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# GEOGEBRA IN TEACHING AREA CALCULATION IN CHEMISTRY DEGREE COURSES – A REPORT FROM PÁXIS TEACHER

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**Abstract:** This article is an excerpt from my Master's research in which the objective was to use Geogebra as Information and Communication Technology - ICT in teaching Integral Area Calculus to understand graphic visualization by students, justified by the researcher's inquiry into in relation to teaching practice itself, seeking to use resources to minimize students' difficulties and contribute to the study of the whole. To this end, we followed a methodological path based on the observation of the researcher's teaching practice in his work environment, the Federal Institute of Education, Science and Technology Goiano - Campus Ceres in the class of the 1st period of a degree in Chemistry of a qualitative nature based on studies de Bicudo (2012), the assumptions of Ausubel's Meaningful Learning; Novak; Hanesian (1980) combined with the assumptions of Zabala's Didactic Sequence (2007). The research was of a Positivist nature in two stages: the first in the classroom in a traditional way and the second in the computer laboratory using GeoGebra to solve and visualize the defined integral. At the end of the activity, the students responded to an email discussing what they thought of the two methodologies used. Thus, the research concluded that the use of ICT in teaching the calculation of the area of a defined integral was better understood by the students, as they interacted with the computer when solving the activities and, therefore, contributed to the construction of their knowledge.

**Keywords:** Teaching praxis. GeoGebra. Calculation. Information and Communication Technology.

## INTRODUCTION

This chapter deals with a reflection on the Master's research trajectory carried out by the author who writes to you and understanding it is extremely important to situate the context of Differential Calculus (CDI) in undergraduate courses and its role in professional training. This anguish of understanding the CDI, at the same time that I realized the difficulty of learning, began my journey as a researcher in this component that is so important in the training of a professional.

As an academic on the Mathematics degree course, I observed that there were not many differences between the teaching methodologies practiced by primary and secondary school teachers. The classes taught were in the traditional format, condensed into the teacher

During my master's research, I was able to learn about Meaningful Learning - AS studies according to the assumptions of Ausubel, Novak and Hanesian (1980), a very positivist relationship regarding the use of technologies in CDI classes (MACHADO, 2016).

Therefore, I begin to reflect on the following questions: What resources could we use to minimize students' difficulties and contribute to comprehensive learning? How could Information and Communication Technologies – ICTs help me and help students build the concept of Area Calculation? With this new perspective and in view of these and other concerns, I decided to propose research resulting in the master's thesis

According to Segundo Valente (1993), optimists tend to present arguments that are not very convincing and often do not take into consideration, the role of the teacher in defending the use of computers in teaching, in addition to deficiencies brought about from basic education, mainly regarding knowledge of polynomials, functions and graphs (IGLIORI, 2009; NASSER, 2007).

Although it was not the focus, we found at the time that the CDI had a high failure and abandonment rate. Several researchers, including Barufi (1999), Nasser (2007) and Rezende (2003) have shown that this is a scenario that is repeated in several Brazilian universities, being one of the reasons for student dropout and failure.

The text presented aimed to situate the reader in how we think about research. Our concern, based on the teaching of topics related to Calculus and the situation of students entering higher education, was justified due to their recognized learning difficulties.

Thus, we thought of a master's degree research in which we identified and analyzed the possible contributions of using the GeoGebra software as an object of study in the Calculus teaching and learning processes based on the tripod: Meaningful Learning – Information and Communication Technology – Didactic sequence. The route will be more detailed later in this chapter.

Thus, at the end of the research, we developed a proposal for an activity in the form of an educational product, with the aim of contributing to the practice of Calculus teachers at IFGoiano, creating, through GeoGebra, a didactic sequence for the study of area calculation that can be accessed and used by the reader in accordance with the description in the bibliographic reference Machado (2016).

The study of Calculus in academic environments is considered complex according to Barufi (1999). Therefore, this research work presented a proposal highlighting how technological tools can contribute to the learning process. Starting from an analysis of the current panorama of research related to the teaching of Calculus, it was observed that researchers' concern with teaching this discipline is growing, and several studies related to the topic can be found in the literature.

The problems involved in learning Calculus are quite complex. But the literature cited in this dissertation points out that the use of educational software can bring contributions in different aspects. As an example, we can mention the visualization and analysis of graphics (NASSER, 2007) and the use of ICTs, which can create a more conducive environment for work and contribute to the understanding of new concepts.

