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Semantic Networks Approach to Teachers' Epistemological Beliefs about Differential Calculus

Acercamiento mediante redes semánticas a creencias epistemológicas sobre el cálculo diferencial

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Artículo de investigación científica y tecnológica

***Abstract*— The purpose of this paper is to carry out a study on the epistemological beliefs that professors from the Mathematics Department of the Technological University of Pereira, Colombia, expressed, concerning the teaching and learning process of differential calculus, and more specifically the mathematical object *derivative* in a course named Mathematics I. This research aims to analyze epistemological beliefs that mathematics professors at this university have in relation to the epistemological process of teaching and learning differential calculus. A multiple case study was carried out, by conducting thirty-nine interviews with the same number of teachers who have taught the subject Mathematics I. Semantic Networks were designed to represent their epistemological beliefs about their vision against the branch of mathematics called differential calculus. A constructivist conception of the teaching of differential calculus by teachers was found, emphasizing the concepts and focusing on the teaching of applied mathematics. The teachers considered that the concepts of limits and functions should precede the teaching of the derivative. Differential calculus must be learned as it will serve as the foundation of other professional training courses; some teachers considered that this branch of mathematics has applications in the working life of the future engineer.**

***Index Terms*— Constructivist Conception, Derivative, Differential Calculus, Epistemological Beliefs, Functions, Semantic Networks.**

***Resumen*— El propósito de este trabajo es el de realizar un estudio sobre creencias epistemológicas que profesores del departamento de matemáticas de la Universidad Tecnológica de Pereira Colombia manifestaron sobre el proceso de enseñanza y aprendizaje del cálculo diferencial y principalmente del objeto matemático derivada en la asignatura Matemáticas I. Esta investigación pretende analizar creencias epistemológicas que profesores de matemáticas de esta universidad poseen frente al proceso epistemológico de la enseñanza y el aprendizaje del cálculo diferencial. Se realizó un estudio de caso múltiple, mediante la ejecución de treinta y nueve entrevistas a igual número de docentes que han impartido la asignatura Matemáticas I, se diseñaron redes semánticas para representar creencias epistemológicas de los mismos, en torno a su visión frente a la rama de las matemáticas denominada cálculo diferencial. Se encontró una concepción constructivista sobre la enseñanza del cálculo diferencial por parte de los docentes, enfatizando en los conceptos y enfocando la enseñanza hacia la matemática aplicada. Los profesores consideraron que los conceptos de límites y funciones debían preceder a la enseñanza de la derivada. El cálculo diferencial debe ser aprendido en tanto que servirá como fundamento de otros cursos de formación profesional, y algunos consideraron que esta rama de las matemáticas tiene aplicaciones en la vida laboral del futuro ingeniero.**

***Palabras claves*— Cálculo Diferencial; Concepción Constructivista; Creencias Epistemológicas; Derivada; Funciones; Redes Semánticas.**

I. INTRODUCTION

THE teaching of differential calculus is notable for being a source of serious problems, both for students and educators in the appreciation of its basic ideas. The mathematical object called the derivative, is one of the fundamental concepts for the study of this vast branch of mathematics - calculus-, but frequently the treatment that is given to this subject in high school focuses on the management and application of formulas and algebraic resources, which can cause difficulties for students to understand this mathematical object [1]. This teaching practice is not different from that carried out at the university level [2] where it is reduced to a massive, decontextualized and algorithmic explanation, which turns learning into a formal process linked to a series of rules, axioms,

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postulates and theorems; these aspects constitute an end in itself far from everyday reality.

In many cases, such learning is reduced to the level of arithmetic, thanks to the use calculators, where the only important thing is to get the answers to the exercises proposed in a textbook or those proposed by the teacher. The teaching and learning of differential calculus at the university level has been a controversial topic worldwide, given the low figures of academic achievement by students and the high levels of repetition of this subject.

The origin of this school problem may point to a variety of causes, from a poor preparation of young university students in workplace [4] and its effect both on learning and on the student's beliefs in relation to mathematics.

In fact, a change in the epistemological beliefs of educators may influence their conceptions about the teaching and learning of mathematics. A position on epistemological beliefs is that of [5]- [6] who consider that these are expressions of predilection that cannot be judged.

For [2], the human dimension of this phenomenon is linked to frustration for both students and teachers, hence the relevance of analyzing the aspects that originate the poor results in their teaching and therefore in their learning.

