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# Evaluation of the perception of a virtual learning object with activities to promote study habits in the subject of differential calculus

# Evaluación de la percepción de un objeto de aprendizaje virtual con actividades para fomentar hábitos de estudio en la asignatura de cálculo diferencial

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**Abstract**

The study and understanding of Differential Calculus are essential for Engineering, providing the bases for the topics in the development of Competences of Integral Calculus, Vector Calculus, Differential Equations and physics subjects. This study proposes to evaluate the perception of a virtual learning object with activities to promote study habits in the subject of differential calculus. The proposal consists of analyzing the perception of a virtual learning object about Functions of the Differential Calculus subject, which includes activities of study habits, obtained from a group of students of the second semester of engineering level. The results are encouraging since the students identified as positive aspects the dynamism of the object, the usefulness of using technological tools to strengthen learning.

**Learning objects, Study habits, SCORM**

**Resumen**

El estudio y comprensión del Cálculo Diferencial es esencial para las Ingenierías, proporcionado las bases para los temas en el desarrollo de las competencias del Cálculo Integral, Cálculo Vectorial, Ecuaciones Diferenciales y asignaturas de física. Este estudio propone evaluar la percepción de un objeto de aprendizaje virtual con actividades para fomentar hábitos de estudio en la asignatura de cálculo diferencial. La propuesta consiste en analizar la percepción de un objeto de aprendizaje virtual de tema de Funciones de la asignatura de Cálculo Diferencial, que incluye actividades de hábitos de estudio, obtenida de un grupo de estudiantes del segundo semestre de nivel ingeniería. Los resultados son alentadores ya que los estudiantes identificaron como aspectos positivos el dinamismo del objeto, la utilidad de usar herramientas tecnológicas para fortalecer el aprendizaje.

**Objetos de aprendizaje, Hábitos de estudio, SCORM**

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## Introduction

The confinement forced humanity to make pedagogical changes and generated new scenarios in the teaching-learning process, physical spaces were adapted to virtual spaces; and consequently, changes in strategies to generate skills and competencies in students, which will allow them to apply them in different situations or use them as resources to acquire new knowledge. To achieve this behavior, habits fulfill an essential task since they are behaviors that are learned by repetition and are powerful factors in students.

The virtual space is an opportunity for students to develop study habits since they are the methods and strategies that a student usually uses to deal with a quantity of learning content. This study proposes to evaluate the perception of a virtual learning object with activities to promote study habits in the subject of differential calculus.

The methodology consisted of analyzing the perception of a virtual learning object, which includes study habits activities, obtained from a group of second semester engineering level students.

The methodology was the generation of a learning object, the implementation of the learning object (VLO) in an educational platform, the experience of a group of students using the VLO, and the application of a survey and analysis of results at the end of the VLO.

## Problem statement

According to (TecNM, 2016) the specific competence of unit 2 of the differential calculus subject indicates that the student analyzes the definition of real function and identifies types of functions and their graphic representations, has several proposed learning activities to be carried out, which take time and complexity:

1. Identify when a relation is a function between two sets. Identify the domain and range of a function. Represent real functions of a real variable in the Cartesian plane (graph of a function).

2. Recognize when a function is injective, surjective, or bijective.

3. Thoroughly analyze the sine and cosine functions; It is suggested to use traditional methods and Technology of the information and communication (ICT).

4. Graphing various functions.

5. Investigate the graphs and characteristics of the remaining trigonometric, inverse trigonometric, and hyperbolic functions using ICT.

6. Given any function, build its graph by using ICT, varying its arguments and parameters.

7. Recognize the graphs of circular trigonometric functions and graphs of exponential functions of base e.

8. Graph functions with more than one correspondence rule.

9. Graph functions involving absolute values.

10. Perform the operations of addition, subtraction, multiplication, division, and composition of functions.

11. Recognize the graphical change of a function when its parameters are varied.

12. Through an exercise, use the concept of a bijective function to determine if a function has an inverse, obtain it, and check through composition that the function obtained is the inverse.

13. Identify the relationship between the graph of a function and the graph of its inverse.

14. Propose functions with domain in the natural numbers and range in the real numbers.

15. Prepare in work teams a mathematical modeling (obtaining the function) that corresponds to the professional profile, depending on the application, with the use of ICT.

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**General objective**

The objective of this research is to evaluate the perception of a virtual learning object with activities to promote study habits in the subject of differential calculus.

