c) No recibo clase de cálculo diferencial
2. El lugar donde te imparten la clase de Cálculo Diferencial es:
   a) Cómodo b) Caluroso c) Incómodo d) Con distracciones e) Otro (Especifica) _____
3. El profesor que imparte la asignatura de Cálculo Diferencial, crea un ambiente:
   a) Relajado b) Estresante c) Tranquilo d) Entretenido e) Otro (Especifica) _____
4. El profesor de la clase de Cálculo Diferencial, ¿Promueve el trabajo en equipo?
   a) Sí b) No
5. El profesor de Cálculo Diferencial, ¿Relaciona lo que te enseña en clase con el campo profesional?
   a) Sí b) No
6. ¿Consideras que tu profesor de Cálculo Diferencial, está suficientemente capacitado para impartir la clase?
   a) Sí b) No c) La falta preparación, se nota inseguro
7. Además del pizarrón, tu profesor de Cálculo Diferencial, ¿Utiliza el proyector para dar clase? Si tu respuesta es sí explica si te gusta más el uso del proyector o no y por qué.
   a) Sí b) No _____
8. Si has faltado a Cálculo Diferencial, ¿Qué te impide asistir a la clase?
   a) Atender a mi familia b) Trabajo c) Economía d) Mi horario e) No me gusta la clase
9. ¿Cómo te sientes en la clase de Cálculo Diferencial?
   a) Confiado b) Seguro c) Motivado d) Asumido e) Inseguro
10. Para realizar tus estudios profesionales, cuentas con el apoyo económico de:
    a) Padres b) Abuelos c) Hermanos d) Otro (Especifica) _____

Source: *Own creation*.

3. Satisfaction survey

Once the January-June 2024 semester had ended, the analysis of grades began in order to identify whether the selected students had managed to obtain passing grades this time.

At the same time, a digital questionnaire was created using Google Forms to identify how students felt after completing their course.

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This questionnaire consists of 15 multiple-choice questions (see Figures 3 and 4), which allow us to find out whether the student acquired the expected knowledge, recommendations, their state of mind, and also economic aspects. The questionnaire was administered to all Industrial Engineering students in the Differential Calculus groups enrolled in the aforementioned period, using Google Forms at the end of the semester, sent to their institutional email addresses and, in some cases, administered in person.

Figure 3. *Student satisfaction survey, part 1.*

Source: *Own creation*.

Figure 4. *Student satisfaction survey, part 2.*

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Source: *Own creation*.

DISCUSSION AND ANALYSIS OF RESULTS

From the results obtained, it can be emphasized that:

1. Diagnostic exam

The following figures show the graphs with the results obtained:
In Figure 5, we can see that only 5 out of 39 students passed the arithmetic exercise, i.e., 12.8% of the students.

Figure 5. *Graph of results for exercise 1.*

Source: *Own creation*.

In Figures 6, we can see that only one student passed the first algebra exercise, while five out of 39 students who took the exam passed the second exercise, as was the case in arithmetic.

Figure 6. *Graph of results for exercises 2 and 3 related to algebra*.

Source: *Own creation*.

In the area of trigonometry, Figure 7 shows that only one student passed the first exercise, while in the second exercise, the pass rate was 48.7%.

Figure 7. *Graph of results for exercises 4 and 5 related to trigonometry*.

Source: *Own creation*.

These results show that most students in the industrial engineering program do not have the fundamentals for studying differential calculus at the beginning of their career, as only one student managed to answer all five exercises correctly. It is important to mention that the student who achieved a perfect score is from another country, which could lead to further research related to students' prior knowledge or knowledge acquired in basic education in our country, where topics such as arithmetic, algebra, and trigonometry are addressed.
Based on our data analysis, we can say that there are deficiencies in the prior knowledge of mathematics among students newly enrolled in our institution. Therefore, it is important to maintain communication with educational authorities and secondary school teachers

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, especially with the schools from which our students come, so that greater attention is paid to strengthening mathematics at that educational level.
Another strategy would be to design a course exclusively on arithmetic, algebra, and trigonometry to improve students' knowledge level.

2. Questionnaire

To administer this questionnaire, 24 students who repeated the Differential Calculus course from two groups in the August-December 2023 semester were considered. Originally,
35 students, but 11 had already dropped out of the course.
It is important to mention that two questionnaires were administered, one providing information on the August-December 2023 semester, which is the course for repeat students (left side of the figures), and the other providing information on the January-June 2024 semester, for new students (right side of the figures).
These questionnaires consisted of 10 multiple-choice questions addressing topics that provided insight into the teaching method used in both semesters, as well as taking into account the economic and emotional aspects in both cases.

The results obtained are shown below in the following figures.

