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Artículos científicos

Impacto de cursos introductorios de matemáticas en estudiantes del Centro Universitario de los Valles de la Universidad de Guadalajara

Impact of introductory Mathematics courses on students of the University Center of the Valleys of the University of Guadalajara

Impacto dos cursos introdutórios à matemática nos alunos do Centro Universitário de los Valles da Universidade de Guadalajara

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Resumen

Los estudiantes que ingresan al Centro Universitario de los Valles carecen de algunas habilidades Matemáticas. Por ello, con este estudio se buscó identificar las fortalezas y debilidades en estas habilidades, así como determinar si al cursar al menos un curso de matemáticas se logra mejoría en esos aspectos. Para ello, se estableció una comparación de resultados entre los estudiantes de nuevo ingreso de las licenciaturas en Administración, Turismo, Contaduría Pública, Tecnologías de la Información, y las ingenierías en Mecatrónica, Electrónica y Computación, Instrumentación Electrónica y Nanosensores, Diseño Molecular de Materiales, Geofísica y Sistemas Biológicos. En concreto, se aplicó el mismo examen al inicio y al final del semestre 2022A. Con base en los resultados, se pudo concluir que mejoraron las habilidades mediante los cursos iniciales de matemáticas. El promedio general aumentó de 52.978 al inicio del semestre a 63.948 al finalizar. Asimismo, disminuyó el porcentaje de estudiantes con calificación reprobatoria, del 58.11 % al inicio del semestre al 34.88 % al final. En casi todas las carreras se observó una mejora en el promedio: la mayor fue en ingeniería en Electrónica y Computación, con un aumento superior a 24 puntos; solo en ingeniería en Geofísica empeoró al bajar un poco más de 1 punto. En síntesis, pudo observarse la mejora en las habilidades de los estudiantes una vez que cursaron al menos una materia del área de matemáticas en el primer semestre; sin embargo, aún queda una gran oportunidad de mejora en estas habilidades, por lo que se tendría que mantener el apoyo y seguimiento de los estudiantes.

Palabras clave: mejora, habilidades matemáticas, nuevo ingreso, licenciatura, semestre.

Abstract

The students who enter the University Center of the Valleys lack some Mathematics skills. The study sought to identify the strengths and weaknesses in these skills, as well as whether, by taking at least one Mathematics course, an improvement was achieved in them, and to compare the results among new students of the Bachelor's Degrees in Administration, Tourism, Public Accounting, Information Technologies and Engineering in Mechatronics, Electronics and Computing, Electronic Instrumentation and Nanosensors, Molecular Design of Materials, Geophysics and Biological Systems. The same examen was applied at the beginning and at the end of the 2022A semester, based on the results, it could be concluded that skills improved through the initial Mathematics courses. The general average increased from 52,978 at the beginning of the semester, to 63,948 at the end, the percentage of students with a failing grade also decreased, from 58.11% at the beginning of the semester to 34.88% at the end. In almost all the careers an improvement in the average was observed, the highest was in Electronics and Computer Engineering with an increase of more than 24 points, only in Geophysics Engineering it worsened by dropping a little more than 1 point. It was possible to observe the improvement in the students' skills once they completed at least one subject in the Mathematics area in the first semester, however, there is still a great opportunity to improve these skills, so support and follow-up should be maintained of the students.

Keywords: Improvement, mathematical skills, new students, bachelor's degree, semester

Resumo

Os alunos que ingressam no Centro Universitário Valles carecem de algumas habilidades matemáticas. Portanto, este estudo buscou identificar os pontos fortes e fracos dessas habilidades, bem como determinar se a realização de pelo menos um curso de matemática melhora esses aspectos. Para tanto, foi estabelecida uma comparação de resultados entre alunos ingressantes das licenciaturas em Administração, Turismo, Contabilidade Pública, Tecnologia da Informação, e engenharias em Mecatrônica, Eletrônica e Computação, Instrumentação Eletrônica e Nanossensores, Projeto Molecular de Materiais, Geofísica e Sistemas Biológicos. . Especificamente, o mesmo exame foi aplicado no início e no final do semestre 2022A. Com base nos resultados, pôde-se concluir que as competências melhoraram ao longo dos cursos iniciais de matemática. A média geral passou de 52.978 no início do semestre para 63.948 no final. Da mesma forma, o percentual de alunos com nota reprovada diminuiu, passando de 58,11% no início do semestre para 34,88% no final. Em quase todos os cursos observou-se uma melhoria na média: a maior foi em Engenharia Electrónica e de Computação, com um aumento de mais de 24 pontos; somente na engenharia em Geofísica piorou caindo pouco mais de 1 ponto. Em síntese, pôde-se observar a melhora nas habilidades dos alunos uma vez que cursaram pelo menos uma disciplina da área de matemática no primeiro semestre; No entanto, ainda existe uma grande oportunidade de melhoria destas competências, pelo que o apoio e acompanhamento dos alunos teria que ser mantido.

Palavras-chave: aperfeiçoamento, habilidades matemáticas, ingressante, bacharelado, semestre.

Fecha Recepción: Enero 2023 **Fecha Aceptación:** Julio 2023

Introduction

The University Center of the Valleys (CUValles) of the University of Guadalajara, based in Ameca, Jalisco (Mexico), is a higher education institution whose academic offering has different degrees in which various mathematics courses are taught, essential axis for the training of these future professionals. However, due to the diversity of institutions from which these students come (the majority from populations in the Valleys Region of the state of Jalisco, Mexico), their academic training is diverse, particularly in the mentioned discipline.