Allevato (2010) and Skovsmose (2001) investigated learning using ICTs as teaching tools. The authors analyzed the impacts they had on student learning, bringing valuable reflections to mathematics education, problem solving and the consistency of collaborative work, establishing a research scenario very different from the idea of exercises for transmitting algorithms.

Numerous researchers have pointed out factors that affect students' performance in this subject. Silva and Borges Neto (1994) highlighted several factors, among them, that the teaching of Calculus could become more meaningful if teachers knew in what and how the contents taught were being applied.

The studies carried out by these researchers indicated that, often, when teachers are asked by students about the importance of the content studied in Calculus, some were unable to respond.

In this context, we assume the hypothesis that the use of mathematical software can contribute to the teaching of Calculus, based on an interdisciplinary approach and the use of technological resources, in addition to the development of didactic sequences related to the construction of knowledge. Based on this conjecture, we aimed to ask the following question: Did the use of GeoGebra software as a technological tool help academics in understanding Calculus?

As specific objectives, there were:

- Develop, test and evaluate exploratory activities with the GeoGebra software, related to calculating the area of real functions;

- Explore the construction of academic knowledge based on the concepts of didactic sequences;

- Analyze and compare teaching practice, pre and post-research, and;

- Analyze student performance based on post-activity questions.

The master's thesis was divided into 5 chapters, in which: in chapter I we brought the reader a brief historical description of Calculus, the main mathematicians who developed it, the importance of studying this component, the teaching of Calculus in undergraduate and, specifically in the case of this work, in the Chemistry degree course at the Federal Institute of Education, Science and Technology Goiano – IFGoiano – Ceres campus, Meaningful learning theory and learning Differential and Integral Calculus.

In chapter II, we discuss Information and Communication Technologies, GeoGebra, didactic sequence and learning object. In chapter III, we present the methodology used to develop this research and, finally, in chapter IV, we provide the reader with a presentation of the analysis and discussion of the research results.

In addition to the descriptive chapters, we begin with the Introduction, where we expose the general and specific objectives and the research problematization and justification, in addition to the final considerations and the educational product.

In this text, the reader will be able to briefly understand the research path taken and the contributions that the use of GeoGebra provided in teaching and learning area calculation.

## LEARNING DIFFERENTIAL AND INTEGRAL CALCULUS I

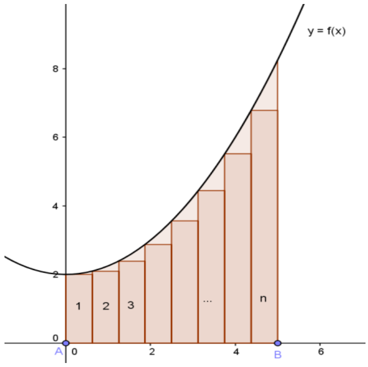
Differential and Integral Calculus, also called Infinitesimal Calculus or simply Calculus, is an important branch of mathematics, developed from Algebra and Geometry, which is dedicated to the study of rates of variation of quantities (such as the slope of a straight line) and the accumulation of quantities (such as the area of a curve or the volume of a solid). Where there is movement or growth and where variable forces act producing acceleration, Calculus is the mathematical tool to be used.

The solution to these problems was developed in Europe in the 17th century in a process that involved mathematicians from England, France and Germany, generating much controversy about who was first. French historians cite Pierre de Fermat as the father of Calculus, the English give fame to Isaac Newton and the Germans to Gottfried Leibniz.

History reports Isaac Newton and Gottfried Leibniz as the pioneers for having found that differential calculus arose from the tangent problem while integral calculus arose from the area problem, so that both are, in fact, strictly related to realizing that the derivation and integration are inverse processes. Hence the name Differential and Integral Calculus.

Many mathematicians came after these three. But it was the German mathematician Berard Riemann (1826 – 1866) who contributed not only to the development of geometry and number theory but also to mathematical analysis. Among countless works carried out, one of his achievements was to clarify the concept of integrability of a function through the definition of what we currently call Riemann Integral.

Let's take a brief look at Riemann's study.




Graph 1: RIEMANN SUM OUTLINE

Source: Made by the author on GeoGebra

With this graph, Riemann showed that the approximation of the area under the curve f(x) is to divide the interval (A, B) into infinite rectangles and add their areas as an approximation, known as the Riemann Sum.

