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Research Article

Does the use of the calculator reduce anxiety in the study of differential and integral calculus?

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ABSTRACT

The objective of this research is to study if the use of the calculator decreases students' anxiety in the subject of differential and integral calculus. Specifically, the research is carried out with 30 engineering students. Auzmendi anxiety factor questions are used to measure anxiety. The study is carried out in two moments; in the first the calculator is not used and in the second if they use it. In the second case, the calculator is used in problems involving the application of derivatives and integrals. The results indicate that the students reduce their anxiety when they use the calculator. Thus, in seven of the nine questions, students who use the calculator obtain a higher mean, it helps to reduce anxiety. In general, t-student test indicates that the moment students use the calculator they have less anxiety, and it helps to reduce errors in the mathematical process. Teachers should consider the calculator as a resource that motivates the student and helps reduce anxiety. In addition, the use of the calculator helps to reduce mathematical errors in basic operations and in the application of derivatives and integrals.

Keywords: differential calculus, integral calculus, Casio calculator, anxiety

INTRODUCTION

Differential calculus forms, along with integral calculus, one of the most substantial branches of mathematics (Wenzelburger, 2003). However, it is important to indicate that there are difficulties related to the knowledge of the basic concepts in mathematics, and they are most evident in the subject of differential and integral calculus, which is presented as one of the great problems for students in their first years of engineering semesters (Amorim & Felicetti, 2015). Given the learning difficulties that students present in differential and integral calculus, the teacher must present new teaching-learning strategies. In addition, to the learning difficulties of the subject, it can be said that anxiety towards study of calculus and low academic performance of the subjects is one of the biggest problems that teachers have to face (Rocha et al., 2020). For this reason, some researchers have emphasized the importance of studying students' anxiety towards differential and integral calculus (e.g., Daza & Garza, 2020; Delgado et al., 2017). Also, Kim and Park (2014) indicated that motivation, anxiety, and emotions are decisive in learning mathematics. When students' anxiety is high, their learning process is difficult to initiate, and their learning is easily interrupted (Bandura, 1986). Anxiety is a variable that facilitates academic performance since moderate levels of it will produce in the student body a state of alertness or attention that will improve their performance (García et al., 2013). Besides Delgado (2017) indicated that the relationship between students with a negative attitude towards the calculus content and different aspects related to the class is cause for concern given that the school system continues to enter engineering students with low knowledge of mathematics and negative anxiety.

In order to reduce students' anxiety in differential and integral calculus subjects, it is important to consider the presence of technology in classes, since it can help improve learning in terms of how they can influence the affective environment (Rivero, 2004). Thus, Galbraith and Haines (1998) considered that it was important to study attitudes towards mathematics with the use of technology, specifically in activities related to mathematical modeling. Moreover, Puerto and Minnaard (2003) recommended that the teaching of mathematics and its edges be done actively, developing a way of thinking that can make sense of the environment and applying all available technology. Otherwise, Puerto and Minnaard (2003) indicated that the scientific and graphing calculators have generated new questions regarding what changes are needed in the calculus curriculum and how their use should be integrated into teaching.

Several researchers have studied in depth the use of the calculator within the teaching-learning process of mathematics (e.g., Alcas, 2013; Gamboa, 2007; Guzmán et al., 2021). Within these investigations, it can be shown that the students who used the calculator obtained better academic performance than the students who did not use it. In addition, it is important to note that researchers find that anxiety is reduced by significantly improving their mathematical level. In this context, the following research question is posed: does the use of the calculator reduce anxiety of students in the study of differential and integral calculus subjects? It is important to investigate whether the use of the calculator influences anxiety towards differential and integral calculus subject because, as some authors have commented (e.g., Salvatierra, 2021), it directly influences their academic performance. A calculator is a tool that most students use daily in mathematics classes, but unfortunately, they do not know its potential. In this investigation, activities are proposed in which the calculator is used with the development of step-by-step problems of derivatives and integrals, and functions of the calculator that help to develop certain processes of these topics are explored.

Literature Review

Several researchers present proposals to introduce technology into the teaching-learning process in calculus subjects. These researchers have shown that engineering students have significantly improved academic performance with the implementation of technological resources, some of these investigations are reviewed below.

In their study, Quesada and Maxwell (1994) conducted research over three academic semesters and involved 710 students. They compared the performance of college students who were taught precalculus using a graphing calculator and a textbook written for use with a graphing calculator with the performance of students who used the traditional approach, a regular textbook a graphing calculator, and a scientific calculator. On a comprehensive common final exam, students taught precalculus using the graphing calculator scored significantly higher than those taught using traditional methods.

Sahão (2010) carried out partial and unsystematic evaluations of its influence on the teaching and learning of Calculus, but these partial evaluations point to good acceptance and use by students and improvements in user performance. Digital classes, with problem-solving, have been widely used, especially by students who need to miss a class or by those who feel the need to review an explanation to improve their fixation on an idea. In addition, these have helped the students understand the process of solving some problems that the teacher could not solve in the classroom, due to the little time available to develop all the contents related to differential and integral calculus subjects.

In another research, Hazday et al. (2010) addressed the issue of independent student work and presented three experiences in the development of courses in which a Casio ClassPad 300 calculator was used as technological support, taking advantage of the possibilities it offers to facilitate self-learning by students through the called e-activities. The calculator is shown as a useful tool in the teaching-learning process, especially as a support for independent work, which allows the development of skills in an independent and creative way. The students consider that a calculator is a useful tool in the teaching-learning process since it allows them to develop skills autonomously and creatively, which increases motivation in carrying out their work. It was verified that the students who attended these courses obtained better results in the evaluations carried out during their academic year.

