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Calculus I: reflections constructed within the scope of the UESB Interdisciplinary Institutional Tutorial Education Program

Abstract: This qualitative study aimed to foster reflection on the teaching of Calculus I in undergraduate courses offered by a department at the Southwest Bahia State University, Brazil. The aim was to deepen and solidify the training of students in the university's Interdisciplinary Institutional Tutorial Education Program. Data were collected through analysis of institutional documents, a questionnaire, and semi-structured interviews. The reflections enabled students to identify mathematical objects in which undergraduate students have difficulty understanding how these may interfere with the learning of Calculus I, as well as to propose solutions to minimize these difficulties. The study concluded that it effectively contributed to the training of students in the Program, particularly regarding research and the resulting discoveries.

Keywords: Mathematics Education. Calculus Teaching. Tutorial Education Program.

Galvina Maria de Souza
Southwest Bahia State University
Vitória da Conquista, BA — Brasil
0009-0009-5773-2257
galvina.souza@uesb.edu.br

Alexsandra Oliveira Andrade
Southwest Bahia State University
Vitória da Conquista, BA — Brasil
0000-0002-8964-6486
alexsandra@uesb.edu.br

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ARTICLE

Cálculo I: reflexiones construidas en el ámbito del Programa de Formación Tutorial Institucional Interdisciplinaria de la UESB

Resumen: El estudio cualitativo tuvo como objetivo fomentar la reflexión sobre la enseñanza de Cálculo I en los cursos de pregrado de un departamento de la Universidad Estatal del Suroeste de Bahía, Brasil. El objetivo fue profundizar y consolidar la formación de los estudiantes del Programa Interdisciplinario de Educación Tutorial Institucional de la universidad. Los datos se recopilaron mediante el análisis de documentos institucionales, un cuestionario y entrevistas semiestructuradas. Las reflexiones permitieron a los estudiantes identificar objetos matemáticos en los que los estudiantes de pregrado tienen dificultades para comprender cómo estos pueden interferir con el aprendizaje de Cálculo I, así como proponer soluciones para minimizar estas dificultades. El estudio concluyó que contribuyó eficazmente a la formación de los estudiantes del Programa, especialmente en lo que respecta a la investigación y los descubrimientos resultantes.

Palabras clave: Educación Matemática. Enseñanza del Cálculo. Programa de Educación Tutorial.

Cálculo I: reflexões construídas no âmbito do Programa de Educação Tutorial Institucional Interdisciplinar da UESB

Resumo: O estudo, de abordagem qualitativa, objetivou promover reflexões sobre o ensino de Cálculo I nos cursos de graduação ofertados por um departamento da Universidade Estadual do Sudoeste da Bahia. Buscou-se o aprofundamento e a solidificação da formação de estudantes do Programa de Educação Tutorial Institucional Interdisciplinar dessa universidade. Os dados foram produzidos por meio da análise de documentos institucionais, questionário e entrevistas semiestruturadas. As reflexões possibilitaram aos estudantes identificar objetos matemáticos em que acadêmicos de graduação apresentam dificuldades em compreender como elas podem

interferir na aprendizagem de Cálculo I, bem como propor soluções para minimizá-las. Concluiu-se que o estudo contribuiu efetivamente para a formação dos estudantes do Programa, principalmente em relação ao fazer pesquisa e às descobertas decorrentes dela.

Palavras-chave: Educação Matemática. Ensino de Cálculo. Programa de Educação Tutorial.

1 Introduction

Calculus can be understood as a tool for understanding knowledge from areas other than Mathematics and, consequently, for constructing new knowledge. Thus, it is present in the curriculum of several undergraduate programs. However, the teaching and learning processes in this discipline are marked by low student performance, high failure, repetition, and dropout rates, a constant concern for the Mathematics Education community (Ribeiro, Mondini, and Mocrosky, 2019).