The understanding of the studies of this notorious German mathematician is studied to this day in the disciplines of Differential and Integral Calculus – CDI. However, the abstract visualization of these partitions is a complex difficulty presented by students (NASSER, 2007).

Lachini (2001) stated that:

> Differential and Integral Calculus, a branch of Mathematics, has as its main objective the study of movement and variation. Considered as the language par excellence of the scientific paradigm and as an indispensable instrument of thought for almost all areas of knowledge, since its consolidation at the end of the 17th century with Newton and Leibniz, it is placed as a basic and mandatory subject in several undergraduate courses in the area. of Exact Sciences. (LACHINI, 2001, p. 147).

Calculus dealt with the problem of determining a function from information about its rate of change, allowing people to calculate the position of a body from its current position and knowledge of the forces acting on it. Determine the areas of irregular regions in the plane, measure the length of curves and determine the volume and mass of arbitrary solids. It's the part of Mathematics, movements and variations. Where there is movement or growth and where variable forces act producing acceleration, Calculus is the area of Mathematics to be employed.

According to Barufi (1999), Calculus is applied in several areas of Physics, Chemistry, Biology, Economics, Astronomy, Archeology, Medicine, even Psychology and Political Sciences. In this context, the Calculus discipline plays an important role in the training of various professionals. Furthermore, Calculus is the basis of Engineering, Computing and Statistics.

Resende (2003) corroborated when he stated that one of the great challenges in Higher Education is still, without a doubt, the "failure in teaching Calculus", which can be proven by the teachers of these subjects themselves, who have difficulties in getting students to construct the minimum necessary knowledge.

There are significant research notes on the subject and that this interest "is justified both by the fact that Calculus is one of the main reasons for student failure and by its privileged condition in the formation of advanced thinking in Mathematics". IGLIORI (2009)

For Machado (1999), Calculus was:

> [...] in the most varied areas of knowledge, such as Engineering, Chemistry, Physics, Biology, Economics, Computing, Social Sciences, Earth Sciences, etc., the systematic analysis of models that allow predicting, calculating, optimizing, measuring, analyzing the performance and performance of experiments, estimate, carry out statistical analyzes and also develop efficiency standards that benefit the social, economic and humanistic development of different countries around the world. (MACHADO, 1999, p.125).

In this aspect, D'Ambrosio (1993) also cited the systematization of teaching knowledge when stating that:

> [...] The complexity of Mathematics, especially due to its relationships with other eras of knowledge and the social, political and economic implications, has justified, since Antiquity, reflections, theories, and studies on its teaching. (D'AMBROSIO, 1993, p.9)

The same author completed:

> [...] Naturally, just as it happens today, teacher training is essential, and a teacher must master the subject matter of his classes from a critical and more advanced point of view. (D'AMBROSIO, 1993, p.10)

On a technical-didactic level, the approach to Calculus content still remains quite distant from what the student expects and needs to experience in class to become an efficient user of the vernacular. Currently, much has been discussed about the teaching-learning-evaluation process in teacher training courses. Skovsmose (2001) stated that:

> It is necessary to intensify the interaction between Mathematics Education (MI) and Critical Education (CE), so that EM does not degenerate into one of the most important ways of socializing students in a technological society and, at the same time, destroy the possibility to develop a critical attitude towards this technological society. (SKOVSMOSE, 2001, p. 14)

This is the picture of Calculus classes in undergraduate courses at most Universities. I reflected on the relationship between this problem, pointed out by the author, as a failure in undergraduate courses in Mathematics, as there are no subjects that aim to contextualize with related areas of knowledge.

The graduation students, more specifically those who take the Calculus discipline, are required to have knowledge in certain areas of mathematics, such as functions, geometry and trigonometry, as they constitute the basis of Calculus. However, the Calculus teacher often does not take into consideration, the difficulty this student had in learning in Basic Education or whether this student saw this content in High School and simply ignores this situation. This "ignoring" of the student's prior knowledge causes numerous difficulties in learning Calculus.

The research carried out for this work showed that Calculus is one of the subjects whose failure, dropout and repetition rates are high in several universities in Brazil and abroad. The "failure in teaching Calculus" as one of the great challenges in teaching Mathematics at higher education. This situation has caused concern not only due to failure, but also due to the difficulty in making students adequately learn the concepts and procedures of Calculus. (BARUFI, 1999; NASSER, 2007; REZENDE, 2003).

