REVISTA ELECTRÓNICA AMIUTEM

GEOGEBRA AS A TEACHING STRATEGY IN THE ANALYSIS OF CIRCULAR HELIXES FOR TEACHING VECTOR FUNCTIONS TO ENGINEERING STUDENTS IN VIRTUAL MODALITY

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Resumen

Este trabajo muestra los resultados de un estudio de caso realizado con un grupo muestra de 30 estudiantes de tercer semestre de la carrera de Ingeniería Mecatrónica del Tecnológico Nacional de México campus Instituto Tecnológico de Matamoros en la asignatura de Cálculo Vectorial en el periodo agosto-diciembre del 2020. Se utilizó el software dinámico de licencia libre GeoGebra como una estrategia didáctica para la enseñanza de las funciones vectoriales correspondiente a la unidad 3 del programa, se realizó un análisis de la hélice circular, sus características y algunas aplicaciones en ingeniería. Cabe mencionar que este proceso se llevó de manera virtual con apoyo de la plataforma TEAMS derivado del confinamiento por Covid-19. Como conclusión se pone de manifiesto los beneficios del uso de la aplicación en la adquisición del conocimiento y el desarrollo de competencias en los estudiantes.

Palabras claves: educación superior, estrategia didáctica, GeoGebra, hélice circular.

Summary

This paper shows the results from a case study carried out with a sample group of 30 third semester Mechatronic Engineering students from the National Technological Institute of Mexico, Technological Institute of Matamoros campus for the assignment of Vector Calculus during the August-December period of 2020. The free dynamic software GeoGebra was used as an educational strategy to teach vector functions corresponding to Unit 3. An analysis was carried out of the circular helix, its characteristics, and some engineering applications. It is worth mentioning that this process was carried out virtually with the support of the TEAMS platform derived from the Covid-19 confinement. In conclusion, the benefits from the application use in the acquirement of knowledge and the skill development in the students are presented.

Keywords: higher education, teaching strategy, GeoGebra, circular helix

Introduction

We found ourselves with a need, derived from the Covid-19 confinement, to continue educational work from home using technological tools that allowed us to continue developing a "logic-mathematical thinking in the profile and contribute the basic tools for the introduction to the study of calculus" (TecNM, 2010). In the National Technological Institute, Matamoros Institute of Technology campus, GeoGebra is used as an educational strategy, which is a dynamic program for the teaching and learning of Mathematics in

education. The educational work has had to adapt through technological tools, among which stands out using different platforms and applications through virtual communication in online courses in which the users access the mathematical knowledge through documents and virtual tutoring, discussion groups, videos, websites (Sucerquia, Londoño & Jaramillo, 2013), among others.

Mathematics is considered the base in the complex processes of knowledge since people must possess critical, reflexive, and analytical thinking which develops the capacity for reasoning, formulating, and problem-solving (Garcia, Izquierdo, 2017). The Objective of this investigation carried out as a case study, is to analyze the knowledge acquired by the engineering students using GeoGebra as an educational strategy in the analysis of the circular helix while teaching the vectorial functions in virtual mode.

Theoretical Reference

Definition of helix: Being a, b, $c \in$ R, with a and c non zero. Consider the curve $a \ni t \mid \longrightarrow$ ($a \cos(\frac{t}{c})$, a $\sin(\frac{t}{c})$, b $(\frac{t}{c}) \in$ e³. If $b \neq 0$, it can be said that the trajectory for t is a helix.