In his research, Mena (2014) studied anxiety in mathematics in the subjects of general mathematics, differential and integral calculus, and differential equations, and applied Fennema and Sherman (1976) instrument. The researcher determined that a not very high percentage of students present a high or very high level of mathematical anxiety and those women present greater anxiety than men. Also, he determined that there are significant differences between anxiety levels of general mathematics students and students of differential and integral calculus and differential equations, with greater anxiety in differential and integral calculus and differential equations.

In a more recent investigation, Salvatierra (2021), indicated that the use of the Khan Academy platform made it possible to strengthen calculus I in the topics of derivatives for the students who made up the experimental group of engineering careers, who obtained considerable academic achievements. In addition, they demonstrated confidence, autonomy, and motivation during learning, consolidating their calculation skills and logical skills. The use of technology and the manipulation of the online platform allowed for tracking the student's interactions when coming into contact with the tools and interacting with videos solved exercises, and skill challenges.

Anxiety

Math anxiety consists of a series of feelings of anxiety, terror, nervousness, and physical symptoms that arise when doing mathematics or related subjects (Fennema & Sherman, 1976). Otherwise, for Sierra et al. (2003), anxiety refers to a state of agitation and unpleasant restlessness characterized by the anticipation of danger, the predominance of mental symptoms, and the sensation of a catastrophe or imminent danger, that is, the combination of cognitive and physiological symptoms, manifesting a startle reaction, where the individual tries to find a solution to the danger, so the phenomenon is perceived with total clarity. Besides, Richardson and Suinn (1972) stated that mathematical anxiety involves feelings of tension and anxiety that interfere with the manipulation of numbers and the solution of mathematical problems in a wide variety of situations that occur in the teaching-learning process. Also, Hembree (1990) indicated that mathematical anxiety is a manifestation of anxiety in any type of situation, where an activity related to mathematics has to be carried out. It is important to indicate that mathematical anxiety can have negative results on students, such as avoiding university engineering courses since they involve the frequent use of mathematics (Legg, 2009).

Casio fx570/991 Calculator

In this investigative work, it is important to explore some tools that Casio offers. Casio EDU+ tool is a service application for scientific calculators, for this, it is important to scan the corresponding QR code from ClassWiz calculator, this gives access to additional functions not available on the calculator. The main functions are online chart display and sharing charts and formulas between students and the teacher. With Casio EDU+ application you can create online classes, this is a complement to Casio fx 570/991 calculator. The objective of this feature is to observe and manage graphs, tables, and formulas, with this tool it is possible for the teacher to view all the exercises carried out by the students on the screen and share them with the work group (Yos, 2021).

Moreover, emulators are programs that emulate the operations of scientific and graphing calculators, they allow the use of all the functions of a calculator on a computer or on a mobile device, which gives the teacher the option to prepare teaching activities. An emulator is an effective tool for the design of learning activities in such a way that the student can learn with better results since the program does and shows the operations in the same way as the calculators. In addition, it allows teachers to create materials for their mathematics classes (Vallejo & Reyes, 2021).

METHODOLOGY

This section describes methodology used in this research. Specifically, this is a quantitative investigation.

Participants

The participants of this study corresponded to the first-year students of engineering of higher education in Ecuador, in 2021 academic period. Participation was voluntary and anonymous. Sample size of this study corresponds to n=30. The students are in their first year of university (approximately 18-20 years of age).

Table 1. Anxiety factor questions

Questions	Items
1 R	Calculus is pretty bad for me.
2	Studying or working with calculus does not scare me at all.
3 R	Calculus is one of the subjects I fear the most.
4	I have confidence in myself when I face a calculus problem.
5 R	When faced with a calculus problem I feel unable to think clearly.
6	I am calm when faced with a calculus problem.
7 R	Working with calculus makes me feel nervous.
8	I do not get upset when I have to work on calculus problems.
9 R	Calculus makes me feel uncomfortable and nervous.

Note. *Calculus: Differential and integral calculus

Instrument

In this research, a factor from Auzmendi (1992) attitude scale toward mathematics instruments is used. Specifically, anxiety factor is selected.

Attitude scale towards mathematics (EAM) allows an exhaustive analysis of the attitude toward mathematics students, collecting the most significant factors for their study Auzmendi (1992). EAM consists of 25 items on a five-point Likert scale ranging from one (strongly disagree) to five (strongly agree). As in other investigations (e.g., Liu et al., 2007; Segarra, 2022), the third item of Likert scale, which was in the original version of EAM, was eliminated with the purpose of encouraging students to indicate a level of certainty. EAM establishes five factors: liking, anxiety, motivation, usefulness, and confidence. This research works with anxiety factor and the questions are adapted to calculus subject as has already been done in another research (e.g., Daza, 2018). Five of anxiety factor items have inverse scores (1, 3, 5, 7, and 9). Responses for these items must be reversed before being added to the total anxiety factor score. To obtain the partial result for each factor, the scores obtained in the corresponding items are added. **Table 1** presents anxiety factor items.

Procedure

The questions about anxiety factor of EAM instrument were given to the students; in this test, they had 10 minutes to answer nine questions. For the application of the survey, the respective accompaniment of the teacher was carried out with the purpose of guaranteeing control of the application of the instrument. Specifically, the students were given the test, and they solved it in differential and integral calculus class. Differential and integral calculus course begin with the theoretical part, rules, and exercises on limits, derivatives, and integrals (moment 1). Subsequently, the application of the derivatives and integrals is carried out (moment 2). The survey is applied in both moments, at the end of moment 1, which lasted four weeks with a total of eight hours of study. Also, moment 2 has a duration of four weeks and eight hours of study. It is important to indicate that in the second moment, CASIO fx 570/991 calculator and ClassPad.net tool are used. Also, it should be noted that at the first moment, no technological tool is used to support the teaching-learning process.