Students are also responsible for failure in Calculus due to immaturity, lack of commitment and, mainly, the lack of prerequisites after having interviewed some teachers in their research. The difficulties in learning Calculus are the truest confirmation of the difficulties in learning Mathematics in the broadest sense. In fact, in primary and secondary education, it is generally possible to hide learning difficulties through the student's assimilation of the stages of the subject. In higher education, the continuity of these stages is no longer possible, since there is no type of preparation for this: the contents that are part of the network of meanings of Calculus are either ignored or found camouflaged under other ideas in basic teaching. mathematics. IGLIORI (2009).

## MEANINGFUL LEARNING

Ausubel, Novak and Hanesian (1980) defended the thesis that learning, through metacognition, makes the learner evolve in levels of knowledge and uses organized strategies, which can be more effective. This is because it better suits the cognitive difficulties encountered in the process of mental construction of knowledge on the part of the student.

For Ausubel, meaningful learning is the entire process in which new information or knowledge is related in a non-arbitrary way to the learner's cognitive structure. For the author, it is where the logical meaning of the learning material transforms into psychological meaning for the student. In this case, the teacher must think about the student's learning and, therefore, build the teaching plan, always considering this plan to teach with mathematical language.

The learner's prior knowledge serves as an organizational matrix for the incorporation, understanding and fixation of new knowledge when it is "supported" on specifically relevant knowledge (subsumers) pre-existing in the cognitive structure. In this case, new ideas, concepts, propositions can be learned significantly as other specifically relevant and inclusive ideas, concepts, propositions are adequately clear and available in the learner's cognitive structure and function as "support" points for the former.

In general, Ausubel, Novak and Hanesian (1980) presented two basic types of learning in their theory, one by perception and the other by discovery. For them, both can be mechanical or meaningful, where the occurrence of meaningful learning presupposes the learner's willingness to relate the material to be learned in a substantive and non-arbitrary way to their cognitive structure; presence of relevant ideas in the student's cognitive structure (subjects or prior knowledge) and potentially significant material.

## REVIEW OF LITERATURE

In this section, we provide the reader with a synthesis of the methodological framework, didactic sequence, in addition to addressing ICT in the teaching of Calculus, the GeoGebra software, and learning object.

A teaching of Calculus based on interdisciplinarity was proposed, in order to provide much more structured and rich learning with the use of technological resources, more precisely with the use of educational software. The proposals for interdisciplinarity on the table point to horizontal and vertical integrations between the various areas of knowledge.

Bicudo (2012) reported about qualitative research:

> The qualitative encompasses the idea of the subjective, capable of exposing sensations and opinions. The meaning attributed to this research conception also encompasses notions regarding perceptions of differences and similarities of comparable aspects of experiences, [...] It is understood that the notion of rigor would not be applicable to qualitative data, since they precision and objectivity would be lacking, making the application of quantifiers difficult or impossible. (BICUDO, 2012, p. 116, emphasis added).

Observing is learning to inquire. It is to equip your gaze for reflective action and to avoid getting lost in the immense pedagogical space of the classroom, diverting your focus to the detriment of issues that are not part of your research.

For Silva (2006):

> Qualitative research is characterized by presenting questions to be investigated that are not established through the operationalization of variables, and the phenomena are addressed in all their complexity. On the other hand, it is descriptive because it aims to describe the characteristics of the phenomenon, seeking to establish relationships between variables (SILVA, 2006, p. 59).

In the case of the consultation in question, the research method is observation of the researcher's teaching practice during classes as the main conductor of the class.

## FOLLOWING TEACHING

A didactic sequence is "a set of ordered, structured and articulated activities to achieve certain educational objectives, which have a beginning and an end known to both the teacher and the students" (ZABALA, 2007, p. 18).

It is understood that a didactic sequence must be a set of activities linked together, planned by the teacher in detail to teach content. Also organized according to the objectives that the teacher wants to achieve for their students' learning and involving assessment activities that can take days, weeks or throughout the year.

According to the author, every didactic sequence must have three stages: planning, execution and evaluation. In the present study, it was planned by the subject teacher with the aim of allowing students to visualize the definition of area calculation in GeoGebra with Riemann divisions and identify the lower and upper sums of this mathematician. In the assessment, students were required to be able to relate the Fundamental Theorem of Calculus with the areas of Chemistry and know how to use GeoGebra in constructions and graphical analyses.