Considering the curve from various perspectives and orientations in R³, it is possible to represent it in different planes (Figure 1).
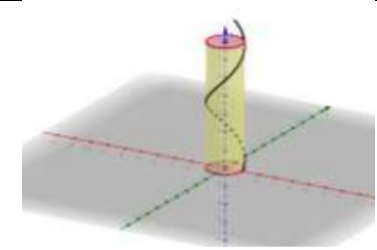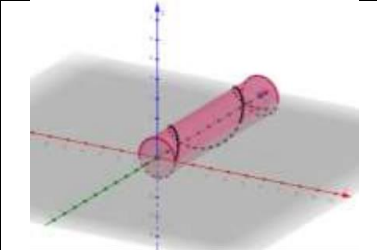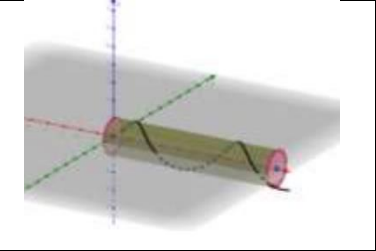
$x(t) = a \cos t$, $y(t) = a \sin t$, $z(t) = bt$	$x(t) = a \cos t$, $y(t) = bt$, $z(t) = a \sin t$	$x(t) = bt$, $y(t) = a \cos t$, $z(t) = a \sin t$
The ends of the cylinder that form the circular helix are found on the *xy* plane.	The ends of the cylinder that form the circular helix are found on the *xz* plane.	The ends of the cylinder that form the circular helix are found on the *xy* plane.

Figure 1. The helix in different planes.

Considering the equations $x(t) = a \cos\frac{t}{c}$, $y(t) = a \sin\frac{t}{c}$, and $z(t) = b\frac{t}{c}$, we can observe in figure 2 a variation in the radius of the curve as the constant a increases.
Considering that a is positive and whole, as a increases, so does the radius of the cylinder formed by the helix. It is also possible to see how the helix changes when the value of b varies in the equations $x(t) = a \cos\frac{t}{c}$, $y(t) = a \sin\frac{t}{c}$, and $z(t) = b\frac{t}{c}$, as shown in figure 3.

Considering a and b as a positive constant less than 1, the passage is less.

Now, when the value of *c* varies only for the parametric equations that contain a trigonometric function, we can see the passage of the curve varies once more, as observed in figure 4.

Considering *a* = 1, *b* = 1, and *c* = 1	Considering *a* = 3, *b* = 1, and *c* = 1	Considering *a* = 5, *b* = 1, and *c* = 1
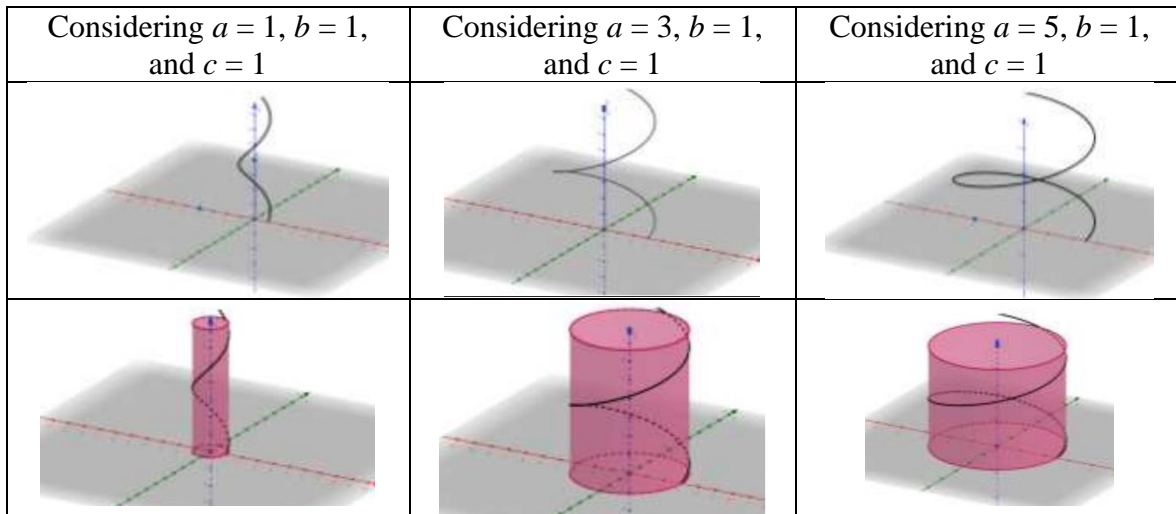
Figure 2. Variation in the radius of the helix