In this regard, the research by Rosa, Alvarenga, and Santos (2019) stands out. They analyzed the academic performance of students enrolled in Calculus IA, as the authors called it, between the first semester of 2010 and the second semester of 2016 at the Federal University of Goiás, Brazil, focusing on enrolled students, passing and failing rates, and final grade point averages. The results obtained highlighted the existence of unsatisfactory performance, evidenced by high failure rates and low final grade points, with an average failure rate of 65%, with a final grade point average of 4.1 out of 10.0.

Seeking to establish a relationship between the assessment process, teaching strategies, and the high failure rates in Calculus I, whose syllabus and workload are similar to those of the study by Rosa, Alvarenga, and Santos (2019), the study presented in this article corroborates the results presented by Bezerra and Gontijo (2020). In the study, the authors concluded that, regardless of the assessment process or teaching strategies implemented, the lack of basic prerequisites for students entering university, combined with a lack of maturity for academic studies and a lack of motivation, coupled with difficulties in learning concepts specific to Calculus, directly impact student performance and, consequently, failure and dropout rates. Cavasotto (2010), Donel (2015) and Bellettini and Souza (2018), regarding the lack of basic prerequisites of students, highlight that low performance in Calculus can be attributed to difficulties arising from learning gaps in mathematical content discussed in Basic Education. Gaps that, according to Nasser et al. (2019), generate deficient and unconsolidated elementary mathematical knowledge.

Regarding difficulties in learning concepts specific to the discipline and a lack of motivation to study, Souza (2022) argues that the teaching and learning processes of Calculus are also influenced by students' difficulties related to Calculus concepts of a historical-epistemological nature. Therefore, it is important to conduct further studies that highlight methodological alternatives to minimize these difficulties, particularly focusing on contextualizing concepts within the specific areas of the undergraduate program in question, without losing sight of the *comprehensive student education* for their professional performance.

It is noteworthy that this comprehensive student education (Souza, 2022) is understood in line with Camarena's (2013) vision. In other words, it is an education in which “the mathematical objects presented in teaching and learning situations must establish links with other sciences, daily activities, and the future professional's performance” (Souza, 2022, p. 82). This allows students to mobilize mathematical knowledge when needed.

Thus, it can be seen that the studies[1] cited were based on the reflections and conclusions

[1] The study is an integral part of the project *Alternative methodologies in teaching Mathematics*, approved by the UESB Ethics Committee, no. 69682223.7.0000.0055.

Educação Matemática Debate
v. 9, n. 16, p. 1-12, 2025

of researchers from the Mathematics Education community and Calculus teachers. No studies were identified that addressed the issues raised in the study presented here, particularly those linked to Tutorial Education Programs (PET). Given this scenario, this aspect justifies the research proposal that gave rise to this article, as it seeks to understand, from the perspective of undergraduate students, how mathematical concepts that were not developed by them during Basic Education can hinder the learning of the content taught in this discipline. Thus, the study was conducted within the scope of the Differential and Integral Calculus I course, a common curriculum for undergraduate programs in the Exact Sciences offered by the Department of Exact and Technological Sciences (DCET) at the Vitória da Conquista campus of the Universidade Estadual do Sudoeste da Bahia [Southwest Bahia State University — UESB]. The objective was to promote reflections on the teaching of Calculus I in these undergraduate programs, aiming to deepen and solidify the training of a group of students in the Interdisciplinary Institutional Tutorial Education Program (PetiInter) at this university.

Data production was primarily conducted through the analysis of syllabi for Calculus I courses offered at UESB, semi-structured interviews with professors who teach Calculus at the institution, and the development, administration, and analysis of a questionnaire addressed to students in the programs involved.

Regarding the structure of the article, in addition to this introduction, there is a brief section in which some clarifications are made about the Tutorial Education Programs, the precepts of the theory that supported the study, the methodology and methodological procedures used, followed by the discussion and analysis of the data produced and, finally, by the final considerations.