For Zabala (2007), a didactic sequence is one of the best ways to improve educational practice. Therefore, the contents worked on must contribute to the formation of conscious, informed citizens and agents of transformation of the society in which they live. In this context, the research was based on its definitions of didactic sequence to guarantee significant learning through the resumption of students' previous knowledge, proposing a problem situation in which the student puts the acquired knowledge into practice, relating it to the new and, based on the construction of knowledge, seek their own solutions and try new paths.

Briefly, Zabala (2007, p. 92-93) thus defined the set of necessary interactive functions that favor the teaching-learning process, based on the teacher's planning:

> (a) plan teaching activities in a sufficiently flexible way to allow adaptation to students' needs throughout the teaching/learning process;
>
> (b) count on the contributions and knowledge of students, both at the beginning of the activities and during them;
>
> (c) help them find meaning in what they are doing so that they know what they have to do, feel that they can do it and that it is interesting to do it;
>
> (d) establish goals within the reach of students so that they can be overcome with the necessary effort and help;
>
> (e) offer appropriate help, in the student's construction process, for the progress they experience and to face the obstacles they face;
>
> (f) promote self-structuring mental activity that allows the maximum number of relationships to be established with the new content, attributing meaning to it to the greatest degree possible and fostering meta-cognition processes that allow you to ensure personal control over your own knowledge and processes during learning;
>
> (g) establish an environment and certain relationships presided over by mutual respect and a feeling of trust, which promote self-esteem and self-concept;
>
> (h) promote communication channels that regulate negotiation, participation and construction processes;
>
> (i) progressively enhance students' autonomy in defining objectives, planning the actions that will lead them to them and in carrying them out and controlling them, enabling them to learn how to learn;
>
> (j) evaluate students according to their

> capabilities and efforts, taking into consideration, their personal starting point and the process through which they acquire knowledge and encouraging self-assessment of skills as a means of promoting control and regulation strategies for their own activity. (ZABALA, 1998, p. 92-93).

The didactic sequence of this study was designed so that the notions of area calculation could be discussed, problematized and mediated by the teacher, in order to value the teaching-learning process in the appropriation of knowledge. The student was understood as the subject of his learning, where he argued and built his own knowledge through interaction with his colleagues and the teacher. The teacher assumed the role of mediator of discussions, a guide of possibilities in the construction of knowledge.

## GEOGEBRA

The resulting readings on the two themes – Calculus and ICT's – were made with the aim of understanding the subject of study of our research and developing a theoretical contribution on the teaching of Calculus using ICT's, seeking to maintain a convergence of points of view. of the authors researched who discuss these themes.

For D'Ambrósio (1993), society is gradually making this resource available and, therefore, the teacher has to think about this reality in which he is inserted and how to associate different methodological elements for his work in the classroom, as it is where the construction of knowledge takes place.

The use of the computer can help to reframe concepts through visualization, previously explored in an algebraic-analytical way; innovate manipulation through the creation of a new pattern of exercises and examples, those carried out from an extremely repetitive perspective, in addition to expanding the application through the possibility of mathematically modeling new problems and situations that have been little explored until now.

Currently, there are several software programs that help teachers teach Calculus, some more focused on graphics, others on Geometry and Algebra. But all with diverse operational tools for constructing and applying concepts in Mathematics and Statistics such as Winplot, Wingeom, Graph Equation, GeoGebra, among many others.

There are countless researches related to the topic of this work that gave us the basis for choosing the GeoGebra software. Santos et al (2012) carried out research in an Information System class and concluded that the results provided elements that allow considering the potential of using GeoGebra in the elaboration and development of activities aimed at understanding the meanings of mathematical and didactic objects within the scope of university mathematics.

In addition to the various research regarding the use of GeoGebra in teaching Calculus, it was observed that the software used is dynamic where the user can manipulate the number of partitions with the "mouse" and visualize the Riemann sums with the calculation of the area.

## THE RESEARCH PATH

The study in question was based on my teaching practice as a Calculus teacher for the classes of the Chemistry degree course at IFGoiano/Campus Ceres as follows: the incoming classes from 2013.1 to 2014.1, the teaching practice was based on memorization, in repetition, in "memorizing" the formulas and techniques of Integral defined without any type of contextualization with the academic area of activity, verified by the authors. In the class of 2014.2, with 35 incoming students, a new teaching praxis was used, that of the present study.