Considering *a* = 1 and *b* = 1/2	Considering *a* = 1 and *b* = 1/10	Considering *a* = 1 and *b* = 1/25
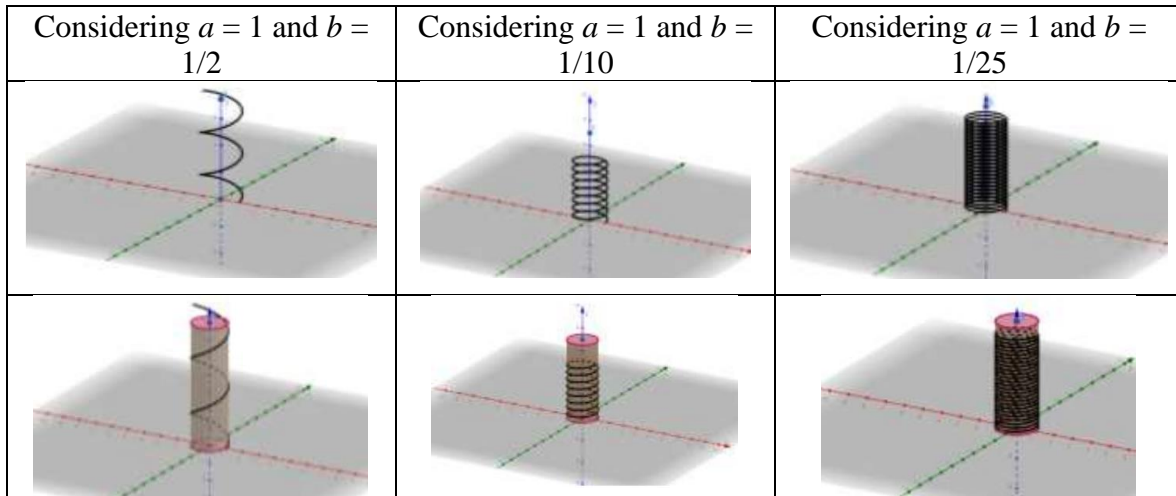
Figure 3. Analysis of the passage of the helix

Considering *a* = 1, *b* = 1, and *c* = 2 only for trigonometric functions	Considering *a* = 1, *b* = 1, and *c* = 10 only for trigonometric functions	Considering *a* = 1, *b* = 1, and *c* = 30 only for trigonometric functions

Figure 4. Variation of the constant *c*.

Methodology

The activities are developed virtually due to the Covid-19 confinement. The study was carried out in four phases: 1. Student survey, 2. Designing the activities to be carried out using the software, 3. Implementation in the classroom, activities, and assigned homework, and 4. Obtained results.

Student Survey

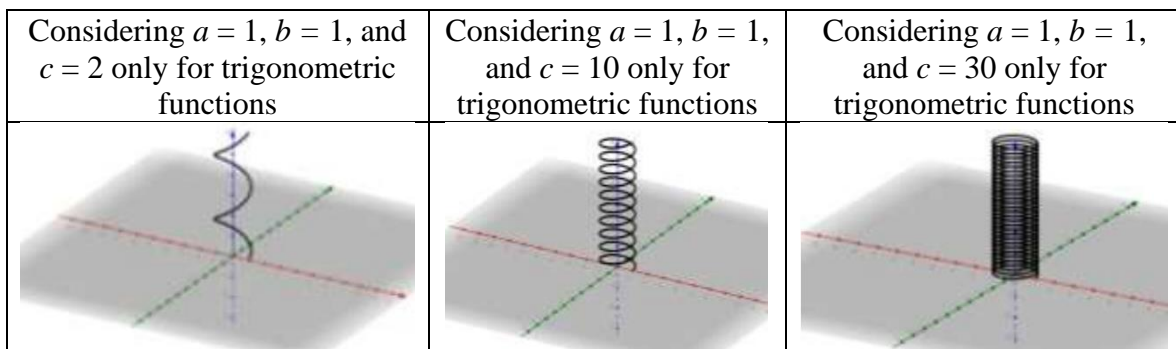A student survey was carried out to know if they were familiar with the software. The questions were the following: 1. Do you know about the software GeoGebra? This question had three possible answers: 1. I know about the app, but I haven't used it. 2. I know about it, and I have used it. 3. I don't know about it and have not used it.