**Specific objectives**

- Design and develop a virtual learning object related to the topic of Functions in the Differential Calculus subject, which includes activities to improve reading optimization, through techniques to strengthen reading comprehension.
- Apply the learning object to a group of second semester engineering students.
- Evaluate the perception of students regarding the activities and strategies for the promotion of study habits.
- Get feedback on the areas of improvement of the features topic learning object.

**Justification**

Education in the modern situation has denoted the need to strengthen various learning mechanisms, including e-learning and self-learning and the trend of using technology as a fundamental tool in the teaching-learning process. According to a study carried out by (Lezama & Galdámez, 2017), it indicates the existence of a correlation between the levels of study habits and the levels of academic performance of students who study algebra.

It is also important to highlight that the study and understanding of Differential Calculus is essential for Engineering, providing the bases for the topics in the development of Competences of Integral Calculus, Vector Calculus, Differential Equations, and physics subjects. The implementation of learning objects seeks to support self-learning and strengthening the academic performance of students, organizing educational content in a modular, reusable, and flexible way using information technologies, including the ExeLearning tool, the SCORM set of technical standards, the GeoGebra tool and the Moodle educational platform.

**Referential Framework**

***Teaching learning process***

In the present investigation that consists of the evaluation of the perception of a virtual learning object with activities to promote study habits in the subject of differential calculus, It is essential to start from this referential framework of the teaching-learning process, which is the process par excellence to train students in order for them to acquire knowledge, skills, competencies and, preferably, proactive attitudes to solve problems in the context that develop; it is the process where teacher and student are involved, where the first is responsible for the instruction of their students and the second are the receivers and reproducers of the knowledge acquired once the teacher provides them with the didactic strategies to achieve this task.

The most complex and frequent challenges faced by higher education in Mexico are dropout, student lag, and low terminal efficiency rates. In general figures, as a national average, it is mentioned that of 100 students who enter the University, only between 50 and 60 students finish taking all the subjects of the study plan five years later, and of these, only 20 are awarded a degree during the first year of graduation, as stated in their study (Mondragón Albarrán *et al*., 2017). These are alarming figures in the sense that terminal efficiency is disrupted from the beginning of a professional career in students, since in the case of this research, the subjects related to mathematics, which are regularly taught in the first semesters of the entire educational offer, are triggers not only for failure but also for desertion.

"The learning process in the human being differs from everyone —some may be more responsible and skilled; others, feel motivated, or quite the opposite—; commitment to studies and cognitive ability even vary from person to person. Therefore, if the habit of study is not put into practice as a discipline, there will be no academic progress, that is, only the implementation of good study habits will allow the learning process to improve (López, 2009)", as they refer to (Aguirre & Advíncula, 2021) in their research.

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According to (Fernández & Batista, 2020) the teaching-learning process is historically conditioned in response to the demands of learning knowledge, the intellectual and physical development of the student and the formation of feelings, qualities, and values, all of which achieve, in general sense and, with the objectives proposed at each level and type of educational institution. On this occasion, the authors of this manuscript, to promote study habits in students in the subject of differential calculus on the topic of functions, have provided them with a virtual learning object so that they can acquire skills for the implementation of functions in daily life.

In order to understand the teaching-learning process, it is necessary to return to what they point out (Fernández & Batista, 2020) who affirm that considering that learning forms a unit with teaching; through teaching, not only learning, but human development is strengthened, as long as contexts are designed in which the participating subjects appropriate the resources that allow them to operate with the environment and face the world with a scientific, personalized and creative attitude, it is a process that places everyone in a variety of situations that challenge the way they think, feel, and act. In this process, the contradictions between what is said, what is experienced and what is executed in practice are revealed.

**Study habits**

In his article (García, 2019) he mentions that according to the Royal Spanish Academy "study habits are a special way of proceeding or behaving acquired by repetition of the same or similar acts or originated by instinctive tendencies". Study habits are conceptualized as the methods and strategies that a student usually uses to deal with several learning contents. The study habit requires strong amounts of effort, dedication, and discipline. But it is also fed by impulses that may be generated by the expectations and motivations of the student who wishes to learn (Mondragón Albarrán et al., 2017).