This, based on the contextualization with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the academic area of activity, in addition to the use of GeoGebra in the graphical analysis of an integral, aimed at building knowledge divided into two stages: the first carried out in the classroom in a traditional way and the second stage in the computer laboratory through the development of a didactic sequence to assist in visualizing the area of a function.

As a research proposal, in the class of 2014.2, the proposal was to continue classes with the same criteria as previous classes in a traditional way. Additionally, at the end of the theoretical approach in the classroom, students were sent to the computer laboratory to develop a didactic sequence using GeoGebra as a technological tool.

This practical activity lasted 3 hours and was carried out in the computer laboratory with students from the 1st period of the Chemistry degree course. The activities were carried out individually, with the teacher establishing that everyone must participate in the execution of the task and in handling GeoGebra, in which initially, 3 hours were used to familiarize themselves with the software through the explanation of the software commands, its functionalities, the menu and input field. To this end, an area calculation exercise was carried out with the same content as the didactic sequence so that students could visualize the steps to be followed.

After this stage, all thirty-five students received a description of the activity with two problem situations and a script of the activities briefly described and, after delivering this script, the students began to develop the activity and were instructed not to report to the teacher to "remove" doubts about how to solve the problem, as the objective of the activity was the construction of knowledge.

Finally, after the activities, the teacher asked the students to send him an email evaluating the activity worked on, answering the following questions: "What did you think of the classes in the classroom?" and "What did you think of the activity developed here in the laboratory"?

## ANALYSIS AND DISCUSSION OF RESULTS

Classroom observations made it possible to plan and structure ideas in order to investigate students' actions during Calculus classes and verify some extremely important criteria. Of these, classroom praxis stood out as basic and essential characteristics as an intentional act of providing students with the appropriation of knowledge.

As the research took place in two stages, the analysis of the results also took place in the same way and, in a didactic way, was divided into two sections: without the use of the learning object and with the use of it.

The first stage of this work lasted four months and the students were deliberately invited to send an email to the teacher responding to what they thought of the classes before using the technological resource.

With the students' reflections, I was able to observe that the research in question systematically corroborated Barufi (1999). The Calculus classes taught were the same as previous classes and the teaching practice was centered on memorizing exercises without context within the scope of each course.

It was observed that the students did not like "calculation for the sake of calculation" and did not feel comfortable in the classroom with theoretical definitions without contextualization and that the great difficulty in the procedures for solving and analyzing an integral were consequences of an unattractive methodology by students.

Using GeoGebra, the students observed that the sum of the rectangles, with the Geogebra command "lower sum" and "upper sum" resulted in an approximate value of the area of the region they had to calculate.

Therefore, they were able to computationally observe the theoretical concepts studied in the classroom and relate the area calculation to the Riemann Sum.

It was observed at the end of the activities and from the discussions carried out by the students that Calculus became more attractive for learning and that the use of GeoGebra in the construction and visualization of graphs became more intriguing in the construction of students' knowledge.

## FINAL CONSIDERATIONS

This chapter brought an excerpt from the master's research in which the author believed that the search to answer the question raised in this project made me reflect on the teaching practice in teaching Calculus and leave the comfortable side of traditional teaching, to another side, using ICTs as a learning object. The conclusion was reached that the teacher must stop and consider his teaching praxis, thinking about which trend this praxis fits into. This problematization, during the research, transformed into aspects that were observed and that permeated the work, research and studies.

The objective of this work was to contemplate the concept of integral seen in the classroom, using GeoGebra and, at the end of the activity, to understand the students' behavior with regard to this applied teaching. The activities developed with GeoGebra showed that it is possible to teach Calculus in a dynamic way, making the class more interactive, thought-provoking and attractive, with the student participating and interacting with their colleagues in the construction of their own knowledge.

The research showed that carrying out investigative activities contributed to the creation of an environment for discussion and collaboration that is not always possible to have in the traditional classroom, in which the learning process is, most of the time, centered on the teacher. We therefore emphasize that the development of investigative activities using educational software can decisively help to create a learning environment that complements traditional classroom teaching.

It was observed in this work that Calculus classes became more attractive to students, as they realized the connection between the theory explained in the classroom and the contextualization with the area of coverage, through carrying out practical activities using GeoGebra software to build knowledge.

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