Designing activities using the software

To design the activities, the topics corresponding to unit three about Vectorial Functions of a real variable were taken as a base. These topics are: 3.1 The definition of a vectorial function of a real variable. 3.2 Limits and continuity of a vectorial function. 3.3 Derivative of a vectorial function. 3.4 Integration of vectorial functions. 3.5 Length of the arc. 3.6 Tangent vectors, normal and binormal. 3.7 Curvature. 3.8 Applications. Different activities were carried out through the use of the TEAMS platform.

Implementation in the classroom, activities, and assigned homework

The students were taught how to use the application. First, curves in 3 dimensions with different helix characteristics were graphed as shown in table 1.

Table 1.

Vectorial functions graphs.

Unit 3 Vectorial functions of a real variable. Topic 3.1 Graph of a vectorial function of a real variable.

Student name: Control No.:

Vectorial Function	Graph (graph in GeoGebra and paste)	Characteristics
R(t)=4cost i + 4cos t j + 2t k		
R(t)=4cost i + 2t j +4cos t k		
R(t)=2t i+ 4cost j+4cos t k		

Also, there were activities in which the usage of different resources is evident as shown in figure 5, on paper and with the software.
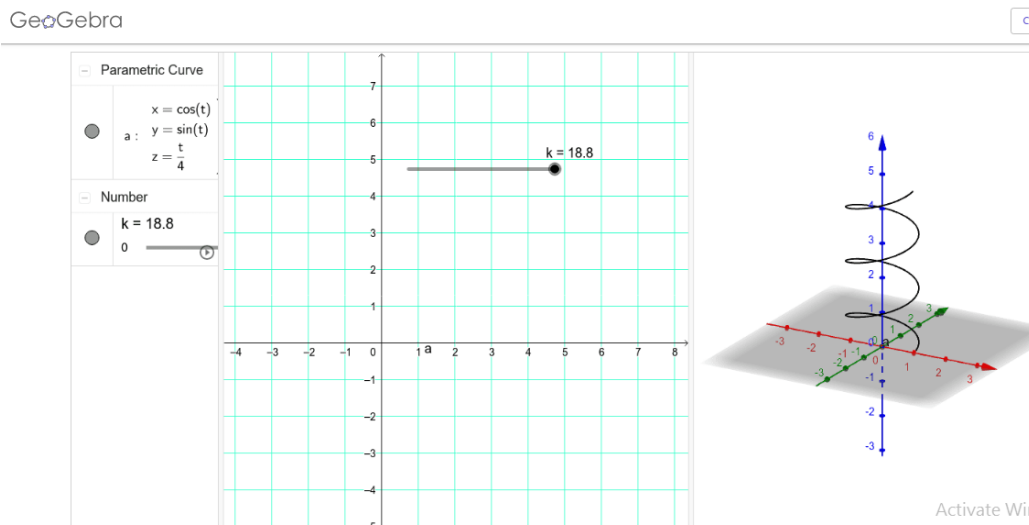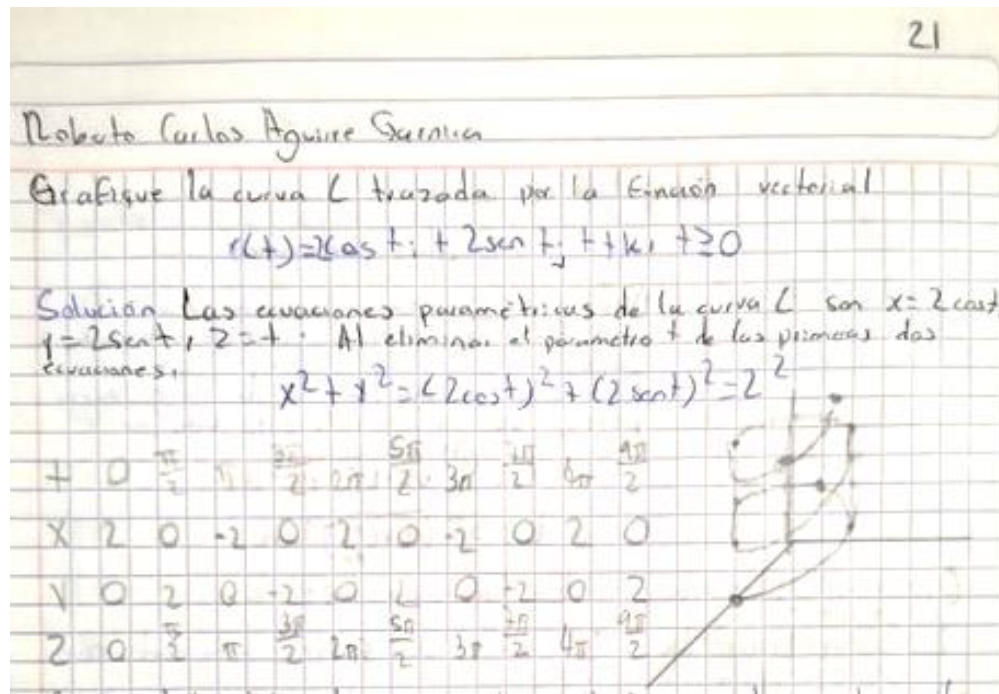
Figure 5. Graph of the helix using pencil and notebook and the application using GeoGebra.