(Sánchez, 2017) says that study habits are fundamental in the life of each student, because with their impulse their academic performance will be reflected, depending on how effective they are, the student will generate good results. The student's context has a lot of influence on his daily activities, since he may have various obligations that prevent him from doing certain tasks, in this way the context, culture and various ideologies can generate changes in the student's academic and social environment. In this regard, the authors of this article consider that for a student to acquire and practice study habits in the learning process, they require tenacity, perseverance, and openness; and in this way they can facilitate the uptake of knowledge and consequently, obtain a good academic performance.

Study habits correspond to behaviors established and associated with the way in which the student achieves or does not achieve his academic objectives. Currently there are productive study habits such as completing tasks on time, maintaining order in the material, studying with a strategy and in an appropriate environment, underlining, making schemes, etc., and unproductive such as postponing academic activities, studying in an inappropriate environment and without an orderly strategy, studying tired, copying summaries from other classmates, etc. with negative implications at the level (Ramírez Montaldo et al., 2020). "Good study habits help to comply with learning strategies, improving academic performance" (Meza et al., 2020).

Subjects related to mathematics are considered complex in most undergraduate students, since there are regular failure rates above 40%, such is the case of students from the Tecnológico Nacional de México Campus Zacatecas Norte. In the study by (Lezama & Galdámez, 2017) whose purpose was to determine the relationship between study habits and the academic performance of algebra students from a private university institution in San Pedro Sula during the 2016 academic year, in the research results demonstrate the existence of a statistically significant relationship between the levels of study habits and the levels of academic performance of students who study algebra. This is an example of efforts carried out in universities to promote and identify study habits in the context of mathematics.

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It has been observed that motivated students learn more quickly and effectively than students who are not motivated (Jiménez Reyes et al., 2019), in common agreement with the authors of this research, given that even motivation is part of the set of habits of study that a student must have, in such a way that, as teachers, we must implement different strategies to motivate students in subjects related to mathematics, so that for this occasion virtual learning objects have been provided not only to motivate, but to promote study habits in students.

It is important that the university student knows that there are different study methods and techniques, analyzes them and can incorporate them into their habits. Currently, one of the limitations of the professional future is the lack of knowledge of modalities to learn and understand with repercussions on academic performance (Soto & Rocha, 2020). Similarly (Bedolla Solano & others, 2018) mention that reflecting on the habits that should be formed and the study techniques that students should apply to obtain sustainable learning contributes to improving their academic performance at the university.

**Virtual learning objects**

"In recent years, several initiatives have emerged at the national and international level, to provide digital materials at the service of the academic community, supporting the teaching and learning processes" (Herrera, 2007). (Callejas Cuervo et al., 2011) mention that the Virtual Learning Objects suggest three phases of development, the first is joint planning, composed of gathering requirements and brainstorming for the gestation of the project, which is supported by a group of design experts, the second part consists of didactic and computer proposals where a preliminary graphic design is carried out and its approval is evaluated, finally a navigation map based on a script writing information.

A Virtual Learning Object, commonly called a VLO, is also known in some contexts as LO, which stands for Learning Object. (Uptc, 2014) consulted by (I. I. S. Medina, 2014). On the other hand, according to (J. M. C. Medina et al., 2016), Virtual Learning Objects allow the generation of concepts and thought structures from the development of activities proposed by the educational institution on a specific area of knowledge, they are considered as learning resources. great potential for the teaching process.

A Virtual Learning Object is understood as "structures organized and designed by multidisciplinary teams that can use the advantages provided by AR (augmented reality) to accept the attention of the public, which is aimed at teaching" (Tovar, 2014; quoted in Bravo 2014), this is how they integrate it in their study (Bucheli et al., 2018). The learning objects are intended to facilitate a flexible and personalized education, allowing students and teachers to appropriate teaching resources according to their own needs, concerns, learning and teaching styles according to (Maldonado et al., 2015).

According to the Universidad Nacional Abierta y a Distancia (UNAD) (2008), some of the relevant benefits that can be obtained by maintaining an approach associated with the construction of objects are: streamlining research processes, being aligned for the development of skills, facilitating the tailored learning, dynamic and permanent adaptability to the demand for information and communication, time savings for teachers and students and researchers, simultaneous access, which allows the utility in more than one sequence for training processes in various areas of knowledge, promote collaborative work and autonomous learning, hypertexts and remote access to updated learning content, as mentioned (Pascuas Rengifo et al., 2015) in their manuscript. While (Veytia Bucheli & Contreras Cipriano, 2019) argues that VLO can be used through different mobile devices and are compatible with various browsers (eg, Mozilla FireFox, Internet Explorer, Safari, Google Chrome and Opera), which support the HTML language regardless of the operating system you have (Windows, Mac, Android or Linux).