Figure 8 shows that, in both the normal course and the repeat course, the subjects are taught in person and, in the normal course, at least one of the students answered that they were not being taught.

Figure 8. *Results of question 1, related to the format of the class: in person or online.*

Source: *Own creation*.

Question number two sought to obtain information regarding classroom comfort, to determine whether climatic conditions such as heat were a variable that affected the teaching of mathematics (see Figure 9). In both cases (normal course and repeat course), the majority of students felt their classroom comfortable; however, in the first course, 30% of the students answered that it was hot.

Figure 9. *Results of question 2, related to the comfort of the place where they received their class*.

Source: *Own creation*.

Figure 10 shows that the group of repeat students felt stressed by the teacher who taught the subject in their regular course, which can be considered an important variable in learning mathematics.
The teacher who taught the regular course created a stressful environment, unlike the teacher who taught the repeat course, in which case the students noted that the environment was calm and entertaining, favoring their learning.

Figure 10. *Results of question 3, related to the teaching style and atmosphere created by the teacher*.

Source: *Own creation*.

Question 4 (Figure 11) sought to determine whether a teaching style that encourages collaborative work is a determining factor in student performance during the course, noting that more than half of the students in the regular course said that there was no teamwork, which could be an important factor in mathematics teaching, as there was a high failure rate.

Figure 11. *Results of question 4, related to the promotion of teamwork in the classroom during mathematics class*.

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Source: *Own creation*.

For question number 5 (Figure 12), 52% of students in their normal course indicated that the teacher in the mathematics class did not relate what was taught in class to the professional field. However, the teacher who taught the repeat course did relate the subject matter to the professional field, allowing students to increase their interest in the subject.

Figure 12. *Results of question 5, relating what the teacher teaches in class to the professional field*.

Source: *Own creation*.

For question number 6 (Figure 13), in both courses, the students determined that the teacher was qualified to teach the subject. However, 26% of the students in their first course (normal course) believed that the teacher was not qualified to teach math class.

Figure 13. *Results of question 6, related to the teacher's training to teach the subject*.

Source: *Own creation*.

The next question (Figure 14) sought to determine whether students considered the use of a projector or overhead projector to be a valuable teaching and learning tool.

Figure 14. *Results of question 7, on the use of projectors in class*.

Source: *Own creation*.

Question 8 (Figure 15), related to the reasons that prevented students from attending class, shows that not liking the class, and even feeling unmotivated in it, causes student absenteeism, which can increase the dropout and failure rates. In this case, 30% of students in their normal course did not like the class and 26% did not like the schedule. In the repeat course, 43% of students did not answer because they attended their class.

Figure 15. *Results of question 8, related to the reasons that prevent students from attending math class*.

Source: *Own creation*.

For question number 9 (Figure 16), it can be seen that 43% of students in their normal course felt bored in class, and 26% expressed insecurity; while in their repeat course, most students felt motivated, confident, and secure.

Figure 16. *Results of question 9, related to the feelings students may have when taking their class*.

Source: *Own creation*.

To learn about the socioeconomic aspect, question number 10 was asked (Figure 17), in which most

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students receive financial support from their parents, with few students paying for their studies themselves or receiving support from someone other than their parents.

Figure 17. *Results of question 10, related to the socioeconomic status of students.*

Source: *Own creation.*

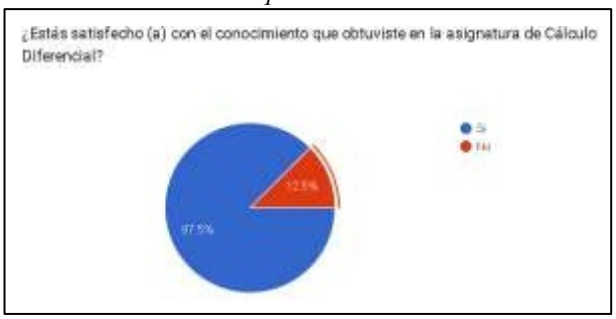
In general, students are satisfied with their teachers, but some did not like their schedule and therefore do not attend all their classes. It would be necessary to find out the reasons why the schedule is an impediment to attending classes, whether it is because they work or because they live far from school. Most students are not bothered by the classroom, although some said it felt hot. In this regard, it should be mentioned that all classrooms have air conditioning, so it could be said that the infrastructure is not a factor that contributes to failure. As for the atmosphere created by the teacher, when they were in a normal course, it felt stressful and teamwork was not encouraged. The teacher did not make the class interesting, they found it boring, and they felt that the teacher was not prepared to teach mathematics, so the teaching style may have had an impact on their failure. Finally, most students are supported by their parents in their studies, so the economic factor can be ruled out as a major factor in their failure in the subject.