Instrument Validity

To determine the validity of the questionnaire, exploratory factor analysis method was used. Kaiser-Meyer-Olkin (KMO) test and Bartlett's sphericity test (BTS) were used (KMO=0.71, $p<0.01$). Besides, BTS indicates that the correlations between the elements are not an identity matrix. The extracted factors explain 71% of the total variance of the data. The correlations between the corrected items of the scale range from 0.41 to 0.72. These values indicate that questions should not be deleted, and that the questionnaire is valid.

RESULTS

In this section, the results are presented to answer the research question proposed above. The student's anxiety was measured in two moments: the first moment after having finished the theoretical and practical part of the derivatives and integrals in which technology was not used (M1); The second moment, at the end of the topic of application of derivatives and integrals, Casio fx-991 calculator, and Casio ClassPad.net (M1) platform were used as technological support.

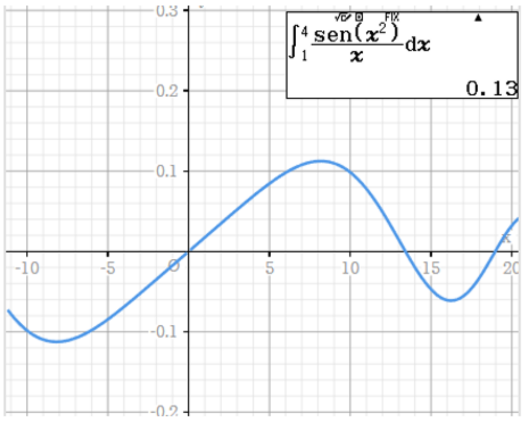

Figure 1. Graph of a function generated with Casio fx-570/991 calculator & ClassPad.net (Source: Authors)

Materials

The software used in the second moment is the emulator of Casio CLASSWIZ fx-570/991 calculator. This emulator was developed by Casio to make it easier for students to access new technology to improve student learning and support teachers in classroom management. The emulator is available on the official Casio website. The fx-570/991 calculator model has 552 functions that allow working on topics such as linear algebra, physics, differential and integral calculus, statistics and probability, trigonometry, and discrete mathematics. This calculator is not a graphing calculator, but thanks to QR option that it has included, the graphs can be generated using ClassPad.net application, as can be seen in **Figure 1**. ClassPad.net is a web service that allows you to perform complex calculations, graphing functions, using a computer algebra system and the statistical system. In addition, CASIO ClassPad.net allows you to manipulate a variety of mathematical content intuitively and with simple operations, another important aspect is that it allows you to share the material with other people on the web.

Problems

Below are some of the examples used in the classes of differential and integral calculus subject at moment 2. Exercises from moment 1 are not added since the purpose is to verify the use of the calculator. It is important to indicate that the student uses the calculator to help solve problems, not to solve them; for example, it can be used to verify results or processes, and also, to make graphs and draw conclusions. These problems were selected since they are very common within the subject, and they are problems that contain several edges, which implies that the student has to reason before starting the development phase. Specifically, the problems are selected from the book by Aguilar et al. (2010).

Problem 1

You want to make a book with a surface area of 600 cm^2 and you want to put two cm top and bottom margins and two cm and one cm sides. Find measure of the sheet so that the written part has maximum area.

Process: The equation of the area of the sheet is generated: $A = x \times y = 600\ y = \frac{600}{x}$.

The values of the margins that are decreased must be considered: $(x-3)(y-4) = xy - 4x - 3y + 12$.

So, the value of y is replaced: $f(x) = \frac{600}{x}x - 4x - 3\frac{600}{x} + 12$ is reduced: $f(x) = 612 - 4x - \frac{1800}{x}$.

When the function is obtained, the maximum area can be realized in several ways, in this case the students explore three alternatives.

In alternative 1, students perform problem manually (**Figure 2**). In procedure 2 the students use the calculator to check the result. In this procedure, you work in calculate menu and use the derivative option and solve function.

Then, it can be determined and: $y = \frac{600}{x}$; $y = \frac{600}{21.21}$; $y = 28.29$.

For the sheet to have a maximum area: $x = 21.21$; $y = 28.29$.

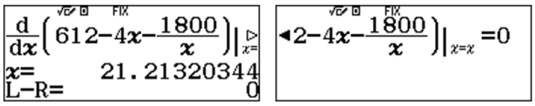

Figure 2. Manual solution-1 (Source: Authors)