Mathematics is an essential tool in a variety of university disciplines. According to Roick and Ringeisen (2018), they are recognized as a fundamental component in higher education, while Bertrand *et al*. (2021) emphasize that the importance of mathematics lies in its role as a foundation for disciplines such as engineering, science, business, and economics. Douglas and Salzman (2020) add that mathematics is acquiring growing importance in industry and society in general, which is why they affirm that university mathematics programs should adjust to the demands that the labor market requires, since the contents of the courses must have a practical application.

Given what these authors have stated, a significant aspect to consider is the level of mathematical skills of students entering university, since deficiencies have been identified that often contribute to them abandoning their university studies. Therefore, it is vitally important to analyze the factors related to the development of these skills.

In this sense, Madison *et al*. (2015) conducted an assessment of high school students' readiness for college mathematics courses and found that two-thirds of students tested were not prepared to take college-level mathematics. In the case of CUValles, it has been observed throughout several school years that new students have a low level of basic mathematical skills. In this regard, Pigge *et al*. (2017) maintain that the transition from secondary education to university can be complicated for students who take mathematics subjects in their first semester.

Regarding this aspect, it is worth highlighting that students of the degrees in Administration, Tourism, Public Accounting, Information Technologies and engineering in Mechatronics, Electronics and Computing, Electronic Instrumentation and Nanosensors, Molecular Design of Materials, Geophysics and Biological Systems of the CUValles take, during their first semester, basic introductory mathematics courses, such as Precalculus, Mathematics I or Mathematical Methods I. These courses are an essential part of their study plan and have a dual purpose: to prepare students for more advanced courses in the area of mathematics and address deficiencies in their training in fundamental mathematical skills. Therefore, it is possible to also consider them as remedial courses.

According to Bertrand *et al*. (2021), introductory mathematics courses seek to equip students with the fundamental knowledge for their future studies, so that the success they achieve in these can influence the direction of their careers. In addition, they highlight the importance of strengthening basic mathematical concepts to overcome any deficiencies that students may have. However, Roick and Ringeisen (2018) point out that an introductory mathematics course in college can become a barrier to completing studies in higher education.

Therefore, in relation to remedial mathematics courses, Er (2018) explains that research on this topic is still inconclusive. While some studies support the effectiveness of these courses, others suggest that they do not completely solve the problem and do not guarantee an obvious improvement in students' mathematical skills. Along these lines, Büchele (2020a) maintains that although remedial mathematics courses are essential in higher education, they have not been conclusively shown to have a significant impact on students' skills.

On the other hand, Mgonja and Robles (2022) argue that successfully completing this type of courses is essential for academic success at university. In the case of Paschal and Taggart (2019), their findings indicate that students who pass pre-calculus college courses are more likely to persist in careers related to STEM (Science, Technology, Engineering, and Mathematics).

On the other hand, Quarles and Davis (2017), regarding the influence of the type of mathematics taught in remedial courses, highlight that training focused on procedural skills may not be equipping students with the skills required to address university mathematics. This observation focuses on the fact that remedial courses tend to focus on procedural skills, which may not adequately connect mathematical ideas with real-life applications.

Logue *et al*. (2016) highlight that there is a low success rate among students who complete remedial courses. Xu and Dagar (2018), in the United States context, point out that many high school graduates are not sufficiently prepared for college courses, leading them to take remedial courses. However, outcomes in these courses are often poor, raising questions about their effectiveness, especially for those students with limited mathematical preparation.

Büchele (2020b) identifies a similar problem in Germany, where students entering university often lack the mathematical skills for the higher education level, motivating the offer of remedial courses.

Cheng (2016) highlights that a significant percentage of new university students do not possess the skills required for higher education. Although some view remedial courses as a way to provide students with the tools to succeed in college, others express concerns about the financial impact and time needed to graduate that these courses may pose.

In line with the above, Rach and Heinze (2016) highlight that the transition to university, especially in the context of advanced mathematics courses, presents significant challenges. Therefore, they affirm that students require appropriate learning requirements when faced with new educational opportunities, and this is particularly relevant in the case of mathematics. They agree that adequate prior mathematical knowledge is essential for university study of this subject, since otherwise it can increase the probability of academic abandonment.

In line with this, the same authors highlight that the first year at university plays a crucial role in success in mathematics, and point out that students often face learning difficulties when beginning their university studies.

Lake *et al*. (2017) highlight the importance of mathematical skills before entering college for retention and successful performance in that area. Additionally, they explain that diagnostic tools are essential to identify students who require additional support, especially those who lack specific skills in mathematics. This highlights the relevance of carrying out diagnostic evaluations for new students at CUValles, not only to detect those who need to reinforce their skills, but also to evaluate whether these improve through mathematics courses in the first semester.

Nortvedt and Siqveland (2018) suggest that students may graduate from high school with the ability to apply mathematical procedures, but may lack strong conceptual understanding. They also emphasize that fluency in basic arithmetic and algebra is essential for tackling more advanced mathematics, which is why Malin *et al*. (2017) share the view that secondary education should prepare students for a successful transition to college.

Taking into account the aforementioned and with the objective of identifying the areas in which new students at CUValles present deficiencies in basic mathematical skills, this study designed an exam with various questions that evaluate these skills. This exam was administered to students at the beginning of the 2022A semester. Subsequently, at the end of the first semester, given that all students took at least one basic mathematics course during this period, the same exam was administered again. The purpose of this second assessment was to compare the results and determine if there had been an improvement in their basic mathematics skills.

On the topic of remedial courses, Boatman and Long (2017) found that they can affect students differently, depending on their level of academic preparation upon entry. In this sense, and despite the widespread assumption that the CUValles remedial mathematics courses taken in the first semester improve the academic performance of students, as noted by Logue et *al*. (2019), this is not always the case, as some students at this institution fail to pass these courses, which can cause problems, such as academic failure.