Thus, differential calculus, as a branch of mathematics, is shown as a challenge for teachers, managers and students of the Technological University of Pereira. This multiple case study is aimed at identifying epistemological beliefs around the teaching and learning process that teachers of the Mathematics Department of this university have about differential calculus, and specifically about its fundamental object of study, the derivative. Let's see some data:

Differential calculus is the neural part of Mathematics I, internal code CB 115, which is taught in 15 academic programs offered by the Technological University of Pereira. In the last 9 semesters (from 2016-1 to 2020-1) 3963 students have enrolled in this course, out of which 1848 (46%) passed, 1384 people failed (35%), and 731 dropped out (19%), that is, 2215 students (54%) failed the course in the semester they enrolled, which makes it the subject with the highest failure rate in all the academic programs offered by the Technological University of Pereira [7] it should be noted that, according to [8], it is extremely difficult to distinguish between knowledge and epistemological beliefs.

II. Theoretical Referents

The term epistemology [9] has its origin in philosophy; however, it has been used in the study that for decades has been carried out on the beliefs that the main promoters of the teaching and learning process have on the origin and acquisition of knowledge. In this sense, [10] defines epistemology as everything that has to do with the origin, nature, limits, methods and justification of human knowledge. It also constitutes an identifiable set of dimensions of beliefs about knowledge as well as how it is known or learned, which is organized as theories that progress in predictive directions and that are activated with the context, operating between the cognitive and the metacognitive dimensions. The author places the beginnings of the study of personal epistemology in the United

their years of junior high school, a misguided choice of vocational profile, poor study habits, to the way in which teachers assume his teaching practice [3].

This paper presents some research on preferences regarding epistemological beliefs shown by professors from the Department of Mathematics of the Technological University of Pereira, compared to the process of teaching and learning differential calculus.

The main motivation for the study of teachers' beliefs is that both teaching and learning are influenced by their epistemological beliefs about use of mathematics in their

States of America and its evolution in different parts of the world during the last four decades; within this perspective, there have been several models and positions [11] , ranging from models that propose a single dimension of epistemological thought that evolves over time in their behavior to theories that propose between 4 and 7 dimensions [12], up to authors who propose a large number of different models and theories of epistemological resources [13].

In this sense, [12] assumes certain number of dimensions of epistemological beliefs that can vary, making up a system where each of those dimensions is related but not linked to the others, thus forming a relatively independent system whose development does not necessarily occur simultaneously or synchronously. In this case, the dimensions defined are as follows:

- The source of authority
- The structure and certainty of knowledge
- The speed of learning, and
- The ability to learn.

All these dimensions are seen in a continuous development that ranges from the simple vision to the more complex vision that weighs the variables that the researcher called sophisticated, which are present in those individuals who are more advanced in certain cognitive aspects. According to these ideas, the transcendence of personal epistemology and its multiple variables is recognized, since when it is constructed, individuals are actively involved in learning, persevere in difficult tasks, understand written material, and deal with unstructured topics, which are fundamental skills for both the student and the teacher [14].

Several researches account for the close relationship between the variables of the teaching and learning process and the epistemological beliefs of the individual [11],[12],[14] [15], [16] .

There are some research studies that show a relationship with knowledge variables such as thought and its direct influence on reflective judgment, manifested in the perception of books and the monitoring of this analytical process [12]. Other works report on the interpretative influence of important topics, the solution of ill-defined problems, and the transfer of learning and conceptual change [17].

An example of the influence of beliefs on learning can be seen in the work of [18], who claims that the simpler, more manageable, more certain and more dependent on authority the knowledge is, the greater the student's tendency to simplify the information. One of the elements that has decisively influenced the relevance of epistemological beliefs in the educational context has possibly been the relationships between the cognitive and learning variables.

Teachers' beliefs are studied in order to understand and interpret their actions and also to promote changes that in turn transform the teaching practices. Research on the epistemological beliefs of teachers has been developed in different settings [19], [20], [21], [22]; these beliefs have been evaluated from the paradigm of the teacher's thinking, which sees the teacher as a reflective, rational subject who makes decisions, makes judgments, has beliefs and generates routines typical of their professional development [9].