2 Tutorial Education Programs

The PET was established by Law No. 11,180 of September 23, 2005, and regulated by Ministry of Education (MEC) Ordinances No. 3,385 of September 29, 2005, No. 1,632 of September 25, 2006, and No. 1,046 of November 7, 2007. The Program aims to "foster tutorial learning groups by granting scientific initiation scholarships to undergraduate students and tutoring scholarships to tutors of PET groups" (Brasil, 2005, p. 5). Scholarships are generally awarded to students who demonstrate outstanding skills and abilities during their undergraduate studies.

Thus, the PET promotes improved academic education by providing students with the opportunity to engage in extracurricular activities under the guidance of a tutor. These activities aim to deepen the program content that integrates the curricular framework of these courses and, consequently, complement the student's academic education.

At UESB, the PET activities are designed to guarantee students the opportunity to experience teaching, research, and extension that foster their academic, scientific, social, and cultural development, necessary not only for entering the job market but also for pursuing graduate studies.

Tutorial Education at UESB was institutionalized by approval from the Council for Teaching, Research, and Extension (Consepe), with the intention of improving teaching through the formation of interdisciplinary groups within the university's undergraduate programs. In this sense, the Program became the Institutional Tutorial Education Program (PETI) and, when comprised of students from more than one undergraduate program, the Interdisciplinary Institutional Tutorial Education Program (PetiInter).

This article is the result of a study proposed as one of the activities carried out within the scope of PetiInter by a group of students from the Cinema, Agronomy, Mathematics, and Computer Science programs, under the guidance of one of the article's authors and with the

collaboration of the other. The group, established in 2021, carried out activities to build and enhance students' knowledge related to the scientific and technological foundations common to these programs, in line with the purposes of the program and the institution.

In this article, aspects of the Anthropological Theory of Didactics, detailed in the next section, were used to support the proposal.

3 Theoretical framework

Considering that data produced in qualitative studies need to be analyzed from the perspective of techniques grounded in Mathematics Education theories, aspects of the *Anthropological Theory of Didactics* (ATD) were chosen to guide the analyses and reflections produced by this investigation.

This theory was developed by the Frenchman Ives Chevallard and collaborators from 1981 onwards, with Anthropology as its central axis to highlight how men and women relate to mathematical knowledge. In this context, research supported by ATD focuses on mathematical activity in the field of human activities and social institutions of educational systems, in which "the object of investigation emerges from Didactic Systems defined between subject-institution-knowledge and the relationships that exist in these institutions" (Souza, 2022, p. 62-63).

However, educational systems are influenced by elements of the social system of education, such as Pedagogical Policy Projects for courses, Teaching Plans, teachers, students, the Base Nacional Comum Curricular [National Common Curriculum Base] — a document that guides Brazilian Basic Education curricula — and teaching resources. These elements determine, among other things, the learning[2] that should become knowledge for students, aimed at developing citizens (Henriques, Nagamine, and Nagamine, 2012).

In ATD, each of these elements is considered an *institution* that makes up the Didactic Systems, defined as

> a social device that imposes on people who occupy a position within it *their own ways of doing and thinking with restrictions and conditions* that influence the construction of concepts and properties that determine the existence of an object of knowledge to be taught (Souza, 2022, p. 63).

However, the research takes place at a research institution, considered a reference institution. In this study, the reference institution is the Exact Sciences programs of the Department of Exact and Technological Sciences at the Universidade Estadual do Sudoeste da Bahia, Brazil.

Mathematical objects are understood in ATD as "entities that emerge from existing systems of practices within institutions" (Souza, 2022, p. 63).

Thus, ATD was designed to study *didactic organizations*, built for the teaching and learning of a mathematical object through *mathematical organizations*. Therefore, it is necessary to understand Didactic Systems so that the teaching and learning processes fulfill their role. This requires studying each of the elements that comprise these systems, that is, understanding the subject, the knowledge to be taught, understanding how institutions operate, and the relationships that exist between these elements.

To this end, ATD presupposes, among other things, the analysis of institutional

[2] In ATD, learning and knowledge have distinct meanings; *learning* is related to the area, produced over time by the academic community, while knowledge, related to the person, is constructed by them through cognitive activities (Chevallard, 1991).