Therefore, this work focused on identifying whether mathematics courses that students of Administration, Tourism, Public Accounting, Information Technology, as well as engineering in Mechatronics, Electronics and Computing, Electronic Instrumentation and Nanosensors, Molecular Design of Materials, Geophysics and Biological Systems taken in the first semester have an impact on improving their mathematical skills. The objective is to determine if this contributes to correcting the deficiencies with which they enter, which, in turn, would allow them to perform better in subsequent courses.

Methodology

In the first instance, we proceeded to identify the bachelor's degrees from the Centro Universitario de los Valles (CUValles) that have at least one mathematics course, either Mathematics I, Precalculus or Mathematical Methods I in the first semester. In this sense, the careers were the following: bachelor's degree in Information Technology, engineering in Mechatronics, engineering in Electronics and Computing, engineering in Electronic Instrumentation and Nanosensors, engineering in Molecular Design of Materials, engineering in Geophysics, engineering in Biological Systems, degree in Administration, degree in Tourism and degree in Public Accounting.

Subsequently, the schedules and teachers of these courses were identified, who were asked for support in administering an exam. This was designed to evaluate the basic mathematics skills of students, according to the study programs of the upper secondary level. For this, the total number of new students of the previously mentioned degrees of the CUValles of the University of Guadalajara for the 2022A semester (January to June 2022) was determined as the study universe. Then, the same exam was applied at the beginning and at the end of the 2022A semester, in the first class and in the last, of the identified groups of these degrees. The exam was made up of 15 multiple choice questions, where basic mathematical skills were taken into account.

Once the exam was administered at the beginning of the semester, it was evaluated, concentrated, and the results were analyzed. This was also done when administering the exam for the second time at the end of the semester. The results of the two moments of application of the exam were then compared in order to identify the impact of these courses on the improvement of the mathematical skills of the first-year students of the bachelor's degrees that were part of this research. It should be noted that Excel and Minitab were used to analyze the responses. Table 1 presents the information on the population that was part of this research.

Table 1. Comparison by educational program at the beginning and end of the 2022 semester A

Educational program	Total students at the beginning of the 2022A semester	Total students at the end of the 2022A semester
Bachelor of Information Technology	32	24
Engineering in mechatronics	54	24
Electronics and Computer Engineering	34	29
Engineering in Electronic Instrumentation and Nanosensors	33	12
Molecular Materials Design Engineering	20	12
Geophysics Engineering	17	12
Biological Systems Engineering	35	18
Degree in administration	72	64
Bachelor of Tourism	36	32
Degree in public accounting	80	31
TOTAL	413	258

Source: Own elaboration

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Results

With the analysis of the answers, it was possible to identify the number that were correct, incorrect and without answers (table 2).

Table 2. Distribution of response types

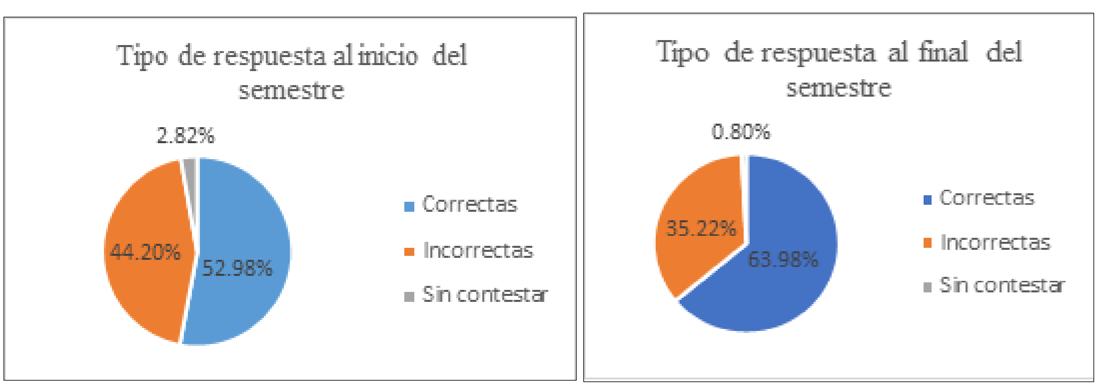
Type of responses	Frequency before starting the semester	Frequency at the end of the semester
Correct	3282	2476
Incorrect	2738	1363
Without answer	175	31

Source: Own elaboration

On the other hand, Figure 1 shows that 52.98% of the answers were correct at the beginning of the semester, while at the end of the semester it increased to 63.98% of correct answers, which represents an increase of 11%.

Similarly, 44.20% of the answers were incorrect at the beginning of the semester, while 35.22% were incorrect at the end of the semester; That is, a decrease of 8.98% was achieved. It is also observed that at the beginning of the semester there were 2.82% unanswered responses, while at the end of the semester there were only 0.8%.

Figure 1. Type of response (at the beginning and end of the semester)



Source: Own elaboration

Table 3 presents the frequency of students considering the number of correct answers obtained at the beginning and at the end of the semester. It is observed that at the beginning of the semester only 3 students answered the fifteen questions correctly, while at the end of the semester 5 students answered the 15 questions correctly. Likewise, it is observed that at the beginning of the semester one student got only one question correct, while at the end no student got only one question correct. At the beginning of the semester, 14.73% of the students answered 7 questions correctly, a higher percentage than is recorded in the table, which corresponds to a score of 46.66 on the scale from 0 to 100; while at the end of the semester the highest percentage was 16.66%, which corresponds to question eleven, in which 43 students obtained eleven questions correct, which is equivalent to a score of 73.33 on the scale from 0 to 100.