According to [9], among the aspects that influence the teachers’ beliefs are:

• The implementation of the curriculum;
• approaches to teaching
• teaching strategies;
• efforts to make curricular adaptations;
• the flexibility to consider alternative teaching approaches,

just to mention some elements of and educator’s work in which his epistemological beliefs are related.

Research studies show that the epistemological beliefs that are held about mathematics are explicitly or implicitly related to practice, and therefore to the practicing or training educator regarding the teaching and learning processes of mathematics [23], [24], [25] .

In the traditional view of learning mathematics, it is thought that the teacher is the one who possesses and imparts knowledge; therefore, the teacher is the center of the process, while the student is a passive recipient of knowledge who receives information from his teacher or books; the student, therefore, under this perspective, has the role of assimilating, mechanizing algorithms, memorizing and using concepts, generally in situations of a routine and repetitive type, where the answers are correct or incorrect. In this view, the student can learn if he is able to repeat the information provided by the teacher. Consistent with this, teaching in this paradigm is approached as a process of transmission of knowledge generally carried out by the teacher, while the student listens, mechanizes and practices. The teacher leads the students to get the correct answer, so that they can reproduce information or procedures after being presented. In this approach, an extreme form of teaching is reached, which may be described as an authoritarian model of transmission that occurs when the teacher imposes on the students the methods, they must use to solve problems, that is, he imposes restrictions [26].

III. METHODOLOGY

The epistemological beliefs that some teachers have regarding the process of teaching and learning the derivative mathematical object and, in general, the differential calculus in the course of Mathematics I, were identified from thirty-nine interviews applied to professors of the UTP, of different modalities of labor relations (tenure and temporary professors), with diverse formations in their undergraduate degrees (Engineers, Graduates or Pure Mathematicians) and with various years of working experience.

The information obtained from the interviews was synthesized in two ways:

1. Through semantic networks [27], which attempt to expose the central ideas, points of view and epistemological beliefs expressed by certain professors belonging to the Department of Mathematics of the UTP on issues related to the study of differential calculus and in particular their interpretation on the derivative object. Semantic networks are well suited to the time spent in interviews.

2. Through responses obtained through an electronic survey, designed through the technological tool called "Google Inc. Forms".

The exploration of teachers' epistemological beliefs should be carried out keeping into consideration what the teachers express, and their teaching management in the classroom, so that a more in-depth analysis could be carried out from multiple sources of information data [4], [8]. Unfortunately, for the research reported here, it was not possible to find out information concerning classroom management, since the teachers did not allow data collection in their classes.

Given that the epistemological beliefs of the teachers were organized in networks that favored the individual identification of characteristics [28], it was decided to use the semantic networks for the analysis of the epistemological beliefs expressed by eleven teachers during the process of semi-structured interviews.

In parallel, an electronic multiple-choice survey was carried out, which was applied to twenty-eight teachers assigned to the Department of Mathematics of the Technological University of Pereira, who teach or have taught the Mathematics I course.

In compliance with the literature on epistemological beliefs, a semi-structured interview was designed that addressed the following aspects:

Epistemological beliefs about the differential calculus in a real variable, hereinafter simply “the calculus,” as well as the uses attributed to it, corresponding to the Semantic Network 1.

The preferred contexts for their teaching, seen in the Semantic Network 2.

The applications of calculus to the various fields of science, corresponding to the Semantic Network 3.

The interviews were carried out as follows: seven interviews were answered in writing and four were answered live and recorded in audio with an approximate duration of twenty-five minutes each. Twenty-eight interviews were handled through an electronic survey. It is considered that the teachers interviewed are representative of the population of teachers who teach the course called Mathematics I, since they combine various professional, contractual, experiential and gender profiles.

The use of semantic networks was privileged for the analysis of the interviews carried out with teachers, since network diagrams are a form of linguistic representation of knowledge in which concepts and their interrelations are symbolized by graphics containing general information. For [27], semantic networks are representations of knowledge structures that allow explaining both the rules of use of concepts and the relationships between them. Thus, they are useful for simultaneously studying procedures and their own forms of organization. The diagrams are used to identify epistemological beliefs revealed by the professors, regarding the differential calculus that is taught in the course of Mathematics I, at this University. The diagrams presented here correspond to the synthesis of the interviews carried out with the eleven teachers who kindly agreed to participate. Unfortunately, it was not possible to fully interact with the teachers neither during the interview nor after the analysis of the interviews.

