MENDIVE

REVISTA DE EDUCACIÓN

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Characterization of the current state of the teaching-learning process of Calculus I in the Computer Engineering career of the University of Pinar del Río "Hermanos Saíz Montes de Oca"

Caracterización del estado actual del proceso de enseñanza-aprendizaje del Cálculo I en la carrera de Ingeniería Informática de la Universidad de Pinar del Río "Hermanos Saíz Montes de Oca"

Caracterização do estado atual do processo de ensino-aprendizagem do Cálculo I na carreira de Engenharia Informática da Universidade de Pinar del Río "Hermanos Saíz Montes de Oca"
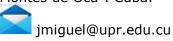
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ABSTRACT

The current development in the field of science, such as the increasingly growing introduction of technologies in processes, both productive and educational, make the training of engineering students in Cuban higher education more demanding, where the role played by the basic sciences and especially the differential and integral calculus of functions of a real variable (calculus I) is fundamental in the achievement of such purposes. The research was motivated by the need to improve the process of teaching - learning the Calculus I in forming Informatics' Engineers at the University of Pinar of the Río "Hermanos Saiz Montes de Oca", so it is proposed as objective, to characterize the current process of teaching and learning Calculus I for students of the Engineering Computer Science at the University of Pinar of the Río "Hermanos Saiz Montes de Oca". It was developed, based on a Dialectical Materialistic approach, using research methods and techniques of a quantitative and qualitative nature. A survey was applied to 31 students of first year of the the career Computer Engineering , to 10 teachers graduated from the career which are part of the collective teaching of it, and eight teachers of the department of mathematics . It is noted that the process teaching - learning of Calculus I, from conception as a process and from the role that develop subjects participants (teachers and students), does not promote productive, creative and activity developer of the student depending on the resolution problems that contribute to the solution of problems of the profession.

Keywords: teaching - learning process; calculus I; Computer Engineering.

RESUMEN
El actual desarrollo en el campo de la ciencia, como la introducción cada vez más creciente de tecnologías en los procesos, tanto productivos como educacionales, hacen más exigente la formación de estudiantes de perfil ingeniero en la educación superior cubana, donde el papel que juegan las ciencias básicas y en especial el cálculo diferencial e integral de funciones de una variable real (cálculo I) es fundamental en el logro de tales propósitos. La investigación estuvo motivada por la necesidad de perfeccionar el proceso de enseñanza-aprendizaje del Cálculo I en la formación de ingenieros informáticos en la Universidad de Pinar del Río "Hermanos Saíz Montes de Oca", por lo que se propone como objetivo, caracterizar el actual proceso de enseñanza-aprendizaje del Cálculo I para estudiantes de la carrera de Ingeniería Informática de la Universidad de Pinar del Río "Hermanos Saíz Montes de Oca". Se desarrolló, sobre la base de un enfoque Dialéctico Materialista, utilizando métodos y técnicas de investigación, de naturaleza cuantitativa y cualitativa. Se aplicó una encuesta a 31 estudiantes de primer año de la carrera de Ingeniería Informática, a 10 profesores egresados de la carrera y que forman parte del colectivo docente de la misma, y a ocho profesores del departamento de Matemática. Se constata que el proceso enseñanza-aprendizaje del Cálculo I, desde su concepción como proceso y desde el rol que desarrollan los sujetos participantes (profesores y estudiantes), no promueve la actividad productiva, creativa y desarrolladora del estudiante en función de la resolución de problemas que tributen a la solución de problemas de la profesión.

Palabras clave: proceso de enseñanza-aprendizaje; calculo I; Ingeniería Informática.

RESUMO
O desenvolvimento atual na área da ciência, além da introdução cada vez mais acrescentada de tecnologias nos processos, tanto produtivos mesmo educacionais, fazem mais exigente a formação de estudantes do perfil engenheiro da educação superior cubana, onde o papel importante das ciências básicas, especialmente, do cálculo diferencial e integral de funções duma variável real (Cálculo I), é fundamental no alcance de tais fins. A pesquisa esteve motivada pelo imperativo de aperfeiçoar o processo de ensino-aprendizagem do Cálculo I na formação de engenheiros informáticos na Universidade de Pinar del Río "Hermanos Saíz Montes de Oca". O fim da proposta investigativa é caracterizar o atual processo de ensino-aprendizagem do Cálculo I para estudantes de la carreira de Engenharia Informática desta universidade em questão. Desenvolveu se a investigação sobre a base duma abordagem Dialético-Materialista, empregando métodos e técnicas de de natureza quantitativa e qualitativa. Aplicou se um inquérito a 31 estudantes de primeiro ano da carreira de Engenharia Informática, a 10 professores graduados na carreira e que são membros do coletivo docente da mesma, também foram seletos oito docentes do Departamento de Matemática. Constata se que no processo de ensino-aprendizagem do Cálculo I, desde sua concepção como processo e desde a missão que desenvolvem os sujeitos participantes (professores e estudantes), não agencia se a atividade produtiva, criativa nem desenvolvedora do estudante em função da resolução de problemas da profissão.