Table 3. Number of correct answers and number of students

	Start of the semester		End of the semester	
Number of hits	Number of students	Percentage	Number of students	Percentage
Zero	0	0	0	0
One	1	0.26	0	0
Two	8	2.1	2	0.77
Three	12	3.15	6	2.32
Four	24	6.31	4	1.55
Five	45	11.84	11	4.26
Six	49	12.89	17	6.58
Seven	56	14.73	22	8.52
Eight	45	11.84	28	10.85
Nine	45	11.84	28	10.85
Ten	50	13.15	27	10.46
Eleven	28	7.36	43	16.66
Twelve	20	5.26	29	11.24
Thirteen	14	3.68	19	7.36
Fourteen	13	3.42	17	6.58
Fifteen	3	0.78	5	1.93

Source: Own elaboration

Table 4 shows the percentage of students who obtained correct, incorrect and unanswered answers to each of the questions at the beginning and end of the semester. It is observed that the question with the most incorrect answers at the beginning of the semester was number 13 with 10.56%; while at the end of the semester the highest percentage of incorrect answers corresponds to question number 5 with 12.03%. It is important to indicate that in question 13 the ability to express the perimeter of a rectangle in algebraic form based on a verbal expression was evaluated. On the other hand, in question 5 the simplification of an expression was evaluated using the concepts of similar terms, laws of signs and use of parentheses.

Likewise, in question number 15 at the beginning of the semester there was a percentage of incorrect answers of 9.24%. This question involved solving a quadratic equation. At the end of the semester, 11.89% of incorrect answers correspond to question number 13.

In addition to the above, it is possible to affirm that the question that the highest percentage of students did not answer at the beginning of the semester was question 15 with 16%. In this question it was needed to solve a quadratic equation. On the other hand, at the end of the semester the highest percentage (16.13%) corresponded to questions 6 and 13 (question 6 referred to identifying an equivalent algebraic expression).

In relation to the correct answers, the highest percentage at the beginning and end of the semester corresponded to question 14. This consisted of identifying the correct procedure to solve a first degree equation with an unknown. Question 3 coincided in a high percentage both at the beginning and at the end of the semester. This question concerned the application of the hierarchy of operations.

Table 4. Response type per question

Question	Percentages					
	Correct answers		Wrong answers		Unanswered answers	
	Start of the semester	End of the semester	Start of the semester	End of the semester	Start of the semester	End of the semester
One	6.28	7.59	7.45	5.14	1.14	0
Two	5.94	6.91	7.78	6.24	2.86	6.45
Three	9.93	8.89	2.85	2.72	5.14	3.22
Four	8.32	8.08	4,711	3.82	6.29	22.58
Five	3.78	3.76	9.75	12.03	12.57	3.23
Six	4.72	4.6	8.58	10.27	13.14	16.13
Seven	8.87	6.7	4.27	6.68	3.42	3.22
Eight	8.2	8.32	4.97	3.82	4.57	0
Nine	6	6.7	7.49	6.6	6.28	6.45
Ten	4.27	5.05	9.6	9.68	5.71	3.23
Eleven	6.55	7.39	6.94	5.42	4.57	3.23
Twelve	9.87	8.6	2.62	3.08	5.14	9.68
Thirteen	3.38	3.68	10.52	11.89	8.57	16.13
Fourteen	9.96	9.17	2.92	2.12	4.57	0
Fifteen	3.93	4.56	9.24	10.49	16	6.45

Source: Own elaboration

On the other hand, Table 5 shows that the general average at the beginning of the semester was 52.978, while at the end it was 63.948. It is important to note that the standard deviation is an indicator that allows us to identify how dispersed the data are around the mean, that is, the data oscillate at a distance of the standard deviation of the mean (Gutiérrez and Vladimirovna, 2017; Levin and Rubin, 2004). In this sense, the standard deviation found at the end of the semester is slightly smaller than the standard deviation at the beginning of the semester.

Table 5. Average and standard deviation of the total number of students

	Average at the beginning of the semester	Average at the end of the semester
Average	52,978	63,942
Standard deviation	19,316	19,248
Number of students	413	258

Source: Own elaboration

Table 6 shows the percentages of students classified depending on the grade range obtained. We observed that at the beginning of the semester 58.11% of the students obtained a failing grade (insufficient), while at the end of the semester for this same range it reached 34.88%.

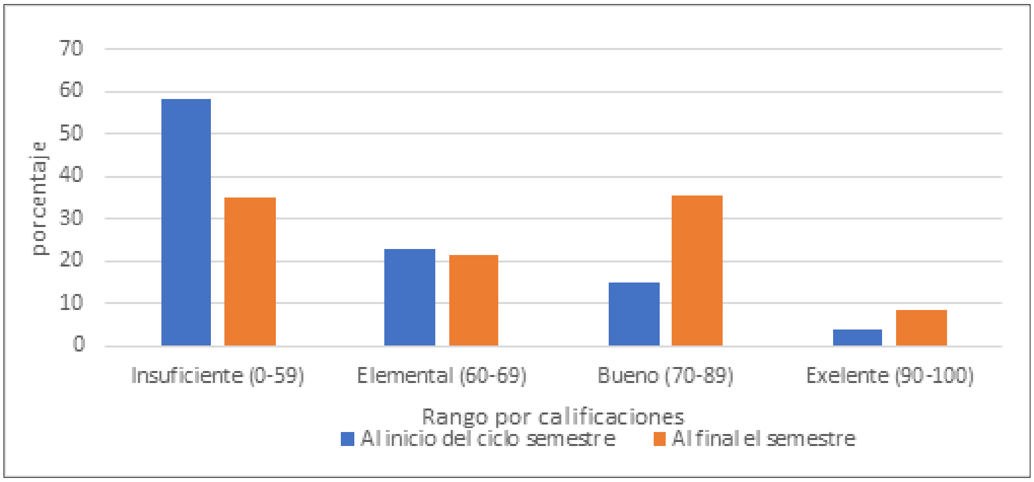
Regarding passing grades, the percentage of students who obtained a grade in the range between 60 and 69 (elementary) at the beginning of the semester was 23% and at the end of the semester it was 21.31%. On the other hand, in the good range (a grade of 70 to 89), at the beginning of the semester there was a percentage of 15.01%, while at the end of the cycle there was a percentage of 35.27%. In the excellent range (a grade of 90 to 100), the percentage at the end of the semester is higher by almost 5 percentage points (this is seen graphically in Figure 2).