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## Diferential calculus

(TecNM, 2016) points out that the subject contributes to developing a logical-mathematical thought for the profile of the engineer and provides the basic tools to introduce the study of calculus and its application, as well as the bases for mathematical modeling. In addition, it provides tools that allow modeling context phenomena; This subject is taught in most of the careers offered by the Tecnológico Nacional México, it contains a total of 5 units: Real numbers, functions, limits and continuity, derivatives, and derivative applications respectively. It is worth mentioning that the virtual Learning Object is based on the theme of functions that corresponds to unit 2 of differential calculus.

## Methodology

This paper analyzes the perception of a virtual learning object, which includes study habits activities, obtained from a group of second semester engineering level students.

The methodology was as follows:

- Generation of a learning object.
- Implementation of the virtual learning object (VLO) in an educational platform.
- Use of the object by a group of students.
- Apply of a survey at the end of the learning object and analysis of results.

In the generation stage of a virtual learning object, it was based on the methodology published in the Guide for the design of virtual learning objects (Martín et al., 2016) and the proposal of strategies to promote study habits in virtual learning objects (Arredondo-Salcedo et al., 2022), focusing on functions of the Differential Calculus subject and included activities to promote study habits of time distribution, reading optimization and exam preparation, see Figure 1.

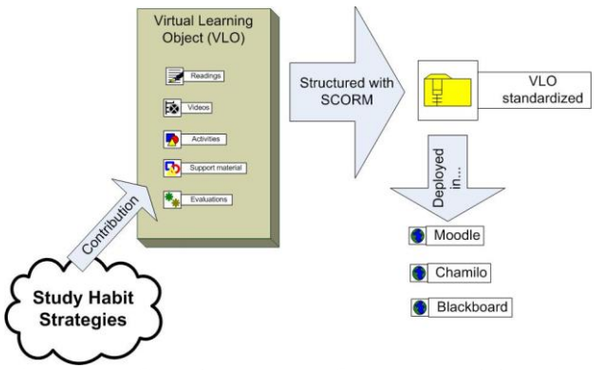


**Figure 1** VLO Implementation. *Source: own elaboration.*

In implementation stage of the virtual learning object, the Open-source eXeLearning software was used to package the educational contents using the Shareable Content Object Reference Model (SCORM) set of specifications, later the SCORM package was included in a course on the Moodle platform available as a learning activity. In the learning activities, the free digital tool was used for the graphic representations of the examples and exercises.

In the next stage, 32 students from the second semester of the Computer Systems Engineering and Public Accountant careers were invited, who entered the course "Introduction to Differential Calculus" available on the Moodle platform of the institution itself and carried out the activities of the learning object for the topic Functions.

As a last stage, a survey was applied to evaluate the perception of the students regarding the learning object and its activities for the distribution of time, optimization of reading and exam preparation, the survey applies a Likert scale to evaluate the experiences they had students regarding the use and perception of learning activities and promotion of study habits.

## Results

After using the learning object, the students had the following perceptions (See table 1), where SA indicates strongly agreed, A means agree, N indicates neutral, D means disagree, and SD indicates strongly disagree:

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| Question | SA | A | N | D | SD |
|---|---|---|---|---|---|
| The learning object of Functions in Differential Calculus helped me understand the topic. | 38% | 56% | 3% | 3% | 0% |
| The underlining technique in the topics helped me to read more efficiently. | 34% | 56% | 6% | 0% | 3% |
| The topic sheet where he proposes the goal of the topic, helped me focus when studying. | 38% | 50% | 9% | 3% | 0% |
| The topic sheet where he proposes the difficulty of the subject, helped me to establish my degree of concentration. | 22% | 59% | 16% | 3% | 0% |
| The topic sheet where it proposes the estimated time of the topic, helped me organize my time. | 25% | 63% | 9% | 3% | 0% |
| Review activities and examples helped me prepare for exams. | 41% | 50% | 6% | 3% | 0% |
| The activities of the learning object helped me to promote study habits (time distribution, optimization of reading and exam preparation). | 31% | 63% | 3% | 0% | 3% |