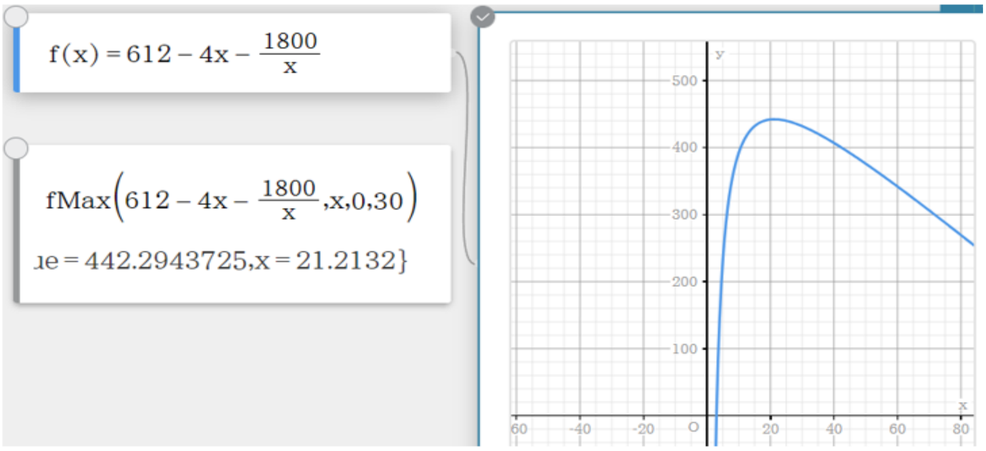

Figure 3. Graph of function $f(x)$ (Source: Authors)

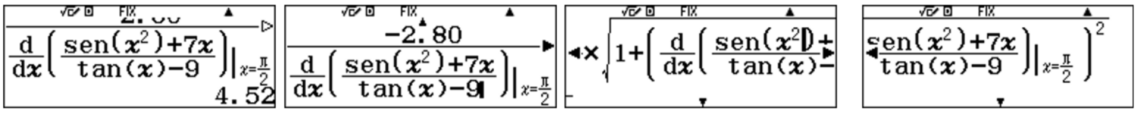

Figure 4. Manual solution-2 (Source: Authors)

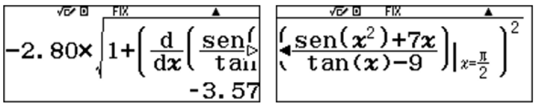

Figure 5. Manual solution-3 (Source: Authors)

Procedure 3: In this process, the students, with the help of the calculator and ClassPad.net tool, make the graph and analyze the maximum point. Specifically, the table menu is used, then QR code is generated, with ClassPad tool max function is used.

In **Figure 3** it can be seen that the maximum is at $x = 21.21$, it can be done with max function or by exploring the values in the respective graph.

At the end the students analyze the three processes and discuss the final result.

Problem 2

Given the function $f(x) = \frac{sin3x^2+7x}{tanx-9}$ compute at point $\left(\frac{\pi}{2}, -2.80\right)$:

a. The length of the tangent and

b. The length of the normal.

Tangent length is $\frac{y_1}{\frac{dy}{dx}}\sqrt{1+\left(\frac{dy}{dx}\right)^2}$.

To calculate the length of the tangent and normal the students use the calculator to check the result. That is, the students previously perform the problems manually (**Figure 4**).

The result indicates that the length of the tangent is 4.52u. Normal length is $y_1\sqrt{1+\left(\frac{dy}{dx}\right)^2}$.

The length of the normal is 3.57u (**Figure 5**).

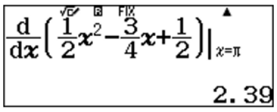

Figure 6. Manual solution-4 (Source: Authors)

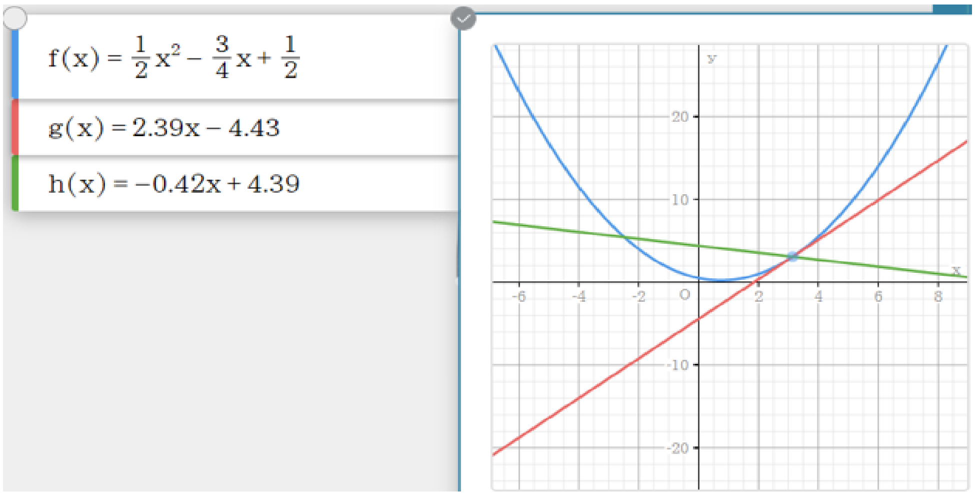

Figure 7. Graph of function $f(x)$, tangent, & normal (Source: Authors)

The students at the end of the problem perform a check of the manual process and result of the calculator, if they are different, the students look for the error and correct them until they reach the correct solution.

Problem 3

Given the function $f(x) = \frac{1}{2}x^2 - \frac{3}{4}x + \frac{1}{2}$ compute at point $P\ (\pi, 3.079)$:

a. The equation of the tangent and normal.

To obtain the equation of the tangent line it is necessary to work with the equation point slope of the line is $y - y_1 = m(x - x_1)$. In this expression, you need to find the slope at point P. The slope at point P can be found by taking the first derivative and evaluating the value of $x = \pi$ (**Figure 6**).

So, $y - 3.079 = 2.39(x - \pi)$.

Therefore, the equation of the tangent line is defined, as follows: $y = 2.39x - 4.43$.