Educação Matemática Debate
v. 9, n. 16, p. 1-12, 2025

documents and interviews with stakeholders involved in the processes, with the aim of understanding how a mathematical object, entangled in an investigation, is approached, highlighting the conditions offered and the restrictions imposed within the reference institution.

The following section details the methodology employed in the study that resulted in this article, as well as the methodological procedures implemented.

4 Methodology and methodological procedures

The study that gave rise to this article, from a methodological standpoint, is qualitative in nature, as it discusses specific issues that cannot be quantified (Minayo, 1994). It is worth noting that, although some data were tabulated and some graphs were created and analyzed, these analyses were descriptive in nature. The study cannot be classified as qualitative-quantitative or mixed methods, as described in Creswell and Clark (2007), since no inferential processing was performed on the data produced.

The idea for the study arose from the need identified by the students in the PetiInter group, particularly those studying Agronomy, Mathematics, and Computer Science, to understand the reasons why passing the Calculus I course was so difficult.

Initially, readings were conducted to highlight the results of other research related to the current study, as proposed by Creswell (2010). To this end, searches were conducted on Google Scholar, selecting articles that addressed the teaching and learning processes of Differential and Integral Calculus I, focusing on content in which students experience difficulties and proposals to minimize them. Priority was given to articles published in the last five years and available in full online. These articles were subsequently discussed on PetiInter.

Considering that document analysis is “a procedure that uses methods and techniques for the apprehension, understanding, and analysis of documents of various types” (Sá-Silva, Almeida, and Guindani, 2009, p. 5), and can be performed using documents from a variety of sources, and considering the institution's Teaching Plans in accordance with the ATD, the syllabi and syllabus of the Differential and Integral Calculus I teaching plans provided by the professors teaching this course that semester were analyzed. The purpose was to identify and understand how the content is addressed, remembering that, in document analysis, facts must be mentioned, interpreted, and information synthesized, as pointed out by Sá-Silva, Almeida, and Guindani (2009). The lesson plans were made available to the students in the PetiInter group by the group's tutor.

Based on this analysis, and considering that a survey is a research technique based on the “direct questioning of people whose behavior one wishes to understand” (Gil, 2008, p. 55), a semi-structured interview was conducted with two DCET/UESB professors who taught Calculus I in the courses involved during the semester in which the study was conducted. The main objective was to understand how this course was conducted from a methodological perspective, in terms of the assessment process, and other aspects related to teaching.

Subsequently, the precepts of ATD were used to analyze the textbook adopted by the interviewed teachers. This analysis considered the organization and structure of the book, as well as the main objects with which the Calculus content interacts, whether mathematical or related to specific applications. Among other aspects, the media and technologies supporting mathematical and didactic organization, the approach to applied projects, whether the author proposes differentiated activities to alleviate student difficulties, and the organization of the chapters were observed.

Finally, 62 students from the Vitória da Conquista campus of UESB who were taking the course in the first semester of 2022 were invited. Of these, 21 were undergraduate students

in Computer Science, 14 in Forestry Engineering, 10 in Physics, and 17 in Mathematics. Participants completed a previously prepared questionnaire, administered between May 18th and 23rd, 2023.

The objective of the questionnaire was to identify the course content in which students reported having the greatest difficulty, as well as to understand the relationship between these difficulties and the mathematics taught in Basic Education. The instrument also encouraged students in the PetiInter group to reflect on these issues and develop research.

It is worth noting that the questionnaire addressed questions about the degree of difficulty of the studied content, as well as the students' level of satisfaction with the learning process. It consisted of six objective questions, with the option for participants to elaborate on each one if they did not find an appropriate answer among the available items or needed clarification on a point.

The data obtained were stored, tabulated, and subsequently analyzed by the students in the PetiInter group. The next section presents the results and discussions based on the analyses performed.