Palavras chave: processo de ensino-aprendizagem; Cálculo I; Engenharia

Informática.

INTRODUCTION

Mathematics occupies an important place in the development of today's societies. The fast growth of science and technology requires the training of professionals with an extensive development in mathematics and scientific skills to meet the new challenges posed by a globalized and competitive world. From this perspective, Cuban Higher education plays a fundamental role in the social, cultural and economic development of the country; therefore, it requires highly qualified professionals with solid mathematical knowledge and a broad domain of technological tools that allow them to face and solve problems related to their profession.

From this point of view, and today it increasingly becomes more evident as the development in the field of science and introducing growing technologies in the processes, both productive and educational, do more demanding training students engineer profile in Cuban higher education, where the role played by basic science, and in particular the differential and integral calculus of the functions of a real variable (CALCULUS I), is essential in achieving such purposes.

Calculus I is the subject whose mathematical content stu dies the real functions of a real variable and their properties. It is present in the curricula of all engineering degrees and it is essential content in the modeling process of science and technology, so their learning is an essential task for part of all those who have the responsibility to teach.

It is undeniable the role played by the Calculus I in the initial formation of an engineer student profile, whose analysis will enable to take decision, make designs and control processes effectively and reliably. Therefore, the modeling, simulation and data analysis are essential tools in the engineering science and modern industry (Iglesias and Alonso, 2017; Cedeño, Escalona and Verdiel, 2019).

Of course, despite the manifest importance of the differential and integral calculus of real functions of a variable for the training of professionals in the engineering sciences, many difficulties are currently being declared in the teaching - learning process of this.

Cuban researchers such as Reyes and Perez (2015) state that the differential and integral calculus taught in the first semester of the first academic year in all engineering majors has historically presented difficulties such as: high rate of disapproval, groups of drag and drop out, great number of students in classrooms, among others, where the lack of motivation for their study and the predominant tendency to a traditional teaching, stand out as the main causes.

Taking into account the previous one, authors like Valdes and Melendez (2016) note that in engineering careers, one aspect that deserves more attention is precisely work with students of first year where obviously problems facing adaptation and coordination between secondary education and higher education, focusing this high way in the teaching and learning of the Calculus I, for which it needs an adequate mastery of knowledge and previous skills to cope new content with success.

Likewise, Martin, Pérez and Martínez (2017) ensure that the integral differential calculus of functions of a real variable constitutes one of the subjects

in which students have the greatest problems, mainly in conceptual training, appreciating a strong predominance of understanding instrumental and showing inadequacies in its didactic conception.

Other authors such as Báez, Heredia and Pérez (2017) argue that there are shortcomings in the teaching - learning process of the differential and integral calculus of real functions of a real variable, which are manifested, fundamentally, in the little emphasis that is made to develop variation thinking in students , through the didactic treatment of the movement of the variable as an integral part of the objects and phenomena of its contents, articulating it with the didactic treatment of the changes of semiotic registers for the conceptual appropriation and with the use of mathematical assistants for understanding the concepts studied.

Despite those difficulties present in the teaching and learning of the CALCULUS I in engineering careers, It continues to be a fundamental tool in the training of these professionals, within which we can stand out a computer engineer; It is a professional with a solid technological training who deals with the capture, transmission, storage, processing, protection and presentation of information through the efficient use of computers and other means, for which he needs to characterize, interpret, communicate and apply the concepts and principal results of the differential and integral Calculus of realgraphical, numerical and verbal, focusing on mathematical models as an essential invariant knowledge and in the nodes of articulation with the rest before subjects and disciplines (MES, 2017).

For both, the differential and integral Calculus of real functions of one variable is a fundamental tool for computer engineering, which is conceived as a discipline increasingly dominated by modeling techniques, a

practice that requires to processes and understand the problem, abstract, model and build, as well as evaluate designs prior to product development. In addition, current curricula recognized in the formation of the engineer computer development of special skills for the professional practice, such as logical thinking, solving problems and capacity for abstraction (MES, 2017).