Table 6. Percentage of students classified by range of grade obtained

Grade range obtained	Start of the semester	End of the semester
	Percentage of students	
Insufficient (0-59)	58.1113	34.8837
Elementary (60-69)	23.0024	21.3178
Good (70-89)	15.0121	35.2713
Excellent (90-100)	3,874	8.5271

Source: Own elaboration

Figure 2. Classification by grade range at the beginning and end of the semester



Source: Own elaboration

Statistical justification to test whether the population means (averages) at the beginning and at the end of the semester are different or equal

Using the *hypothesis testing statistical tool* to verify if the averages at the beginning and end of the semester are significantly different or equal, the set of hypotheses would be as follows:

$$H_0: \mu_A = \mu_F$$

$$H_1: \mu_A \neq \mu_F$$

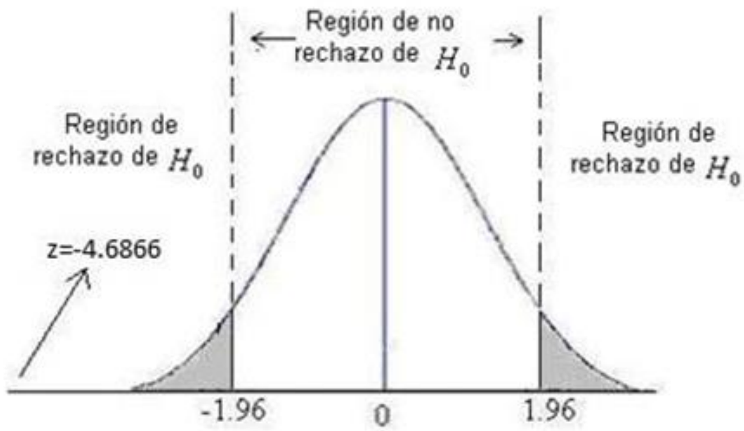
The point estimator of $(\mu_A - \mu_F)$es $(\underline{x}_A - \underline{x}_F)$and satisfies the assumptions of the large sample test. Since the sample size is large, the normal distribution can be used and the sample variances give adequate estimates of the corresponding population variances. Therefore, when substituting the values from table (5) into the test statistic, it becomes:

$$z = \frac{\underline{x}_A - \underline{x}_F}{\sqrt{\frac{\sigma_A^2}{n_A} + \frac{\sigma_F^2}{n_F}}} = \frac{52.978 - 63.942}{\sqrt{\frac{(19.316)^2}{413} + \frac{(19.248)^2}{258}}} = \frac{-10.964}{2.3393} = -4.6866$$

Where $\sigma_A^2$and $\sigma_F^2$are the respective population variances at the beginning of the semester and at the end of the semester. A two-tailed test is required for this application. Therefore, if the significance level is 0.05, the null hypothesis is rejected (H_0) if $z > z_{\alpha/2,}$ or $z < -z_{\alpha/2,}$ where $z_{0.025} = 1.96$ _

By plotting the standardized difference on a graph of the sampling distribution and comparing it with the critical value (the value of the statistic), as seen in the graph in Figure 3, the value of the test statistic is in the rejection region. Thus there is evidence to conclude that there is a difference between the two means. Therefore, with a significance level of 0.05, *the average at the beginning and at the end of the semester are different.*

Figure 3. Representation of the rejection regions for bilateral tests



Source: Adapted from Levin and Rubin (2004)

Now, if you want to prove that the average at the beginning of the semester is greater than the average at the end of the semester, the set of hypotheses is as follows:

$$H_0\colon \mu_A \leq \mu_F$$

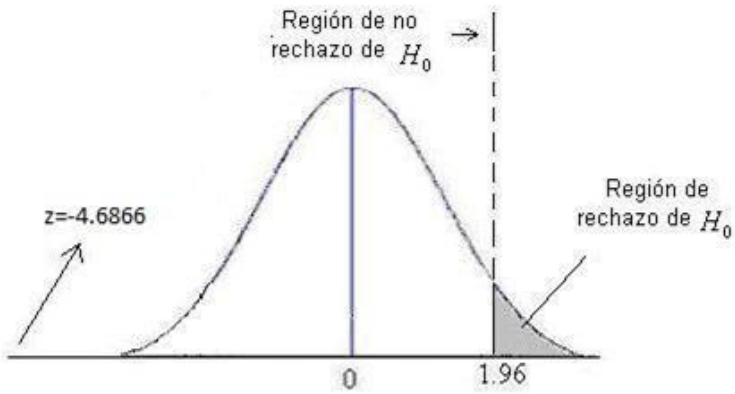
$$H_1\colon \mu_A > \mu_F$$

For this adjustment of the hypotheses, we want to test whether the average at the beginning of the semester is less than or equal to the average at the end of the semester, or if the average at the beginning is greater than the average at the end of the semester. For this set of hypotheses, a one-tailed test is required and by substituting the information presented in Table 5, in the test statistic given by the equation, we have the following:

$$z = \frac{x_A - x_F}{\sqrt{\frac{\sigma_A^2}{n_A} + \frac{\sigma_F^2}{n_F}}} = -4.6866$$

Therefore, if a significance level of 0.05 is used, there is no evidence to reject the hypothesis H_0 since the rejection region is located to the right of the distribution (see Figure 4), that is, the null hypothesis is rejected if $z > z_{\alpha}$, where $z_{0.05} = 1.96$_ Therefore, the data provide evidence to conclude that *The average at the beginning of the semester is less than or equal to the average at the end of the cycle.*

Figure 4. Representation of the rejection regions for unilateral testing and rejection region on the right.