Calculation of the length of the circular helix

Activities were developed virtually such as the calculation of the length of the helix:

Considering the equation $R(t) = a\cos t\, i + a\, sen t\, j + bt k$, determine its length corresponding to the interval $[0, t_0](t_0 > 0)$.

Table 2.

Parametric equations and their derivation.

Parametric equations	Derivation	Derivation squared	note
$x(t) = a \cos t$	$x'(t) = -a \sin t$	$(x'(t))^2 = a^2 sen^2 t$	$x'(t) = \left(\dfrac{dx}{dt}\right)$
$y(t) = a \sin t$	$y'(t) = a \cos t$	$(y'(t))^2 = a^2 cos^2 t$	$y'(t) = \left(\dfrac{dy}{dt}\right)$
$z(t) = bt$	$z'(t) = b$	$(z'(t))^2 = b^2$	$z'(t) = \left(\dfrac{dy}{dt}\right)$

With the data in Table 2, the length is:

$$L = \int_0^{t_0} \sqrt{\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2 + \left(\frac{dz}{dt}\right)^2}\, dt = \int_0^{t_0} \sqrt{(-a\, sen\, t)^2 + (a \cos t)^2 + (b)^2}\, dt$$

$$\int_0^{t_0} \sqrt{a^2 sen^2 t + a^2 cos^2 t + b^2}\, dt$$

Factoring the terms of the trigonometric functions and applying the trigonometric identity $sen^2 \theta + cos^2 \theta = 1$, the result is

$$L = \int_0^{t_0} \sqrt{a^2(sen^2 \theta + cos^2 \theta) + b^2}\ dt = \int_o^{t_0} \sqrt{a^2(1) + b^2}\ dt\ .$$

Considering that a and b are constants and applying the property of the constants in the integral

$$L = \int_o^{t_0} \sqrt{a^2 + b^2}\ dt = \sqrt{a^2 + b^2} \int_0^{t_0} dt = \sqrt{a^2 + b^2}\ t\Big|_0^{t_0} = t_0 \sqrt{a^2 + b^2}$$

As part of the activity, they were asked to find the length for different values for a.

Results

Derived from the first phase, in which the survey was carried out on a sample on the use of the software, it was found that 13% of the students surveyed had already used GeoGebra, 20% had heard of the app but had not used it, and 67% had not heard of it nor had worked with it.

The percentage of passing grades for the assignment was 92%; 15% higher in comparison to the previous unit. This was derived from the continuous use of the software. The skill sets established in the study program were achieved, among which stand out learning different types of curves in space, establishing the parametric equations corresponding to a set of curves in the space. Using TIC to graph lines tangent to different curves, as well as identifying tangent vectors, normal and binormal of the same at some point (TecNM, 2010). Calculate the length of the curve for a certain interval as well as the usage of TIC to apply the properties of the operations with vectorial functions.