Although the Computer Engineering career has its beginnings in Cuba, in which at that time it was called Engineering in Automated Systems of Economic Technical Direction (SAD-TE) and its objective was to train a professional with a broad profile that would cover everything related With the automation of information and decision-making systems for management and technological processes, it was not until the 2002-2003 academic year that due to important changes from the qualitative and quantitative point of view in terms of the training of engineers computer scientists in the country, among which we can mention the opening of said career in other Higher Education Centers (CES), the career is introduced at the University of Pinar del Río "Hermanos Saíz Montes de Oca" (UPR).

The career in the beginning starts with a refinement of the Studio Plan   C, in order to respond to the training of engineers in a new setting, so that the professional model, the objectives and disciplines essential content nor the total hours of the study plan approved by the Ministry of Higher Education (MES) suffer any modification.

The main adjustments made to the study plan by the National Commission of the career of Engineering were focused primarily to reduce the academic component in no more than 10 % and in turn increase at a 10 % labor and

research component and thus contribute significantly to the formation of professional skills, in addition the increasing the independent work assisted by computer technologies (MES, 2017).

The successive modifications of the study plan of the grade, added to its own aspects such as the change in the levels of abstraction when managing computer resources and tools, the diversity of local approaches in terms of technologies, programming languages and application areas, as well as The emergence of the career in all provinces, in addition to the experience of some universities in making adjustments to the study plans to groups of students related to development or research groups, facilitated the approach of the C Plan (modified) to the requirements of Plan D, in terms of the essentiality, presence and flexibility approaches required (MES, 2017).

The transition to Plan D in the Computer Engineering career at the University of Pinar del Río "Hermanos Saíz Montes de Oca", brought with it significant advances in terms of the diversification of the training process with the introduction of its own and optional curricula and optative / electives, given the need to respond to research and development projects in which students were involved. This presupposes a firm and important step in the training of said student, due to the flexibility it provided to the plan, as well as the possibility of assimilating new approaches and technologies that, beyond the base curriculum, required the development of Computer Science.

Furthermore, this curriculum was characterized by a set of modifications motivated mainly by the variation of the object of study, and the need to adapt the designs training stage of transformations in higher education and international standards, reason for

which the introduction of a new study plan fundamentally aimed at satisfying these demands is necessary.

Regarding to the subject Calculus I, the previous curricula were characterized, mainly, by giving great weight to the skills of calculus in detriment of the skills of problem solving and the use of information technologies in the process, as mathematical assistants, fostering in the student a certain conformity with the basic elements of Mathematics, limiting him to investigate other aspects of Calculus I that lead to proposing programming tasks of some algorithms so that they better understand the logic of the methods studied, tasks that model real practical situations and prepare them for their professional performance (Ríos and Bernal, 2018).

In the course 2018-2019 begins to be implemented in the career of Engineering at the University of Pinar of the Río "Hermanos Saiz Montes de Oca", the curriculum E, which is based on the changes that have occurred in the country and that imposed the improvement of the study plans, where the current trend is to consider an undergraduate training with greater essentiality and shorter duration and the training needs of university-level technicians, with a professional training approach towards the solution of more frequent problems of the social and productive environment with a need to adjust to performance in the base link of the profession, where postgraduate education plays a fundamental role as a way to achieve specific competences of the graduate in relation to the tasks carried out, in correspondence with international development in terms of information technology and its relationship with emerging technologies in the teaching - learning process of Cuban universities (MES, 2017).

Precisely, in this same course, in an exploratory study carried out in the Computer Engineering degree at the University of Pinar del Río "Hermanos Saíz Montes de Oca", empirical methods such as documentary analysis, interviews and observation were used, which resulted in the following as the main manifestations in the teaching-learning process of Calculus I:

- Tendency to teaching by transmission-reception of content.
- It is not always clear what is the role of Calculus I and what are its training functions in correspondence with the professional model.
- Insufficient work from Calculus I class in solving professional problems for the engineer in training.
- Not contextualization of the subject with the processes and phenomena under study, essential for the career and future profession.
- Insufficiencies in the methodological work of the teachers, which limits the analysis of the contents within this discipline.
- Insufficient use of the existing relationships between the contents of the different subjects that make up the discipline, so as to facilitate the teaching-learning process.
- Inadequate preparation of teachers in the use of the new technologies.
- Little use of mathematical assistants in teaching.

All this leads to propose as principal contradiction   the one that exists between the reality of the teaching-learning of Calculus I in the career computing Engineering, characterized by transmission- reception of contents, insufficient work with problems of the profession and taking advantage of disciplinary relationships and the need to improve it based on supporting it in the relationship between problems and professional skills; This will allow the teaching - learning process of Calculus I to be significant, problematic, systemic and investigative, thus enabling the training of a competent professional.