In this section the normal line will be obtained, it must be known that the normal line is perpendicular to the tangent line, therefore, the slope of the normal line is: $m_n = \frac{1}{-m_t}$ $y - 3.079 = \frac{1}{-2.39}(x - \pi)$.

Therefore, the equation of the normal line is defined, as follows: $y = -0.42x + 4.39$.

In this problem the students obtain the slope with the use of the calculator, this facilitates the process to obtain the tangent and normal lines. In addition, for the student to understand the problem, the respective graphs are made using ClassPad.net. **Figure 7** shows the graph of the function (blue), the tangent line (red), and the normal line (green).

Problem 4

Study the intervals, where the function $f(x) = \frac{1}{3}x^3 - \frac{1}{2}x^2 - 6x$ is increasing and decreasing.

The interval in which the function $f(x)$ is increasing must satisfy the first derivative test $f'(x) > 0$. Otherwise, for $f(x)$ to be decreasing it must be true that $f'(x) < 0$. Then, the first derivative is obtained: $f'(x) = x^2 - x - 6\ x^2 - x - 6 > 0$.

Increasing: $(x - 3)(x + 2) > 0$ and decreasing: $(x - 3)(x + 2) < 0$.

There are two critical values: $x_1 = 3;\ x_2 = -2$.

To obtain the intervals, the inequalities must be solved, in this case the students make the graph, as can be seen in **Figure 8**.

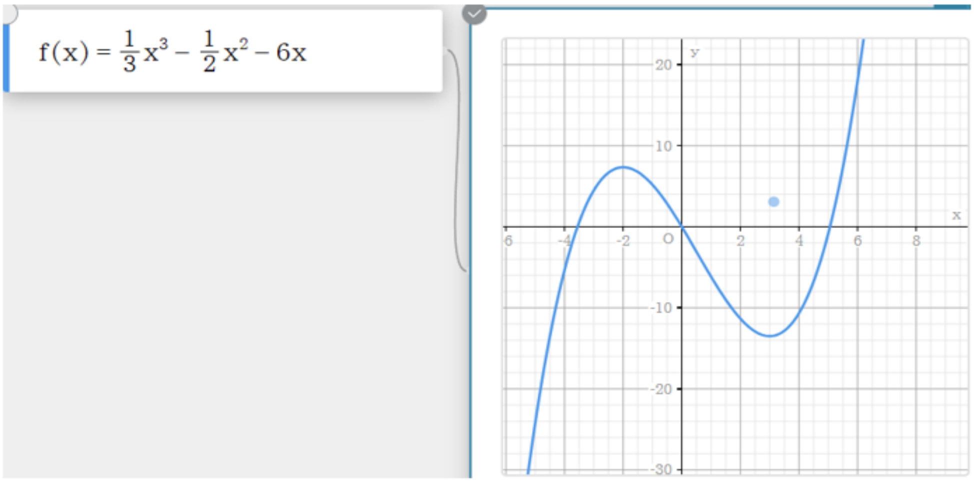

Figure 8. Graph of function $f(x)$ (Source: Authors)

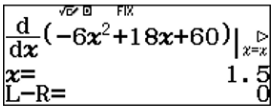

Figure 9. Manual solution-5 (Source: Authors)

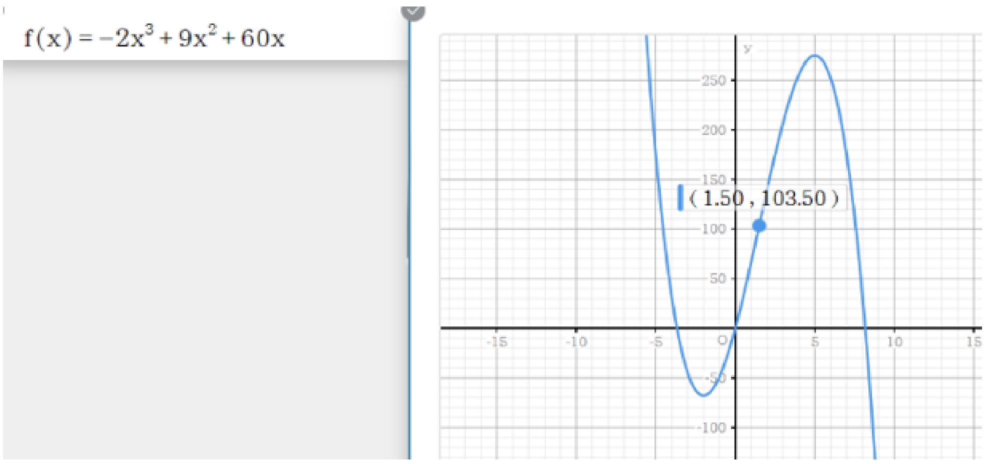

Figure 10. Graph of the function $f(x)$, inflection point (Source: Authors)

Based on the analysis of **Figure 8**, it can be determined that the function is increasing on the intervals $(-\infty,-2)U(3,+\infty)$ and decreasing on the interval $(-2,3)$.

Problem 5

Determine the coordinates of the inflection point and the intervals of concavity for the function $f(x) = -2x^3 + 9x^2 + 60x$. A function has its inflection point at $\left(x_o, f(x_o)\right)$ $si\ f''(x_0) = 0$. Therefore, the first derivative is found: $f'(x) = -6x^2 + 18x + 60$.

The derivative of the first derivative is evaluated (**Figure 9**). The value of x is plugged into the function, getting the inflection point at $(1.5, 103.5)$. We proceed to obtain the intervals of concavity, for a function to be concave upwards it must be determined that $f''(x) > 0$, then: $f''(x) = -12x + 18\ \ -12x + 18 > 0\ x < \frac{3}{2}$.