Although for reasons of space, only eighteen of the thirty-three semantic networks obtained in this research work are presented, these are representative of the set of semantic networks obtained. The diagrams illustrate the beliefs according to the three previous aspects and classified by the different semantic networks.

IV. Results and analysis

Next, some of the semantic networks corresponding to the interviews with eleven teachers of the Universidad Tecnológica de Pereira are presented and discussed. The semantic networks marked with number 1 are linked to the differential calculus and its practical use; the semantic networks marked with number 2 refer to the preferred contexts for the teaching of calculus, and the type 3 ones deal with the various interpretations associated with the application of the derivative. In the wording of the questions, it is understood that "practical use" refers to the use of the derivative in extra-mathematical problems, typical of the daily professional context, while the "application of the derivative" refers both to applications within mathematics as outside of derivative object mathematics.

Semantic Networks 1

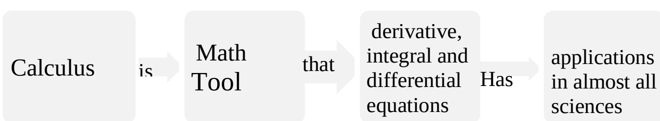

Fig. 1. Semantic Network 1, Professor 1

In Fig. 2. Teacher number 1, the calculus is made up of three elements: tools, components and uses. This idea is recognized when the teacher later states that the main use of calculus is problem solving, with which calculus is a course that students must take as long as it has a definite use, which students must learn. The position of the educator is instrumental who assumes the use of mathematical ideas to solve problems through the application of defined rules. [29]**.**

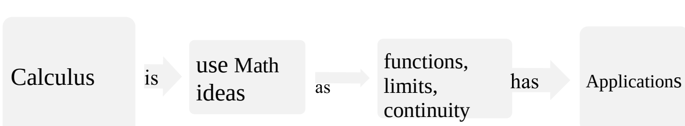

Fig. 2. Semantic Network 1, Professor 2

In Fig. 2, Teacher number two considers the differential calculus as it is used in mathematical contexts related to functions, limits and continuity, which has applications. Again, the teacher's conception is instrumental in nature but it privileges the intra-mathematical link, and presents the superiority of mathematical concepts over phenomena. For this professor, mathematical concepts are privileged over phenomena that can be explained with the concepts. Through the calculus, situations can be shown in which its use is explained. [29]

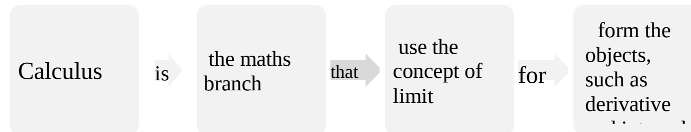

Fig. 3. Semantic Network 1, Professor 3

In Fig. 3., Teacher number 3 perceives calculus as a part of mathematics that appears from the specific idea of the limit, and that helps to build the universal ideas of objects: derivative and integral. [30]

He states that generalization is essential because this is the process that distinguishes mathematical creativity from algorithmic behavior. The teacher's position has a strong school curricular evocation, while the derivative and the integral are justified on the idea of limit. However, this sequence does not correspond to the historical development of the concepts.

In fact, [31] explains the concept of integral without resorting to the concept of limit.

Fig. 4. Semantic Network 1. Professor 4

In Fig. 4, from the perspective of the fourth professor, calculus studies two concepts: continuity and change. His perspective on calculus is curricular, as there is no link with practical phenomena related to change, which can be studied through the derivative. This professor expresses his opinions, in a global and generic way. [32] considers calculus as a mathematical study, which takes in mind two great ideas: continuity and change. Thus, starting from them, the mathematical apparatus called calculus is built. For this teacher, calculation is not linked to context problems that the future professional could address in their working life. [33] controverts how to link mathematical content with areas that may interest the student. For [34] Mathematics in context allows students to build their own mathematical knowledge by discussing and solving problems related to topics of professional interest to the student.

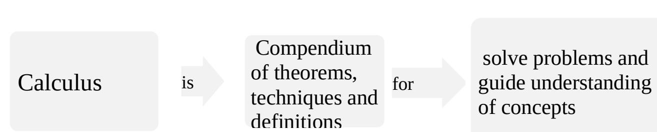

Fig. 5. Semantic Network 1 Professor 5

In Fig. 5 The fifth educator takes calculus as a compendium of ideas that allow the solution of some problems. This representation of the calculation is audacious, since it seems that the calculation is assimilated to formulas, rules or methods to understand concepts, which conditions the epistemological process [33].