Taking into account the above, the objective of this work is to characterize the current teaching-learning process of Calculus I for students of the Computer Engineering career at the University of Pinar del Río "Hermanos Saíz Montes de Oca".

MATERIALS AND METHODS

The work of research was conducted on the basis of a dialectic -materialist approach using research methods and techniques, both quantitative and qualitative nature.

The research was aided by a survey, in which 31 first-year students of the Computer Engineering Career of the University of Pinar del Río "Hermanos Saíz Montes de Oca" participated, during the 2019-2020 academic year, to obtain information about how they are treated with basic concepts of calculus I (limit, derivate, indefinite and definite an integral) and its application to solving problems using mathematical assistants.

In addition, 10 graduate teachers of computer engineering that teach in the same career were interviewed , with the intention to determine to what extent the calculus I have influenced their performance as a professional and how it taxed to the development of the subjects they teach.

Finally, an interview was conducted with eight mathematics professors who in the last five courses taught in the career, to find out how the teaching-learning process of Calculus I have been developing in these last years.

The application of theoretical methods as the historical-logic, the analysis- synthesis and modeling, based on the results that emitted methods of empiric character as surveys, interviews, observation, in order to collect data Nature quantitative and qualitative diagnostic of the process of teaching and learning the Calculus has allowed to characterize the current state of the process in the career informatics Engineering at the University of Pinar of the Río "Hermanos Saiz Montes de Oca" .

RESULTS

From the Survey applied to the 31 students of the Career Informatics Engineering in the University of Pinar of the Río "Hermanos Saiz Montes de Oca", with the aim of determining the student's criteria about the characteristics of the teaching-learning process of Calculus I in the career of Informatics Engineering, the following results were obtained:

- 98.2% of the students (30 students) state that the fundamental concepts of calculus are treated in a "normal" way, or better yet exposed by the teacher, without an analysis to arrive at it.
- 100 % of the students state that the exercises in class and oriented to independent study are fundamentally focused on calculus, without there being a deep analysis for it.
- 47.1% (15 students) recognize that the contents addressed in Calculus I can be used in other situations of practical life and, therefore, it is useful for them.
- 50.9% (16 students) express that they would like to know more about Calculus I and its relationship with professional problems.
- 92.4% (29 students) recognize the use of mathematical assistants as very necessary in the teaching-learning process of Calculus I for solving problems related to their profession.

The interview with 10 graduate teachers of the career computer engineering that teach in that career, in order to determine the criteria on the influence and impact of the teaching-learning Calculus I in the formation of the engineer computer, yielded the following results:

- 100% (10 teachers) consider calculus I very important in the development of problem solving skills for the Computer Engineer; however, 75% (eight teachers) acknowledge that their classes and oriented tasks do not always promote this type of skill.
- 70% (seven teachers) express the need to introduce other methods and means in the teaching- learning process to ach ieve better learning in students.
- 90 % (nine teachers) report that calculus is necessary to be a good programmer, only one teacher highlighted the non- importance of calculus in their training as a computer engineer.

Similarly, the interview conducted with the eight mathematics teachers who in the last five years taught in the career, with the aim of determining the teachers' criteria about the quality of the teaching-learning process of calculus I in the

Engineering career, threw or the following results:

- 80% (six teachers) consider that the main problems in the teaching-learning process of Calculus I is given by the lack of mastery of the basic concepts and the formal accumulation of them.
- 90 % (seven teachers) recognizes, likewise, that the problems in the teaching-learning Calculus I have a methodological and didactic base, because even though most teachers, even when they have years of experience in education, do not have adequate pedagogical training.
- 70% (five teachers) recognizes the need for employment of assistants for mathematical teaching-learning Calculus I. Similarly, 90% (seven) recognizes they do not possess sufficient skills to effectively manage information technology and communications, within these mathematical assistants.

From the analysis of the triangulation of the results obtained with the implementation of the above instruments, we can declare that the process of teaching and learning of Calculus I for the Computer Engineering career from its conception as a process and from the role that it develops the participating subjects (teachers and students), do not promote the productive, creative and developmental activity of the student based on the resolution of problems that contribute to the solution of problems of the profession. In addition, it does not conceive, from the relationship established between science and profession, a comprehensive and systemic treatment in the construction of meaningful learning in students, characterized by low attention to individual differences and the development of related activities with the

profession that motivate the student for the career and for not taking into account the use of mathematical assistants as an essential tool in the development of professional skills and problem solving depending on the professional performance mode.

DISCUSSION

Next, the impact on the teaching-learning process of Calculus I, the treatment of fundamental concepts and the use of mathematical assistants in solving problems, as well as its impact on the training of the Computer Engineer, is conceptually assessed. There have been many studies that have addressed the issue, essentially the ones regarded to solving mathematical problems assistants in engineering careers.