So, interval of concavity upwards is $\left(-\infty, \frac{3}{2}\right)$. Otherwise, for the function to be concave downwards it must be fulfilled $f''(x) < 0$. $f''(x) = -12x + 18\ \ -12x + 18 < 0\ x > \frac{3}{2}$. So, interval of concavity upwards is $\left(\frac{3}{2}, +\infty\right)$.

The graph is generated for a better understanding of the subject. **Figure 10** represents the graph of the function for its verification.

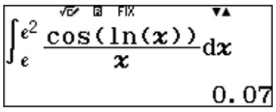

Figure 11. Manual solution-6 (Source: Authors)

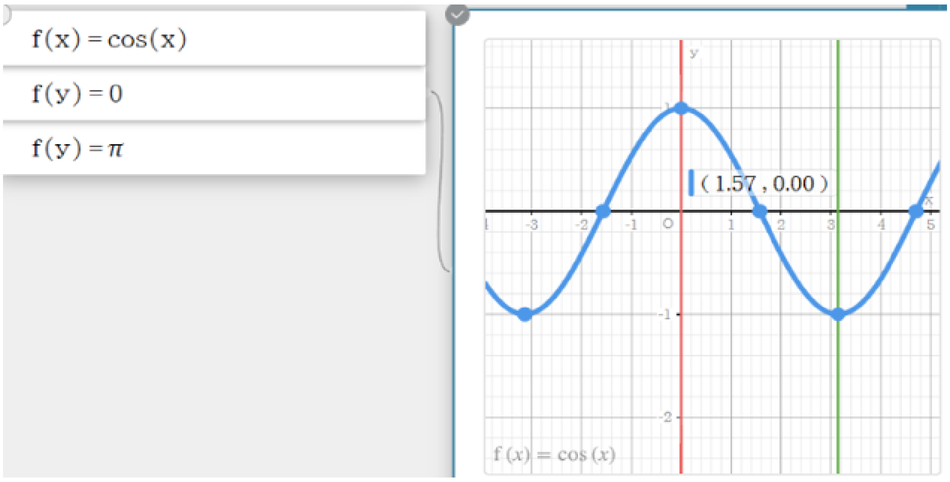

Figure 12. Graph of function $f(x)$, area (Source: Authors)

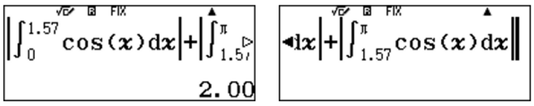

Figure 13. Manual solution-7 (Source: Authors)

Problem 6

Determine the value of the integral $\int_e^{e^2} \frac{\cos(Inx)dx}{x}$. The integral must be solved, for that the integral by substitution is made: $u = \ln(x)$; $\frac{du}{dx} = \frac{1}{x}\ dx = xdu$. Therefore, $\int \cos(u)\, du = \sin(u)$.

So, $\int \frac{\cos(\ln(x))}{x} dx = \sin(\ln(x) + C = \int_e^{e^2} \frac{\cos(Inx)dx}{x} = [\sin(\ln(x)]_e^{e^2} = [\sin(\ln(e^2) - \sin(\ln(e)] = 0.07$.

The result of the integral is 0.07.

Students use the calculator to verify the result. This verifies that the result of the previous process is correct (**Figure 11**).

Problem 7

Find the area bounded by the *x*-axis, the function $f(x) = cosx$ and the lines $x = 0$ and $x = \pi$.

The respective graph is generated with ClassPad.net tool, the graph allows performing the correct operations in obtaining the total area. **Figure 12** shows the graph of the functions.

Figure 12 indicates that there are two areas, the first between zero and the cut point of the function f (1.57). The other area to consider is from 1.57 *y pi*. We proceed to calculate the integral of the function: $\int \cos(x)\, dx = \sin(x) + C = \int_0^{1.57} \cos(x)\, dx = [\sin(x)]_0^{1.57} = [\sin(1.57) - \sin(0)] = 1u^2 = \int_{1.57}^{\pi} \cos(x)\, dx = [\sin(x)]_{1.57}^{\pi} = [\sin(\pi) - \sin(1.57)] = -1u^2$.

In the case of the second area, it is negative since it is below the *x*-axis. Therefore, to obtain the total area, the sum of the absolute value of the two areas must be made: $A_T = |A_1| + |A_2| = |1| + |-1| = 2u^2$.

Students explore functions of calculator and solve the problem, in order to check their work (**Figure 13**).

It can be seen that the process carried out manually coincides with that of the calculator.

Problem 8

Determine the bounded area between the curves $y = x^3 + 1$ y $x - y + 1 = 0$.

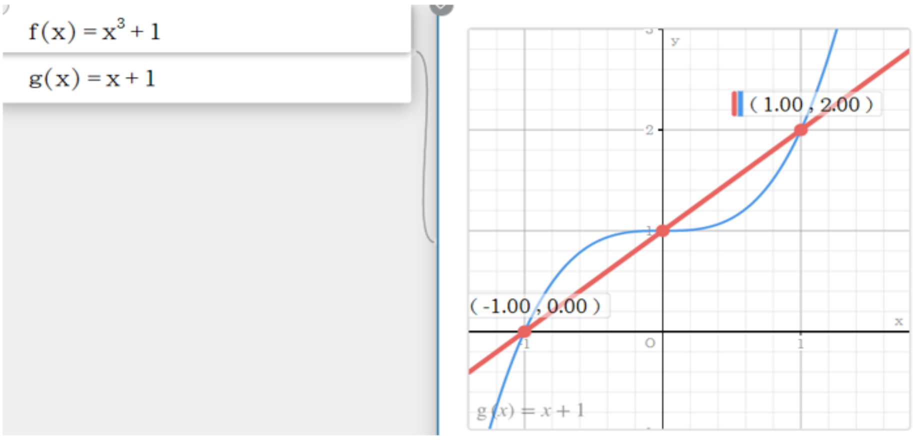

Figure 14. Graph of function $f(x)$, area (Source: Authors)