Source: Adapted from Levin and Rubin (2004)

Now, if the average at the beginning of the semester is lower than the average at the end of the semester, the hypothesis game looks like this:

$$H_0: \mu_A \geq \mu_F$$

$$H_a: \mu_A < \mu_F$$

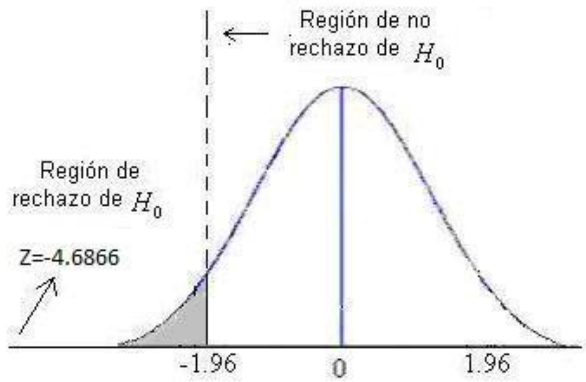
The test statistic is given by:

$$z = \frac{\underline{x}_A - \underline{x}_F}{\sqrt{\frac{\sigma_A^2}{n_A} + \frac{\sigma_F^2}{n_F}}} = -4.6866$$

If the significance level is 0.05, the null hypothesis is rejected (H_0) if $z < -z_{\alpha,}$ where $z_{0.05} = 1.96$.

Figure 5 shows the value of the test statistic and it is observed that it is in the rejection region, so the data gives evidence to conclude that *the average at the beginning of the semester is lower than the average at the end of the semester*. Therefore, we can affirm that the average grade at the beginning of the semester is lower than the average grade at the end of the semester.

Figure 5. Representation of the rejection regions for unilateral testing and rejection region on the left



Source: Adapted from Levin and Rubin (2004)

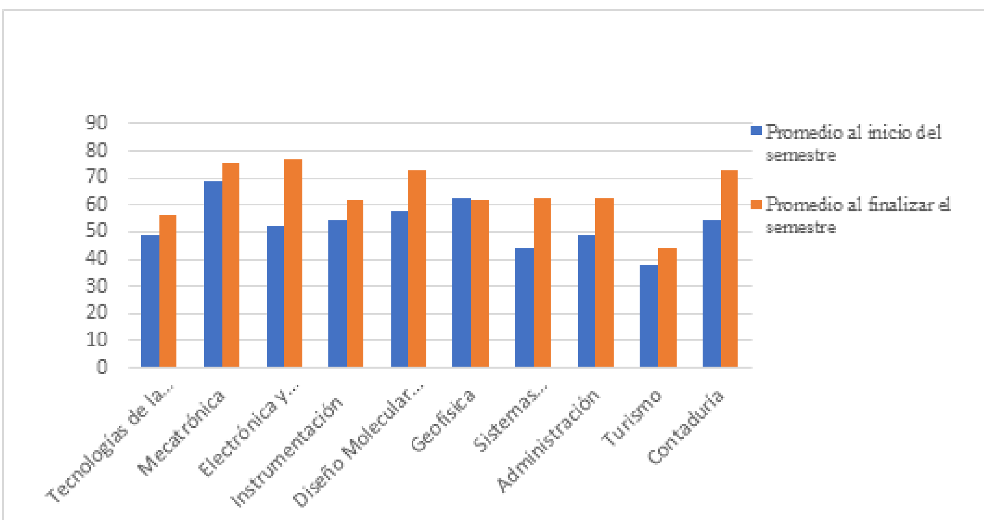
Table 7 shows the averages by educational program at the beginning and end of the semester. A higher average is observed in each educational program at the end of the semester, except in Geophysics engineering, where the average is higher at the beginning of the semester (see figure 6). Furthermore, we can observe that the highest average at the end of the semester corresponds to Electronics and Computer Engineering, and the educational program of the degree in Tourism has the lowest average both at the beginning and at the end of the semester.

Table 7. Average per educational program at the beginning and end of the semester

Educational program	Average at the beginning of the semester	Average at the end of the semester
Bachelor of Information Technology	48,958	56,388
Mechatronics Engineering	68,641	75,833
Electronics and Computer Engineering	52,549	76,666
Engineering in Electronic Instrumentation and Nanosensors	54,343	61,666
Molecular Materials Design Engineering	58	72,777
Geophysics Engineering	62,745	61,666
Biological Systems Engineering	44.19	62,592
Degree in administration	48,981	62.5
Bachelor of Tourism	37.96	44,166
Accounting degree	54.5	73,118

Source: Own elaboration

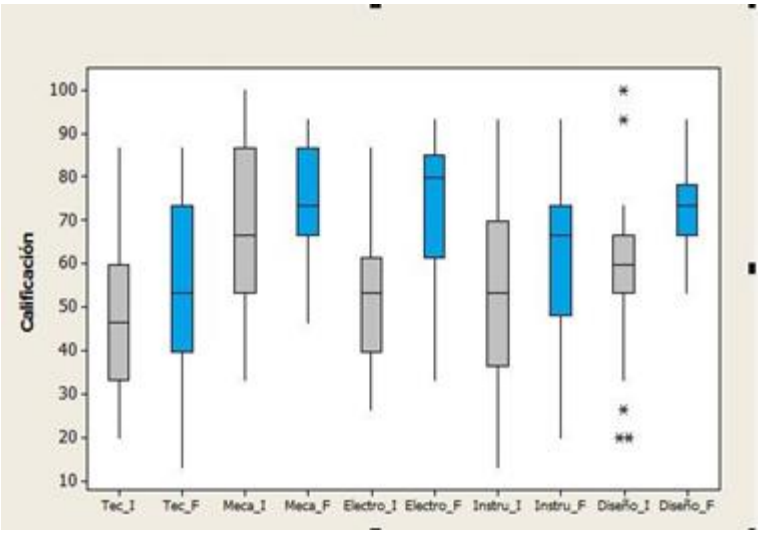
Figure 6. Average by educational program at the beginning and end of the semester