Fig. 6. Semantic Network1, Professor 6

In Fig. 6 For the sixth teacher, calculus is a tool for the professional life of the future engineer. Its approach is pragmatic since it privileges its applicability in the workplace. [35] considers that Mathematics in context allows the student not only to build their own knowledge of a science with meaning and with solid foundations but also to strengthen the development of mathematical skills, through the discussion and solution of problems related to interesting topics for the student.

Semantic Network 2

Next, the semantic networks referring to the preferred contexts for teaching differential calculus are shown and discussed**.**

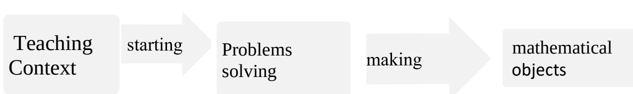

Fig. 7. Semantic Network 2. Professor 1

In Fig. 7, The teacher uses problem solving as the means to motivate the study of mathematical concepts. state that the promotion of meaningful learning depends to a large extent on a suitable selection of mathematical tasks, in order for students to put mathematical objects and meanings into play.

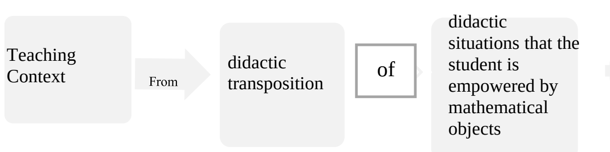

Fig. 8. Semantic Network 2. Professor 2

In Fig. 8 This teacher is based on the idea of didactic transposition [36] as a process by which knowledge is modified and communicated; this process is carried out by the teacher and then presented it to his students through what he calls *didactic situations*.

Fig. 9. Semantic Network 2. Professor 3

In Fig. 9, The third teacher considers it significant to contextualize the teaching of calculus and specifically the derivative object, from problems that he calls *real life*. For [37] Mathematics as a human activity is related to the solution of problems, as well as the ordering of a discipline.

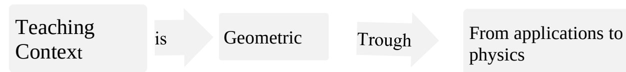

Fig. 10. Semantic Network 2 Professor 4

In Fig. 10, The fourth professor, conceives the teaching of the derivative under a context, which he distinguishes as geometric, referred to the applications in the field of Physics. For [38], contextualized teaching improves the understanding of mathematical knowledge for learners.

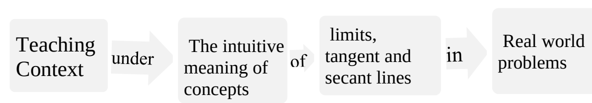

Fig.11. Semantic Network 2. Professor 5

In Fig.11, The fifth teacher indicates an experiential teaching, oriented towards an intuitive approach to the mathematical elements that support the derivative object, focusing his praxis on solving real world problems.

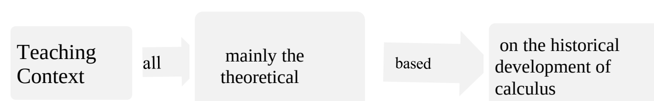

Fig. 12. Semantic Network 2 Professor 6

In Fig. 12, The sixth teacher develops teaching from a formal perspective based on theorems, properties, and proofs. He gives relevance to the historical origins of mathematical objects, favoring a more formal conception of the concepts [27].

Semantic Network 3

Next, the third semantic network is presented, which covers various discussions associated with the idea of applying differential calculus in the course of Mathematics I, at the Technological University of Pereira.

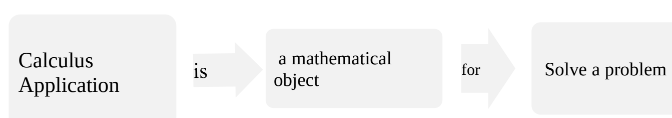

Fig. 13. Semantic Network 3 Professor 1

In Fig. 13, This teacher considers the mathematical application of the derivative to solve a problem. [38] considers that mathematics in a suitable context is justified when utilitarian ends are pursued that include the fulfillment of the economic needs of society.