Regarding the treatment of fundamental concepts in the teaching and learning of the differential and integral Calculus of functions of a real variable in the career of computer Engineering, it Coincides with Valdes and Melendez (2016) when they say that the students fail to mentally represent the fundamental concepts dealt with the subject, which slows down the corresponding development of skills to be able to apply them in practice; Likewise, the means used so far in the process (textbooks) are only limited to presenting the content in a linear way, without the student being able to interact with it.

Taking into account the points made by Coello and Paez (2017), the training in basic sciences enables the engineer to understand, model, analyze productive processes than will face in their professional practice, so the performance of the computer engineer in a given type of productive or service company is based on the skills, knowledge and skills

acquired during its training, which make it competent to perform in any situation. For this reason, the objective needs of society and professional practice are considered of great importance for the transformation and development of the cultural, socioeconomic and political environment of the region and the country.

As for the introduction of mathematicians assistants in the teaching-learning of Calculus I, it coincides with Morales and White (2019), when they say that computer technologies, specifically those attending mathematicians, can contribut e to solving problems By introducing new forms in the teaching- learning process, they increase the ability to perform calculations and are convenient, precise, and dynamic tools for drawing and graphing. All of the above allows students to interact with mathematical objects in more realistic environments.

Therefore, the mathematical assistants in the teaching-learning of Calculus I, in the career of computer Engineering, can be used among other things to provide students and teachers the analysis and the development of logical and algorithmic thinking and. Nevertheless, and as Morales and White say, (2019), it is not widespread the use of this tool for teaching activities.

As Pico, Diaz and Escalona say, (2017), the implementation of the strategy of the learning based on problems, is one of the most used in teaching mathematics, which that if it could be applied for modeling problems of the differential calculus using *software*; It would serve the student to confront their acquired knowledge and thus achieve that students can perform better academically.

Of course, the differential and integral calculus of functions of a real variable, in

the training of Computer Engineers, constitutes a fundamental link, in the first place because it is the subject with which the formation of concepts, properties, theorems and fundamental results of Mathematics and which are essential for the engineer; secondly, because the mathematics, in general, has always been, and today is also an instrument for solving problems of a professional nature leading to a mathematical modeling of the problem.

However, and according to the MES (2017), the Mathematic lost ground continuously with the development of computer and numerical methods. The importance of the symbolic calculation procedures is reduced and the meaning of the set of Numerical Mathematics -Computing- Artificial Intelligence increases. Modern tendency that should be reflected in designing the courses immediately; This reflection will be accentuated with the development of computerization in the country.

Equally, we must give priority to developing the ability to model using the concepts and language of the Mathematics in general and the differential and integral calculus of real functions of one variable in particular, as well as the ability to interpret models and created on the basis of the concepts of the discipline.

Therefore, the formative nature of this subject deals not only to the concepts, definitions and theorems that generally has the Mathematic, but on the contrary, that the language and tools used in this constitute essential basis in developing large part of the materials of Computer Engineering as: Discrete Mathematic, Programming, Data Bases, artificial Intelligence, architecture of Computers, among others; but, essentially, in the own development of the

professionals of the computer science engineering.

Indeed, in spite of the importance that has the Calculus I for technical sciences in general and specifically for the Computer Engineering degree, even many dissatisfactions are perceived in students and teachers of the career, related to inadequate treatment of fundamental concepts of the Calculus I and the use of mathematical assistants in problem solving by engineers in training.

Using mathematical assistants in the teaching-learning of Calculus I in the computer Engineering at the University of Pinar of the Río "Hermanos Saiz Montes de Oca" has not yet reached the prominence that they should have in the process, as a fundamental tool in solving professional problems. In addition, it was possible to verify the little use at present by Mathematics teachers in their teaching learning process of Calculus I, which shows the need to create and apply new didactic proposals that allow the rational and efficient use of the mathematicians assistants, as a way to improve the teaching-learning process of this subject in the career computer Engineering at the University of Pinar of the Río "Hermanos Saiz Montes de Oca".

Essentially, and as it is said by Iglesias and Alonso (2017), all engineer must study math so general and, particularly, the differential and integral calculus of real functions of a variable, because this is the way to form adequately analytical thinking, demonstrative rigor, sense of accuracy, numerical objectivity, attachment to measurement and many other qualities of good engineers, from the first year of their career. Of course, those who further developed the technical areas of engineering during his professional life, or engage in more advanced specializations, will be those who most

require mathematics as a tool in their professional development.

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