Source: Own elaboration

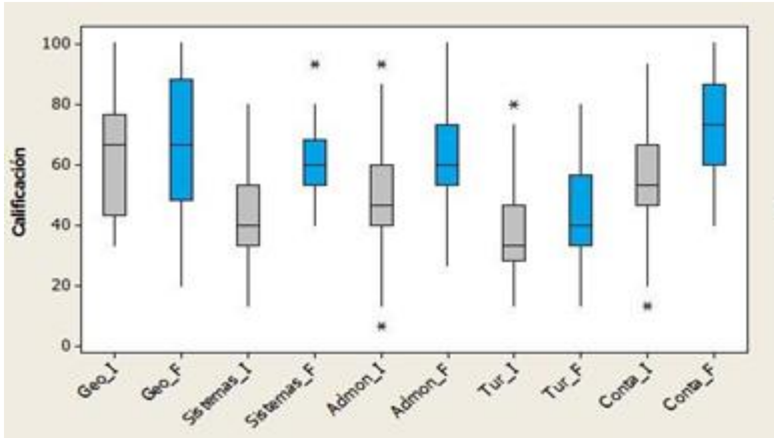
Figure 7 shows the box plots at the beginning and at the end of the semester of 5 educational programs in which Tec_I (bachelor's degree in Information Technology at the beginning of the semester and Tec_F at the end of the semester); Mec_I (Mechatronics engineering at the beginning of the semester and Mec_F at the end of the semester); Electro_I (Electronics and Computer Engineering at the beginning of the semester and Electro_F at the end of the semester); Instru_I (Electronic Instrumentation and Nanosensors engineering at the beginning of the semester and Instru_F at the end of the semester); Design_I (Molecular Design of Materials at the beginning of the semester and Design_F at the end of the semester). It is observed that the boxes of each educational program at the end of the semester have higher ratings than at the beginning of the cycle; On the other hand, the engineering educational program in Molecular Design of Materials has the lowest interquartile range compared to all. In addition, it has less data variability because the length of the box is shorter both at the beginning and at the end of the cycle, but at the beginning of the semester it has 5 outlier values, since it has two values of 20: a value of 26,666, another of 93,333 and another 100, and at the end of the cycle it has no outlier value. Furthermore, it is observed that in each educational program at the end of the semester the median value was greater than at the beginning of the semester.

Figure 7. Comparison of grades by educational program (part I)



Source: Own elaboration

Figure 8. Comparison of grades by educational program (part II)



Source: Own elaboration

Figure 8 shows the box plots at the beginning and at the end of the semester of 5 educational programs in which Geo_I (Geophysics engineering at the beginning of the semester and Geo_F at the end of the semester); Systems_I (Biological Systems engineering at the beginning of the semester and Systems_F at the end of the semester); Admon_I (bachelor's degree in Administration at the beginning of the semester and Admon_F at the end of the semester); Tur_I (bachelor's degree in Tourism at the beginning of the semester and Tur_F at the end of the semester); Conta_I (accounting degree at the beginning of the semester and Conta_F at the end of the semester). It can be seen that the boxes of each educational program at the end of the semester have higher ratings than at the beginning of the cycle.

Discussion

The courses in the area of mathematics that are taught during the first semester are of great importance, since — as López and Cornejo (2020) point out — they complement or correct the learning they obtained in upper secondary education and level them with the demands of University. This is the reason why this study sought to identify whether these courses impact the improvement of students' mathematical skills, since—as López and Cornejo (2020) also state—it is the area in which they present the greatest difficulty students. In fact, the study shows that they do contribute to improvement, which confirms their importance. This was also observed by De la Jara and Tristán (2022), who when implementing them identified a positive impact.

Since this study focused on one semester, it limits the possibility of identifying whether what was observed in this study occurs regularly in different school years. Therefore, it is necessary that this study be extended for longer to verify the positive impact that these introductory mathematics courses have on strengthening the skills of students who enter CUValles and what other aspects they impact.

This makes a lot of sense considering that Logue *et al*. (2016) point out that remedial mathematics courses seek to improve student performance at the university, that is, they not only impact subsequent courses in the area, but also overall performance as students. In this sense, it is worth remembering what was previously noted, that is, the mathematics courses taught in the first semester at CUValles do not have that name, but they fulfill that function, so their importance is of great relevance for a successful career in the professional training of students.

In this regard, Castillo *et al*. (2018) point out relevant elements of mathematics courses, such as the low achievements of students and the impact of low performance on failure and dropping out of school. From here we can highlight the importance of this research related to introductory mathematics courses at the university, since although the first-time students took courses in this area in high school, they arrive with important deficiencies, as could be observed in the results obtained. Therefore, the impact observed on the improvement of mathematical skills due to the introductory courses is fundamental, considering the impact it can have on the reduction of failures, dropouts and the improvement of terminal efficiency.

Definitely, it can be assured that this study proves that these courses are important and that they do impact the improvement of the mathematical skills of first-year students at CUValles.

Conclusions

Through this study it was observed that with the mathematics courses that new students take, they manage to improve their skills in this discipline. This is seen in different aspects, such as the increase in the percentage of correct answers in the exam that was administered at the end of the semester, compared to that obtained at the beginning of the semester. In congruence with this, a decrease in the percentage of incorrect answers was observed in the exam administered at the end of the cycle.