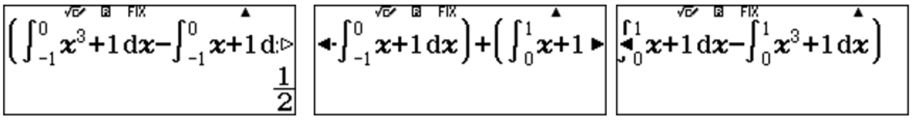

Figure 15. Manual solution-8 (Source: Authors)

To solve this problem, the lower and upper limit must be defined, to obtain these points the students generate the respective graph. **Figure 14** shows the two curves.

Note that it is important to have access to the graph since it gives important information in order to obtain the requested area. Specifically, **Figure 14** shows that there are two areas encompassed by the two curves. Therefore, the calculation of each of the areas will be carried out.

You must integrate the two curves and solve the definite integral, remember that the value of the integral is the value of the area under the curve and the *x*-axis, in this case both will be positive: $\int (x^3+1)dx = \frac{x^4}{4} + x + C$ $\int (x+1)dx = \frac{x^2}{2} + x + C$.

Subsequently, we proceed to calculate the area included in the intervals $[-1,0]$: $\int_{-1}^{0} (x^3+1)dx = \left[\frac{x^4}{4} + x\right]_{-1}^{0} = \left[\frac{0^4}{4} + 0 - \left(\frac{(-1)^4}{4} - 1\right)\right] = \frac{3}{4}$=$\int_{-1}^{0} (x+1)dx = \left[\frac{x^2}{2} + x\right]_{-1}^{0} = \left[\frac{0^2}{2} + 0 - \left(\frac{(-1)^2}{2} - 1\right)\right] = \frac{1}{2}$.

$A_1 = \frac{3}{4} - \frac{1}{2} = \frac{1}{4}u^2$.

Besides, we proceed to calculate the area included in the intervals $[0,1]$: $\int_{0}^{1} (x^3+1)dx = \left[\frac{x^4}{4} + x\right]_{0}^{1} = \left[\frac{1^4}{4} + 1 - \left(\frac{0^4}{4} + 0\right)\right] = \frac{5}{4}$=$\int_{0}^{1} (x+1)dx = \left[\frac{x^2}{2} + x\right]_{0}^{1} = \left[\frac{1^2}{2} + 1 - \left(\frac{0^2}{2} + 0\right)\right] = \frac{3}{2}$.

$A_1 = \frac{3}{2} - \frac{5}{4} = \frac{1}{4}u^2$ $A_T = A_1 + A_2 = \frac{1}{4} + \frac{1}{4} = \frac{1}{2}u^2$.

At the end, use the calculator to check the answer (**Figure 15**). As can be seen in the previous problems, the calculator is used as support and not to fully solve the proposed problem. In some cases, it is very important to have access to the graph in order to correctly develop the problem.

Study of Student Anxiety

In this section, students' anxiety is studied by studying the mean and standard deviation of the scores obtained for each of the questions. The survey is applied twice to the students, before and after the use of the calculator. In this factor, it must be considered that the scale is coded so that the higher the score, the lower anxiety (Flores & Auzmendi, 2018). **Table 2** shows the mean (M) and the standard deviation (SD) of the scores given by the students to the questions corresponding to anxiety factor. The maximum score in M1 was obtained in question 6 (I am calm and calm when I face a calculus problem), with a mean of 2.01. In the case of M2, the maximum score was obtained in question 7 (working with calculus makes me feel nervous, question inverted), with a mean of 2.55. The average obtained by answering all questions of this factor was 1.89 and 2.33 in M1 and M2, respectively.

Table 2. Mean of each item of moment 1 & moment 2

No	Items	Moment 1		Moment 2	
		Mean	SD	Mean	SD
1	Calculus is pretty bad for me.	1.93	0.57	2.00	0.58
2	Studying or working with calculus does not scare me at all.	2.00	0.63	2.40	0.55
3	Calculus is one of the subjects I fear the most.	1.80	0.54	2.47	0.77
4	I have confidence in myself when I face a calculus problem.	1.87	0.67	2.53	0.62
5	When faced with a calculus problem I feel unable to think clearly.	1.60	0.49	1.93	0.51
6	I am calm when faced with a calculus problem.	2.01	0.52	2.47	0.67
7	Working with calculus makes me feel nervous.	1.87	0.62	2.55	0.56
8	I do not get upset when I have to work on calculus problems.	2.00	0.52	2.50	0.81
9	Calculus makes me feel uncomfortable and nervous.	1.90	0.54	2.13	0.43

Note. SD: Standard deviation & Calculus: Differential and integral calculus

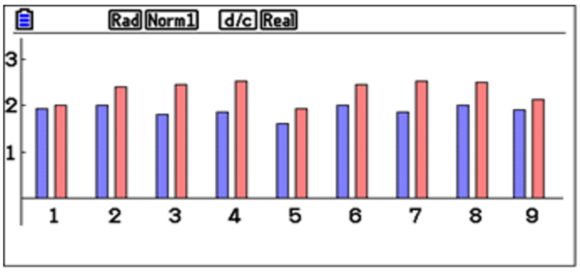

Figure 16. Means of scores corresponding to each question (Source: Authors)