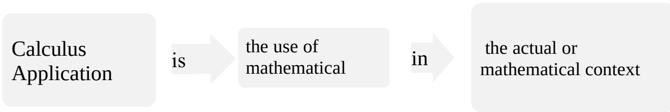

Fig. 14. Semantic Network 3. Professor 2

In Fig. 14, like his previous colleague, this teacher conceives the application as the fundamental part in the use of mathematical objects in different contexts. [38] considers that the appropriate use of mathematics in specific contexts improves students' understanding of topics important to them.

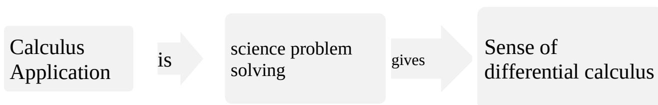

Fig. 15. Semantic Network 3. Professor 3

In Fig. 15 the third teacher perceives the application from the point of view of the problem solving of science, which incidentally makes sense of the derivative object. The professor's position coincides with the proposal of the National Council of Teachers of Mathematics of the States [39], which states problem solving is not only a goal of learning mathematics, but also one of the main ways of doing mathematics.

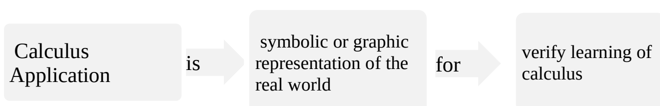

Fig. 16. Semantic Network 3. Professor 4

In Fig. 16., the fourth teacher reflects on the application as a form of representation of problematic situations of the context, which serves to verify learning on the part of the students. Problem solving turns out to be an integral part of mathematics, not an isolated piece of the syllabus. [39]

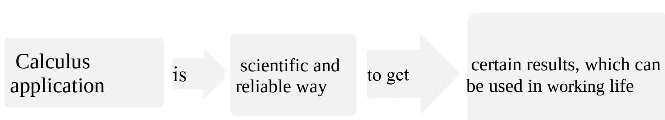

Fig.17. Semantic Network 3. Professor 5

In Fig.17, the fifth teacher considers the application of mathematical concepts as an effective method to obtain some results in a scientific way and not subject to chance, which would give solutions to possible problems in the future working life. This teacher agrees with [39] considering that by solving mathematical problems, students acquire habits of thought, persistence, curiosity, and confidence when facing new situations which will serve them outside of class.

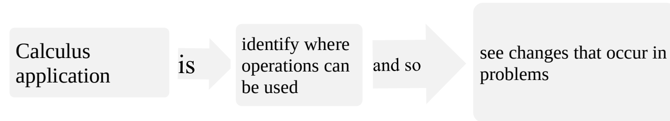

Fig. 18. Semantic Network 3. Professor 6

In Fig. 18, the teacher considers the application of calculus as the use of mathematical tools in which changes in the given problems are distinguished by being affected by the its elements. [39] suggests that students should be encouraged to reflect on their reasoning during the problem-solving process, so that they are able to apply and adapt the strategies they have developed in other problems and contexts.

Next, the most relevant data are presented, which were collected through an electronic survey carried out on twenty-eight mathematics teachers from said university, in March 2018, who kindly agreed to answer it:

65% of the teachers have more than 10 years of professional experience.

61% of the teachers who answered the survey have Engineering as their basic profession (undergraduates).

39% define the Mathematics I course as the use of Mathematical ideas such as: functions, limits, continuity and derivatives.

While another 39% associate it with a scientific tool that uses the same objects.

43% of the respondents focus their course on solving practical problems.

The idea of applying differential calculus is identified as a representation or modeling through mathematical equations and expressions by 46% of the teachers, and as a resource to solving science and engineering problems by 36% of the respondents.

For 43%, the main objective of the Mathematics I course is to teach concepts that will be useful to the student in future scenarios (academic and professional), while 21% believe that the differential calculus allows to form the logical and deductive sense of the students.

50% of teachers use examples from their professional field to motivate some concepts in the Mathematics I course, while 29% relate the concepts of the course to other mathematical concepts.

V.CONCLUSIONS

This research study is concerned about the epistemological beliefs that certain teachers of Mathematics I linked to the Department of Mathematics UTP, express about differential calculus, the preferred contexts for its teaching and its applications. These three categories were proposed *a priori* and their investigation was carried out through semantic networks.