5 Results and discussion

As indicated by the precepts of the Anthropological Theory of Didactics (ADT) that underpin the study, the results and discussion were developed based on the analysis of interviews conducted with teachers, the teaching plans and textbook used in the Calculus I course, the questionnaires completed by students, and the reflections developed within the scope of PetiInter.

5.1 Interviews with professors and analysis of syllabuses and textbooks

After conducting a semi-structured interview with the two professors[3] who teach Calculus in undergraduate Exact Sciences programs affiliated with the Department of Exact and Technological Sciences at the Universidade Estadual do Sudoeste da Bahia, it was found that, in general, Calculus I courses address limits and derivatives with the goal of enabling students to understand the behavior of functions capable of modeling given situations or phenomena.

Furthermore, these courses support other disciplines, such as Physics, considering the application of Calculus I content and concepts in this area of knowledge. Thus, the professors emphasize that studying Calculus I is essential, since its applicability plays an important role in the language and representation of phenomena, constituting a tool for problem-solving, corroborating Catapani (2001).

From this perspective, the understanding of Calculus at UESB converges with Cury's (2003) understanding of this discipline, which stands out in various fields of scientific knowledge, related to working memory and reasoning, with an emphasis on its applicability and relevance to courses in the Exact Sciences, allowing for in-depth exploration of topics essential to academic knowledge.

Regarding teaching strategies, professors reported using expository and dialogue-based classes, with problem-solving and correction of exercise sets, especially those with which students have greater difficulty. Some classes are taught in laboratories with computing resources, such as GeoGebra. Furthermore, students receive tutoring under the guidance of the

[3] It should be noted that the interviews were conducted with professors who taught Calculus I in the courses involved in the study during the semester in which it was conducted. Therefore, the data do not cover all Calculus I courses offered at the various UESB campuses, but only those offered at the reference institution.

instructors who teach them.

Regarding the assessment process, interviews reported that it is conducted through the development and delivery of exercise sets, as well as individual open-ended tests, the latter being the most important among the assessment instruments.

An analysis of the Calculus I syllabuses taught in the courses of interest to the study at the reference institution showed that the course syllabuses are essentially similar, covering *functions of real variables, limits, continuity*, and *derivation*. Students in one course may also be able to take the course in another. It was found that both the teaching strategies regarding the content, limits, and derivatives, and the assessment process corroborate the discourse of the interviewed professors: the methodology section recommends a dialogued lecture, and the assessment section includes exercise lists and individual open-ended tests.

Regarding the textbook used, the interviewed professors mentioned using more than one work to develop the syllabus, as it depends on how the content is addressed in each book. However, they give some priority to the book *O Cálculo com Geometria Analítica* [Calculus with Analytic Geometry] by Louis Leithold, published by Harba in 1994, which is also referenced in the syllabuses. Therefore, it was decided to analyze only this work.

The book is organized into eleven chapters: Real Numbers, Functions, and Graphs; Limits and Continuity; The Derivative and Differentiation; Extreme Values of Functions, Graphing Techniques, and the Differential; Integration and the Definite Integral; Applications of the Definite Integral; Inverse, Logarithmic, and Exponential Functions; Inverse Trigonometric Functions and Hyperbolic Functions; Integration Techniques; Conic Sections and Polar Coordinates; and, finally, Indeterminate Forms, Improper Integrals, and Taylor's Formula.

The analysis was limited to the chapters addressing limits and derivatives, as this is the content included in the course syllabus. It was observed that the author maintains a balance between an intuitive perspective and a rigorous mathematical approach, presenting the topics in a linear and progressive manner. The content is explained with a variety of examples, interspersed with theorems, most of which are accompanied by their proofs. Exercises appear at the end of each section, with progressive difficulty, with answers provided for odd-numbered exercises at the end of the book.

However, there was little conceptual practice; most are procedural, fostering numerical, algebraic, or graphical development, promoting learning through practice. Some exercises are organized into blocks that require the consolidation of procedures in order of increasing difficulty. Problems were also noted in applying the content covered in the sections; however, most of them are applied to mathematics itself or to physical phenomena.