On the other hand, it should be noted that in the exam at the beginning of the semester, only three students answered all the questions correctly; however, at the end there was a slight increase. It was also identified that there was a higher percentage of students with a greater number of correct answers at the end of the semester, compared to those achieved at the beginning of the cycle.

Another important aspect that can be highlighted is the improvement in the average grades, since this increased by approximately eleven points in relation to that obtained at the beginning of the cycle.

Likewise, the percentage of students with a failing grade decreased by approximately twenty-four percentage points in the exam administered at the end of the semester.

Regarding the results by major, in all of them an improvement was observed in the average exam grades at the end of the semester; only engineering in Geophysics did not improve. The educational program in which the greatest improvement was observed was Electronics and Computer Engineering.

Without a doubt, the skills in the area of mathematics with which the new students of the bachelor's degrees that are part of this study arrive are not adequate; however, it is notable that the courses offered during the first semester do impact the improvement of these skills. Furthermore, it can be stated that they fulfill the two functions for which they were designed, that is, to address the deficiencies with which students enter and provide them with the bases for the courses that follow them. This recognizes that continuity must be given with different actions that contribute to the development of these skills so that students achieve adequate academic training in each of their careers.

Future lines of research

In order to deepen the study, it is considered viable to extend the research for more school cycles to verify if the results obtained are constant. Likewise, it is valued as a possibility that could expand the study to integrate aspects that allow identifying whether these courses have an impact on fundamental issues such as educational lag, failure and terminal efficiency. In this way, one could have a better and broader vision of the impact and benefits that these introductory mathematics courses can have.

On the other hand, since the mathematical skills were identified that even with the introductory courses did not improve substantially, specific actions could be designed and implemented to address the improvement of these skills in the courses and study if positive results are achieved with them in the students.

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Appendix 1

University of Guadalajara

University Center of the Valleys

Department of Natural and Exact Sciences

Age_____________ Gender_________ Career____________________________________

Year in which he/she finished high school_________ School of origin__________________

This instrument is diagnostic in nature. The results will provide information that will be useful for better development of your professional training.

Instructions. Each of the following items has only one correct answer. Underline it in each case.

1. The result of the operation $\frac{1}{2} \times \frac{5}{3}$ is

a) $\frac{10}{3}$ b) $\frac{6}{5}$ c) $\frac{5}{6}$ d) $\frac{3}{10}$

2. The result of the operation $\frac{2}{3} + \frac{3}{4}$ is

a) $\frac{5}{7}$ b) $\frac{9}{8}$ c) $\frac{5}{12}$ d) $\frac{17}{12}$

3. Select the correct result of the following operation.

$$3 \times 5 + {}^{6}\!/_{3} =$$

a) 7 b) 11 c) 17 d) 21

4. The expression $-3(x+y)$ is equivalent to

a) $-3x - y$ b) $-3x + 3y$ c) $-3x + y$ d) $-3x - 3y$

5. Simplify the following expression and choose the option that shows the correct result:

$$4(-a)^2 + 7(-b)^3 - 2(a^2 - b^3)$$

a) $-6a^2 - 5b^3$ b) $2a^2 - 5b^3$ c) $2a^2 + 9b^3$ d) $2a^2 - 9b^3$

6. The only expression that **is not equivalent** to $\frac{xy}{z}$ is:

a) $\frac{x}{z}y$ b) $\frac{1}{z}(xy)$ c) $x\frac{y}{z}$ d) $\frac{x}{z}\times\frac{y}{z}$

7. The result of $(x^2y^3)^4$ is

a) x^6y^7 b) x^8y^{12} c) x^9y^9 d) $x^{20}y^{20}$

8. The result $4x^2 \cdot 5x^3 \cdot x^4$ is:

a) $20x^{24}$ b) $9x^{24}$ c) $9x^9$ d) $20x^9$

9. The result of $\frac{6x^{10}}{2x^5}$ is

a) $3x^2$ b) $3x^{15}$ c) $3x^5$ d) $4x^5$

10. The option that corresponds to the development of the expression $(x+5)^2$ is

a) $x^2 + 25$ b) $25x^2$ c) $x^2 + 10x + 25$ d) $x^2 + 10$

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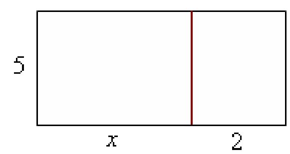
11. The option that corresponds to the expression " *twice a number diminished in 12 is equal to 26* " is:

a) $\frac{x}{2} - 12 = 26$ b) $2x - 12 = 26$ c) $2(x - 12) = 26$ d) $x^2 - 12 = 26$

12. Which expression represents the area of the rectangle?



a) $5x + 2$ b) $5(x + 2)$ c) $10x$ d) $x + 10$

13. If the length of a rectangular court is twice its width , the expression that represents the perimeter of the court is:

a) $2a^2$ b) $3a$ c) $6a$ d) $2(a + a)$

14. The option that shows the correct procedure to solve the equation $3x + 5 = 17$ is

a)	b)	c)	d)
$3x + 5 = 17$	$3x + 5 = 17$	$3x + 5 = 17$	$3x + 5 = 17$
$3x = 17 - 5$	$3x = 17 - 5$	$3x = 17 + 5$	$3x = 17 + 5$
$3x = 12$	$3x = 12$	$3x = 22$	$3x = 22$
$x = \frac{12}{3}$	$x = 12 - 3$	$x = \frac{22}{3}$	$x = 22 - 3$
$x = 4$	$x = 9$		$x = 19$

15. The solution of the quadratic equation $x^2 - 5x = 0$ is:

a) 5 b) 0 c) 0 and 5 d) 0 and -5