From the semi-structured interviews and their representation, it was possible to estimate that the teachers manifest a constructivist view on the teaching of calculus, emphasizing the concepts and focusing the teaching towards applied mathematics (mainly related to physics).

It was observed that the teachers consider that the concepts of limit and function should precede the teaching of the derivative, and that this is studied insofar as it can be applied in problems that use the concept of change expressed by the derivative.

Calculus must be learned insofar as it will serve as a foundation for other professional training courses, although there are no examples of problems or situations from the context of the students that make explicit use of the mathematical concepts studied in the Mathematics I course.

No manifestation of emphasis was appreciated in the algorithms associated with the process of obtaining the derivative of a given function; however, when analyzing the manual surveys, it is inferred that the teachers have the epistemological belief that one way in which the students express knowledge about calculus is through algorithms.

All the professors interviewed and / or surveyed agree that new university students' knowledge about mathematical objects prior to differential calculus (function, variation of a function, slope, average rate of variation, speed, algebraic manipulation of equations, inequalities, basic geometry, arithmetic) is deficient, and they consider that courses prior to Mathematics I should be offered, which we believe could be one way to correct those conceptual deficiencies however, the teachers do not offer alternatives to improve student's performance. It was observed that most of the surveyed teachers present their knowledge about the derivative to the students according to their vast experience, but none of them provide relevant information about specific texts or articles for the teaching of calculus and related topics. It is observed that there is no sequence in the categories proposed in this research. A sequencing or classification of beliefs, based on years of experience, is a hypothesis that should be investigated, but this research does not have enough data to contrast it.

The training and professional qualifications of teachers seem to have a relationship with their epistemological beliefs: Graduates and mathematicians tend to emphasize mathematical formalism and intra-mathematical relationships, while engineers tend to pay attention to extra-mathematical applications or relationships. Some might think that for some teachers the weight of tradition prevents any change. In this sense, it is necessary to clarify that traditional epistemological structures and beliefs are maintained as long as they are useful for a certain society and no alternatives are envisioned. When they are no longer useful, there are people or groups who question those cultural premises. Only after a long process of feedback and resistance is it possible for a positive change to occur in the teaching of the derivative mathematical object, which results in a decrease in the failure rate of this subject.

The teacher's beliefs have about mathematics are directly related to how they teach mathematics and what mathematics to teach. For example, teachers who believe mathematics is a random collection of facts and procedures are more likely to emphasize memorizing facts and practicing procedures. In contrast, teachers who see mathematics as a connected set of concepts that can be used to solve problems are more likely to give students opportunities to make connections. [40].

With the arrival of the global pandemic (2020), the way of teaching and learning mathematics has changed dramatically at all levels - school and university - and although these changes may or may not influence the epistemological beliefs that each teacher has regarding this process, it is a fact that institutions and teachers must get prepared for the present new scenario, from all the perspectives that make part of the educational process.

Teachers are facing an unprecedented emergency of remote teaching all around the world. Experts believe that such changes are here to stay and that teachers will require a tremendous amount of training and adaptation. [41].

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Appendix A. Original version in Spanish

Objetivo: la siguiente entrevista dirigida a Docentes del Departamento de Matemáticas de la U.T.P. tiene los siguientes objetivos: Investigar las creencias que los profesores tienen sobre el objeto matemático derivada. Se indaga sobre:

- Configuraciones Epistémicas (C.E),
- Los diferentes contextos en los que se enmarca su enseñanza,
- Aplicaciones más usadas
- Sistema de Evaluación de estudiantes.

Preguntas referentes a Configuraciones Epistémicas.

Nota: En este trabajo se entiende por: Configuraciones Epistémicas. (C.E) “A los significados matemáticos que se asocian a los objetos matemáticos que intervienen en la solución de tareas matemáticas”.
1. En sus palabras ¿Qué es el cálculo?
2. ¿Para qué sirve el cálculo?
3. ¿Cómo le agrada enfocar sus clases de cálculo?
4. ¿Cuáles son las dificultades más notorias que encuentra en el proceso de enseñanza del cálculo?
5. ¿Cuáles son las dificultades que usted observa en el aprendizaje del cálculo?
6. ¿Qué ha cambiado en su enseñanza a lo largo de los años?
7. ¿Le gusta usar la tecnología (apps) para la enseñanza del cálculo? ¿Si---- no------ por qué? (GeoGebra ®, Wolfram Alpha ®, Derive®, Symbolab ® etc.).