5.2 Analysis of the student questionnaire

The questionnaire administered to the students sought to identify which Calculus I topics students struggle with the most, as well as to understand whether these difficulties stem from gaps left by a lack of established Mathematics in Basic Education or are associated with the epistemological nature of Calculus itself.

Of the 62 students who completed the questionnaire, 41 reported difficulties studying the behavior of *exponential and logarithmic functions*. They explained that a lack of understanding of these functions also compromises their understanding of their limits and derivatives. Furthermore, they highlighted difficulties in performing algebraic procedures and manipulations, and in constructing graphs involving these functions. This group represents approximately 66.13% of the total student body, a significant percentage.

In the Forestry Engineering program, difficulties were concentrated in more elementary aspects, such as defining what characterizes a function, classifying different *types, constructing graphs,* and *trigonometric functions*, in addition to *exponential and logarithmic functions*. Approximately 28.57% of the students, four of whom responded, stated that they did not fully understand the definition and classification of the functions covered.

Among the 21 Computer Science students, all indicated trigonometric functions as the main source of difficulty, a finding also corroborated by the majority of Physics undergraduates. These, like those in Forestry Engineering, presented significant limitations in the study of *trigonometric functions*, as well as in the *definition* and *classification* of these functions.

Finally, in the Mathematics undergraduate program, the greatest challenge identified was in Trigonometry, cited by 11 students, approximately 65% of the total.

Consequently, the greatest difficulty is concentrated in the development of the subject itself. When asked about the degree of difficulty encountered in Calculus I, among the 62 students, 40 rated it as *very high*, corresponding to approximately 64.5% of the respondents.

Regarding the study of limits, specifically, approximately 71% stated they did not understand the content, while 58% classified derivatives as highly difficult, mainly due to the required algebraic manipulations, graph construction, and application modeling.

Regarding satisfaction with the knowledge acquired, 45 students, approximately 72.6%, stated they were satisfied. Even among those with low performance, approximately 55% emphasized that, despite the difficulties they faced, they considered they had learned a great deal throughout the course.

Regarding the number of times they had taken Calculus I, approximately 39% of students reported taking the course for the third time. This data corroborates the findings of Ribeiro, Mondini, and Mocrosky (2019) and Rosa, Alvarenga, and Santos (2019), who emphasize that high failure and repetition rates are present in the teaching and learning processes of Calculus, and consequently, dropout rates. These results may stem from difficulties generated by students' lack of basic prerequisites related to their lack of mathematics learning. These difficulties originate in basic education, as pointed out by Donel (2015), Cavasotto (2010), Bellettini and Souza (2018), and Nasser et al. (2019), or generated by the epistemological nature of calculus itself, as argued by Souza (2022). Thus, the results obtained in this study confirm what has been reported in the specialized literature.

According to Masola and Allevato (2019, p. 5), “difficulty is related to something that has not yet been mastered; an obstacle that, once overcome, can be eliminated or at least minimized; that is, in principle, it involves issues of personal improvement”. From this perspective, it is understood that the learning difficulties observed in the classroom cannot be analyzed homogeneously, as each student has their own way of learning and dealing with the content proposed by the teacher.

5.3 Reflections built within the PetiInter framework based on the verified results

During the discussion, the PetiInter group found, through its analysis, that the Calculus I syllabus in the courses offered at UESB is limited to functions, limits, and derivatives, aimed at understanding the behavior of functions. However, the course is predominantly taught using traditional teaching strategies, based on a teaching model characterized by the centralization of the teacher as the main figure in the educational process, assigning them the role of transmitter of knowledge and conductor of learning (Bueno, Alencar, and Oviedo, 2017; Oliveira and Lopes, 2023). From this perspective, the teacher is considered the holder of knowledge, responsible for passing on information to students, who adopt a predominantly passive stance,

limiting themselves to listening, memorizing, and reproducing the presented content. This approach prioritizes the unidirectional transmission of information, prioritizing teaching authority and the rigidity of traditional methods, which often reduces the possibilities for dialogue, collective knowledge construction, and the development of students' intellectual autonomy.