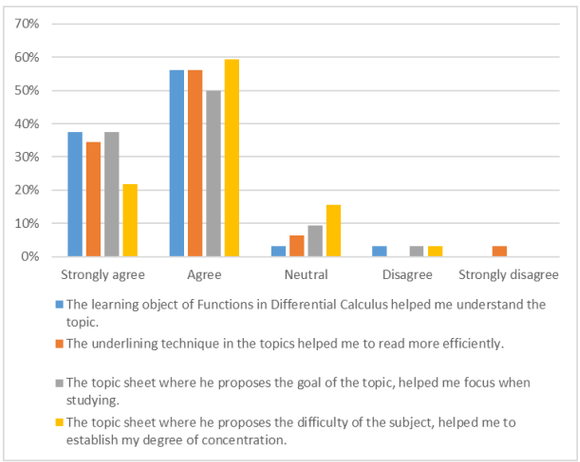
**Table 1** Survey results
*Source: Own elaboration*

About the general panorama of whether the Differential Calculus Functions learning object helped me understand the subject, 94% denote that they perceive a good degree of usefulness of the learning object as support in the self-learning of the subject.

Regarding whether the underlining technique in the topics helped to read more efficiently, 90% positively perceived the use of colors to highlight the main ideas and examples.

Concerning whether the subject sheet where the goal of the topic is proposed helped to focus when studying, 88% had a positive perception regarding the usefulness of the goal.

Referring to whether the subject sheet where it proposes the difficulty of the topic helped to establish my degree of concentration, 81% indicated a good degree of usefulness, it should be noted that 19% perceived this aspect indifferently or negatively, linked to feedback from suggestions for improvement, indicates that the topic sheet can be improved or complemented, see graphic 1.




**Graphic 1** Results of survey part 1
*Source: Own elaboration*

Regarding whether the topic file where it proposes the estimated time of the topic helped to organize my time, 88% indicated a good degree of utility, in the general feedback, the students indicated problems with the loading of the contents, which altered the time dedicated to that topic.

About the review activities and examples helped to prepare for the exams, 91% had a good acceptance of the activities, it should be noted that this was the aspect with the best perception by the students.

Concerning whether the activities of the learning object helped me to promote study habits (time distribution, optimization of reading and exam preparation), 94% thought that the object helped them to promote their study habits, it is important point out that a more detailed follow-up and analysis is required to measure the degree of impact of the use of this type of learning objects on study habits, see graph 2.

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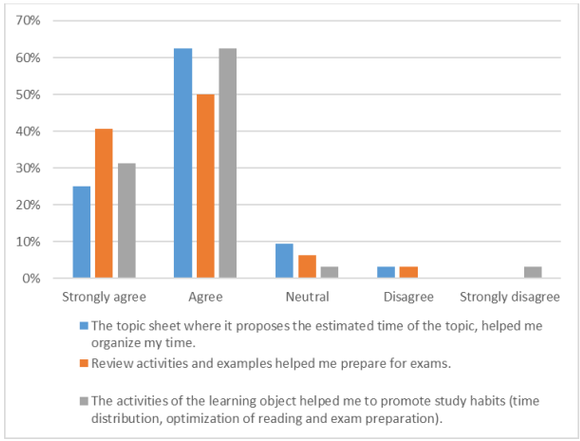


**Graphic 2** Results of survey part 2
*Source: Own elaboration*

As general feedback, the students identified as positive aspects the dynamism of the object, the usefulness of using technological tools to strengthen learning, the simplicity and speed to address the topics. In the negative aspects, the difficulty to visualize some external content, technical difficulties and internet connectivity, the need for the teacher's intervention were pointed out.

Some suggestions for improvement obtained were, give more focus to complex topics, include activities with a higher level of challenge, improve the loading times of digital content, add more strategies to better understand the content and add more practical activities.

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## Conclusions

Once the investigation was completed and according to the results obtained, it was possible to determine and analyze the impact of the use of information technologies in the Differential Calculus subject to promote study habits.

Despite setbacks such as technical difficulties and internet connectivity, it was shown to be a simple and concrete way to generate learning and help in exam preparation, since it includes reading, comprehension and problem-solving activities and mentioning that, including GeoGebra in the virtual learning object helps the student solve problems interactively.

An opportunity for improvement that was detected in the virtual research work is to add more activities in such a way that the degree of complexity of the exercises is greater as the student progresses.

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