Preguntas referentes a Contextos.

8. Profesor, sí vemos la idea de contexto como el conjunto de situaciones o problemas que dan significado a los conceptos matemáticos.
8.1 ¿bajo cuáles contextos le agrada más enseñar la teoría del cálculo diferencial?
8.2 ¿Cuáles contextos se deberían exponer en la enseñanza del cálculo diferencial y que hoy en día no se usan, en el curso de matemáticas I?
8.3 ¿Qué impresiones le ha dejado, el usar tal o cual contexto en sus clases?
8.4 ¿Cuál o cuales considera (de acuerdo a su experiencia), que debería (n) ser el o los contextos más acertados en los que se podría enmarcar la enseñanza del cálculo diferencial?
8.5 ¿Cuál contexto considera que no está acorde con las tendencias actuales de la formación educativa, y las necesidades para preparar profesionales del siglo XXI?
8.6 ¿Le haría alguna modificación al plan de estudios del curso de Matemáticas I?

Preguntas referentes a aplicaciones.

9. Aplicaciones.
9.1 ¿Para usted qué es una aplicación matemática?
9.2 ¿Para qué proponer aplicaciones de la derivada?
9.3 ¿Cuáles son las aplicaciones más importantes del objeto derivada?
9.4 ¿Cuáles no pueden faltar en el curso de matemáticas I?
9.5 ¿Cuáles cree usted que hacen falta en el curso?

Preguntas referentes al sistema de evaluación de estudiantes.
10 ¿Le parece adecuada la ponderación que la UTP, les da a las notas referentes del tema: derivada? ¿La cambiaría? ¿De qué forma?
10.2 ¿Qué opina del formato usado por la UTP, para el diseño de los exámenes?
10.2 ¿Qué modificaciones le haría y por qué?

11. **Sugerencias y varios**
11.1¿Qué sugiere usted que se dé en el curso de matemáticas I, para que la mortalidad o deserción en la asignatura disminuya?

Appendix B. English translation

Objective: the following interview directed to Teachers of the Department of Mathematics of the U.T.P. has the following objectives: Investigate the beliefs that teachers have about the derived mathematical object. It inquiries about:
• Epistemic Configurations (C.E),
• The different contexts in which their teaching is framed,
• Most used applications
• Student Assessment System.

Questions regarding Epistemic Configurations.

Note: In this work it is understood by: Epistemic Configurations. (C.E) "To the mathematical meanings associated with mathematical objects involved in solving mathematical tasks."
1. In your words, what is calculation?
2. What is the calculation for?
3. How do you like to approach your calculus classes?
4. What are the most obvious difficulties you encounter in the process of teaching calculus?
5. What are the difficulties that you observe in learning the calculation?
6. What has changed in your teaching over the years?
7. Do you like to use technology (apps) to teach calculus? Why? (GeoGebra ®, Wolfram Alpha ®, Derive®, Symbolab ® etc.).

Questions regarding Contexts.

8. Professor, we do see the idea of context as the set of situations or problems that give meaning to mathematical concepts.
8.1 under which contexts do you most like to teach differential calculus theory?
8.2 What contexts should be exposed in the teaching of differential calculus and which are not used today, in the course of mathematics I?
8.3 What impressions have you had from using this or that context in your classes?
8.4 Which or which ones do you consider (according to your experience), which should be the most successful context (s) in which the teaching of differential calculus could be framed?
8.5 What context do you consider is not in accordance with current trends in educational training, and the needs to prepare professionals for the 21st century?
8.6 Would you make any modifications to the curriculum for the Mathematics I course?

Questions regarding applications.

9. Applications.
9.1 What is a mathematical application for you?
9.2 Why propose applications of the derivative?
9.3 What are the most important applications of the derived object?
9.4 Which ones cannot be missed in the mathematics course I?
9.5 Which ones do you think are missing in the course?

Questions regarding the student evaluation system.
10 Do you think the weighting that the UTP gives to the notes referring to the topic is adequate: derived? Would you change it? How?
10.2 What do you think of the format used by the UTP for the design of the exams?
10.2 What modifications would you make and why?

11. Suggestions and miscellaneous
11.1 What do you suggest to be given in the course of mathematics I, so that mortality or dropouts in the subject decrease?