The study also found that the textbook is appropriate for the methodology employed, given that it presents a linear development of the topics covered, which are explained step by step, with an emphasis on proving the stated theorems and proposing exercises of increasing difficulty, with a predominance of procedural exercises.

However, the group understood the need to diversify the teaching methodologies and strategies adopted, particularly with an emphasis on the use of technology, without, however, losing sight of the dominant rigor of Calculus. This diversification could minimize the difficulties presented by students, considering that technological resources can even provide visualization of properties that define the behavior of functions, facilitating understanding and comprehension.

Regarding the content with which students experience the greatest difficulty, the group found that these difficulties stem mostly from lack of solid learning in Basic Education, which directly impacts Calculus content. This issue must be addressed primarily through the development of public policies that value education at this level and promote solid, critical thinking, positively impacting the betterment of society. However, at the university level, PetiInter students understand the need for emergency actions aimed at minimizing these difficulties and their consequent negative impacts on the development of Calculus concepts.

Regarding proposals that could minimize student difficulties, reducing failure, repetition, and dropout rates, the group proposed two alternatives: first, the introduction of diverse methodologies in the classroom, among which active methodologies stood out; and second, the creation of videos addressing the content with which students had the greatest difficulty. This last proposal arose primarily from students in the Cinema program, who suggested creating these videos in partnership with the other members of the group, considering that they had already taken and passed Calculus I.

However, the production of the videos did not materialize due to the approaching end of some members of the PetiInter group's activities, while the first proposal remains a suggestion for teachers interested in employing this type of methodology.

The group also proposed the formation of study groups linked to the Department of Exact and Technological Sciences (DCET) at the Universidade Estadual do Sudoeste da Bahia (UESB), composed of Calculus professors and students, to discuss issues related to the teaching and learning processes of Calculus, specifically aimed at UESB students, considering the reality of those entering the institution, as recommended by Masola and Allevato (2019).

This proposal was forwarded to the coordinators of the Mathematics and Mathematics Education departments, as it is understood that the study groups should be established through initiatives by DCET/UESB professors affiliated with these areas. However, at the time of writing this article, these groups had not yet been created. It is worth noting, however, that the institution has other study groups that investigate, among other topics, the teaching of Calculus, most notably the Study and Research Group on Didactics of Experimental Sciences and Mathematics (GDICEM).

Regarding the improvement in the quality of academic education pursued by PetiInter, it is noted that the implementation of the extracurricular activities proposed for research contributed significantly to the development of students, particularly with regard to research

practice and the discoveries resulting from this investigative process.

6 Final considerations

The study presented in this article aimed to promote reflection on the teaching of Calculus I in undergraduate courses offered by one of the UESB departments, aiming to deepen and solidify the training of a group of students in the university's Interdisciplinary Institutional Tutorial Education Program.

After analyzing the data produced, conducted in light of some assumptions of the Anthropological Theory of Didactics (ATD), it was found that logarithmic and exponential functions are the subjects with which students reported having the greatest difficulty, followed by trigonometry and the definition and classification of functions themselves. These results highlight the existence of gaps in mathematics learning in Basic Education, which demands not only discussion and reflection, but also the formulation of public policies aimed at improving this educational segment. It was also found that the difficulties arising from Basic Education are partly responsible for students' poor performance in Calculus I. However, diversifying teaching methodologies and strategies, with an emphasis on the use of technology, may mitigate these results.

Regarding educational development, the study provided relevant insights for the development of PetiInter students, particularly regarding research and the findings arising from the study. Furthermore, the process allowed for the development of a more critical and investigative stance toward the phenomena studied, strengthening the participants' intellectual autonomy. This experience also contributed to the improvement of academic skills and a broader understanding of the role of research in the construction of scientific knowledge.

Conflicts of Interest

The authors declare no conflicts of interest that could influence the results of the research presented in the article.

Data Availability Statement

The data collected, produced, and analyzed in the article will be made available upon request to the authors.

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