Through the use of TEAMS, different suggested techniques, tools, and/or instruments were developed that allowed obtaining the product of the development of the learning activities: conceptual maps, practical reports, case studies, class presentations, tests, problems, evidence portfolio, tests, projects, and surveys as shown in figure 6.
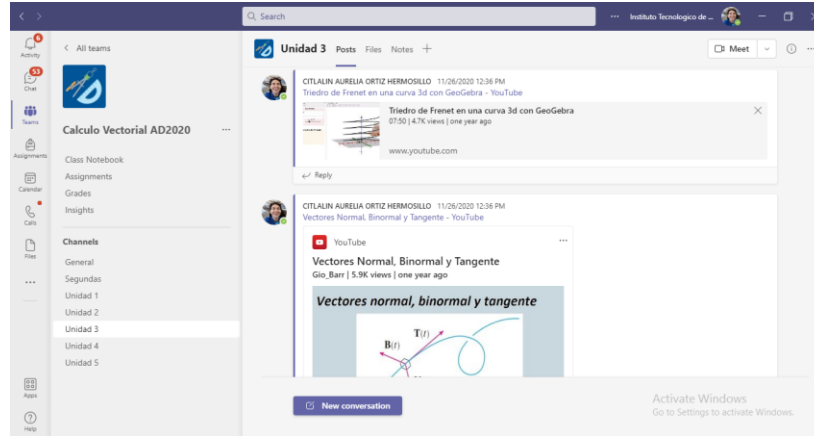

Figure 6. The use of platform TEAMS.

The suggested techniques, tools, and/or instruments allowed the confirmation of the achievement or accomplishment of the student's skill set. Through checklists, verification lists, assessment matrixes, observation guides, co-evaluation, and self-evaluation.

Conclusion

The implementation of GeoGebra as an educational strategy allowed the students to make an analysis of the characteristics of the curve, understand the vectorial functions and its applications in engineering, and acquire a mastery of the unit topics, the achievement of digital skills is evident while applying the acquired knowledge in practice, and using the resources technology offers, such as the use of the software.

The students achieved the different specific and generic skills described in the study program regarding the capacity of abstraction, analysis, and synthesis, the capacity to identify, present, and solve problems, learning and constantly upgrading according to the technological tools applicable to the assignment as well as the teamwork developed through different assignments.

Bibliographical References

Aguirre, Eduardo. (2006). Geometría diferencial de curvas y superficies. *Universidad Complutense de Madrid*. Recovered from http://www.mat.ucm.es/~edaguirr/cys06.pdf

Dirección General de Educación Superior tecnológica [General Office of Higher Technological Education] (DGEST). (2012). Modelo educativo para el siglo XXI: Formación y desarrollo de competencias profesionales. Mexico. Recovered from http://www.itmexicali.edu.mx/informacion/modelo_educativo.pdf

García, J. G. J., & Izquierdo, S. J. (2017). GeoGebra, una propuesta para innovar el proceso enseñanza-aprendizaje en matemáticas. *Revista electrónica sobre tecnología, educación y sociedad*, *4*(7). Recovered from https://www.ctes.org.mx/index.php/ctes/article/view/654

Hermosillo, C. A. O., & Maldonado, M. E. M. (2019). GeoGebra como herramienta en la enseñanza del cálculo para adquirir competencias en estudiantes de ingeniería. *Revista Electrónica ANFEI Digital*. *6*(11) Recovered from https://www.anfei.mx/revista/index.php/revista/article/view/610

Ortiz HCA. GeoGebra, hélice circular. https://www.GeoGebra.org/m/g8mbeqp8.

Tecnológico Nacional de México (TecNM). Study Plan for 2009-2014 authorized by the Subsecretariate of Higher Education and the General Office of Higher Technological Education. Recovered from http://www.dgest.gob.mx/docencia/planes-de-estudio-2009-2010.

GeoGebra. Matemáticas dinámicas para aprender a enseñar. (2020). Consulted between August and December, 2020; from http://www.GeoGebra.org/.

Sucerquia, E., Londoño, R. & Jaramillo, C. M. (2013). El teorema fundamental del cálculo en la educación a distancia virtual. *VI Congreso Internacional de Ensino da Matemática – CIEM - ULBRA Canos /RS – Brasil*. Recovered from http://www.conferencias.ulbra.br/index.php/ciem/vi/paper/viewFile/1280/648.