At this stage of the research, we can see that motivation in the classroom is vitally important for students to perform well and benefit from studying mathematics. Learning mathematics is multivariable, but teaching and learning styles must be improved day by day.

3. Satisfaction survey

The results of the final survey showed that students are satisfied with the lessons taught by their differential calculus teacher, as they say they have acquired the desired learning outcomes (see Figure 18).

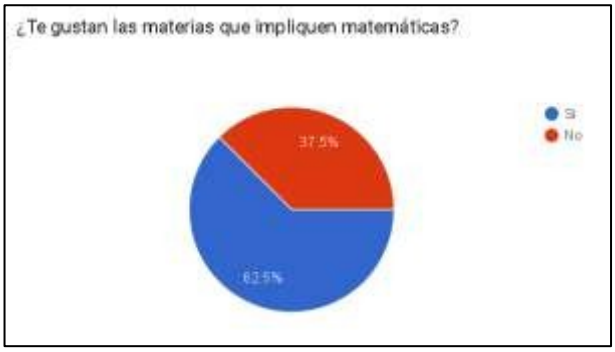
Figure 18. *Satisfaction results: knowledge acquired.*



Source: *Own creation.*

In addition, 62.5% of the students who completed the final survey (Figure 19) mentioned that they do not like subjects that involve mathematics.

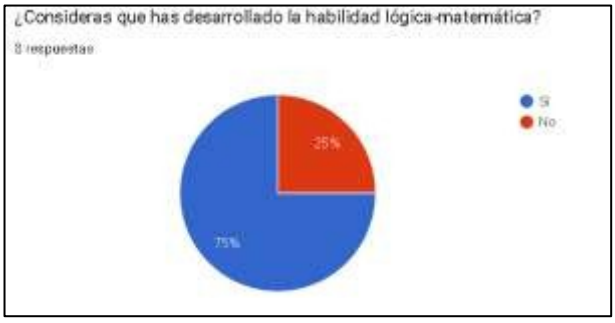
Figure 19. *Satisfaction results: subjects involving mathematics.*



Source: *Own creation.*

However, 75% mentioned that, despite not liking mathematics subjects, they have developed logical-mathematical skills (Figure 20).

Figure 20. *Satisfaction results: development of logical-mathematical skills.*



Source: *Own creation.*

Another important factor observed was that students do not have effective study habits that allow them to understand and acquire knowledge in the area of mathematics (see Figure 21).

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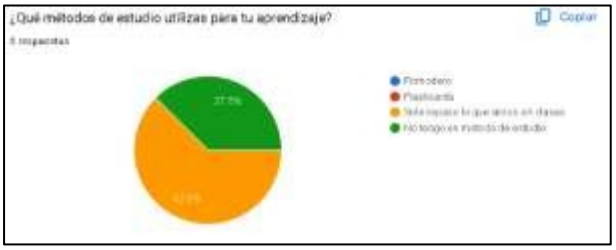
Figure 21. *Satisfaction results: study methods*.



Source: *Own creation*.

Students' study habits are essential for them to successfully understand the topics they are reviewing, and they themselves have stated that they do not have these habits. Therefore, it is necessary to offer workshops and talks on this topic to students. It seems that undergraduate students no longer require this; However, many of the students' failures are because they do not read instructions, do not concentrate, do not understand, do not know how to review, do not use their time well, and all of that boils down to study habits.

CONCLUSIONS

This analysis shows that there are two important factors in student learning: These were the teaching methods of the professors and the lack of study habits on the part of the students, which limits learning. If there is a deficiency in teaching, knowledge is not being acquired through self-study either, which leads students to consider subjects that involve the use of mathematics to be complicated. so they begin to perceive them as tedious or boring, resulting in them failing their subjects and, in many cases, leading them to decide to drop out of their studies.

It should be noted that there are other factors also mentioned by the students, among which economic conditions stand out, since, although they do not intend to drop out, they are clear that one of the reasons they would abandon their studies is the lack of financial resources, which causes them stress and neglect of their classes.

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AUTHORIZATION AND WAIVER.

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Contribution roles table

Role	Author(s)
Conceptualization	María Lidia Palacios Contreras María del Socorro Contreras Ochoa
Methodology	María Lidia Palacios Contreras Claudia Barreto Cabrera María del Socorro Contreras Ochoa Arturo Emmanuel Díaz Domínguez Jesús Recillas Román
Project management	Maria Lidia Palacios Contreras Claudia Barreto Cabrera
Resources	Arturo Emmanuel Díaz Domínguez Jesús Recillas Román
Editorial	María Lidia Palacios Contreras
Validation	Claudia Barreto Cabrera
Supervision	María Lidia Palacios Contreras Claudia Barreto Cabrera

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