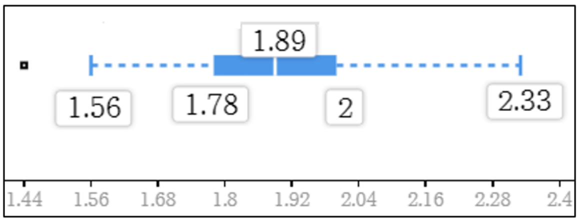

Figure 17. Total M1 scores (Source: Authors)

It is important to mention that Ursini and Sánchez (2019) present the criteria used to classify these variables or factors as positive and negative. Specifically, the author indicates that if the arithmetic mean is greater than 2.50, the factor should be considered positive. In this research, in M1 an average of 1.89 is obtained and in M2 is 2.32, in both moments the arithmetic mean is less than 2.50, this indicates that it is a negative factor towards student learning.

Furthermore, **Figure 16** shows that the mean of all the questions in the initial survey is less than the final survey. However, to verify if the differences between the means of each question are significant, t-student statistical test is applied. Specifically, in P1 (I am quite bad at calculus) and P9 (calculus makes me feel uncomfortable and nervous) the p-value>0.05, this value indicates that there are no significant differences in these two questions. Besides, in the other questions the p-value<0.05, this indicates that there are significant differences between the means. **Figure 16** shows the mean of the scores corresponding to each of anxiety factor items from the two surveys applied. **Figure 16** shows the items in **Table 2** on the *x*-axis. Moreover, the *y*-axis shows the score for each item (minimum score one, maximum score four).

Otherwise, **Figure 17** and **Figure 18** show the box and whisker plots of the total scores obtained by the students in M1 and M2. This type of plot allows you to identify the first and third quartiles, the median (horizontal line).

Also, in **Figure 17** and **Figure 18** it can be seen that the scores obtained by the students from M1 are clearly lower than M2. In M1, 25% of students obtain scores below 1.78 (Q1) and 50% below 1.89 (Q2). Also, an outlier of 1.44 is observed. Moreover, in M2, 25% of students obtain scores below 2.22, and 50% below 2.33 Q2. Also, there is an outlier of 2.78. **Figure 17** and **Figure 18**, on the *x*-axis, show the total scores of the items in **Table 2** in a range from one to four.

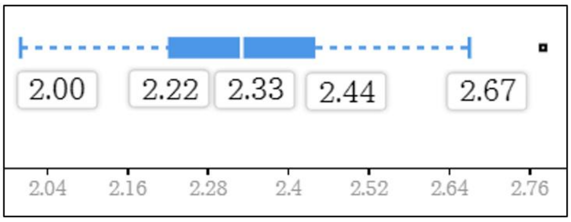

Figure 18. Total M2 scores (Source: Authors)

In addition, a statistical test was carried out to analyze whether there are statistically significant differences between the means obtained in each survey. Specifically, the two-tailed t-student statistical test was applied, taking the parameter $\alpha=0.05$ with a significance level of 5%. Considering the value of p (which results from the statistical test $p<0.01$), it is concluded that there are significant differences between the means of M1 and M2 of anxiety factor. Specifically, students obtain higher scores in M2 compared to M1.

CONCLUSIONS

The purpose of this research was to study whether the use of the calculator decreases anxiety in the study of differential and integral calculus in first-year engineering students. To answer the research question, students solve a set of problems using the calculator and anxiety factor test is applied to them. The scores of the arithmetic mean of each question for moment 1 and moment 2 were studied. The results indicated that the students have a high level of anxiety in the two moments of the test application. It can be said that according to Ursini and Sánchez (2019) anxiety of this group of students is negative, and negatively influences their learning in differential and integral calculus subject. We agree with Garcia et al. (2013) the researchers indicated that a low level of anxiety will produce a decrease in their academic performance in students. It should be noted that anxiety factor has 36% of the items in the entire questionnaire on attitudes towards mathematics by Auzmendi (1992). So, it is clear that anxiety influences the attitude of the student body, in this case to the study of differential and integral calculus. For this reason, we agree with Tezer and Karasel (2010) who determined that one must have positive attitudes towards mathematics in order to have a good academic performance.

An important finding of this research is that at moment 2 when technology is used, specifically, the use of calculator and ClassPad.net tool, students' anxiety towards differential and integral calculus subject is considerably reduced. That is, the use of technology had a positive influence. We believe that these results occur because the student has access to a technological tool that tells him if the work, he does is correct or incorrect. In addition, he has access to the graph of the functions that can help him draw correct conclusions. It should be noted that when the subject advances in the topics of a course, the attitude of the students decreases (Mato, 2010). We agree with Dehesa and López (2021) who indicated that with the use of digital tools, the student can be empowered and thus could reduce their anxiety levels and thus improve the knowledge assimilation process. Also, De Faria (2003) should be considered, who indicated that such a curriculum must be developed, which allows these technologies to become authentic instruments, moreover, the cognitive and affective involvement produced by new technologies must be clear. In this context, these resources should be used to improve the teaching and learning process of mathematics.

Teachers do not use or rarely use the calculator as a strategy for teaching mathematics, so they must use it as a motivating activity that arouses the interest of students. Future research will study the relationship between use of calculator, anxiety towards differential and integral calculus, and the academic achievement of students.

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