ISSN : 2350-0743

www.ijramr.com

International Journal of Recent Advances in Multidisciplinary Research
Vol. 08, Issue 12, pp. 7309-7314, December, 2021

RESEARCH ARTICLE

METHODOLOGICAL ALTERNATIVE FOR THE TEACHING-LEARNING PROCESS OF INDEFINITE INTEGRALS WITH THE USE OF MAPLE MATHEMATICAL ASSISTANT IN THE 1STYEAR OF MATHEMATICS TEACHING COURSE AT ISCED-CABINDA

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ARTICLE INFO

Article History:
Received 10th September, 2021
Received in revised form
18th October, 2021
Accepted 14th November, 2021
Published online 30th December, 2021

Key words:
Maple Mathematical Assistant,
Indefinite Integrals and
Teaching-learning Process.

ABSTRACT

This article was developed with the purpose of presenting a methodological alternative for the teaching-learning process of indefinite integrals using Maple mathematical assistant at the 1st year of Mathematics Teaching course at ISCED-Cabinda, in order to minimize the difficulties found at this level such as students' lack of motivation in relation to the mathematical content taught in the traditional classroom, the failure to achieve satisfactory results intended in the teaching of indefinite integrals, incomprehension of the concept of indefinite integrals, the lack of mention about the application and the relationship between the indefinite integrals and the daily problems of society, limited contents in the 12th grade Mathematics manual and insufficient solved and proposed exercises regarding the indefinite integrals, lack of adequate didactic and bibliographic material for the teaching-learning of these contents, lack mastery of integration rules and techniques in learning, the non-use of information and communication technologies. In this regard, a questionnaire was applied and 5 teachers and 145 students were interviewed, whose collected data were processed by the SPSS statistical software, which allowed the elaboration of a methodological alternative, in order to favor the teaching-learning process and guiding teachers in reducing these difficulties. The alternative was validated through its implementation, with various activities that students were able to carry out in the classroom, and by some teachers, masters and doctors in Mathematics, who favorably approved it as distinct.

INTRODUCTION

Santos et al (2007, p.14) state that Mathematics is a set of logically organized data, and rigorously verified by the efficiency of its structure, with trivial concepts, algorithms that confirm the properties of numbers until its logic that allows arrive at a "mechanical" process. Only after developing their conceptual framework do the algorithms make sense. Quoting FÉTZER AND BRANDALISE (2019, p. 313), learning and teaching Mathematics are inseparable processes and must be constitutive of the knowledge associated with the practice of the Mathematics teacher. New ways of teaching and learning mathematical concepts must be in the current social context, one of the teachers' concerns. In Angola, the teaching and learning of Mathematics at the Higher Institute of Educational Sciences (ISCED) in Cabinda has been the focus of attention by teachers and students who list the most varied aspects found in this process as main causes that need a reflection, not only on their part but also on the part of the competent bodies.

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Mathematical Analysis I is one of the mathematics subjects that constitutes the nucleus of the 1st year in the Mathematics Teaching course. Within this subject, the indefinite integrals stand out, which, in addition to occupying an important place within the curriculum, also significantly influence its teaching-learning. This research aims to examine the effectiveness of using Maple mathematical assistant in the teaching learning process of Indefinite Integrals to minimize the difficulties found at the 1st year of Mathematics Teaching course at ISCED-Cabinda. In general terms, the following difficulties are highlighted: students' lack of motivation in relation to the mathematical content taught in traditional classroom; failure to achieve the intended satisfactory results in teaching indefinite integrals; misunderstanding of the concept of indefinite integral; some teachers do not mention the application and the relationship between the indefinite integrals and the daily problems of society; very limited contents in the 12th grade Mathematics manual and insufficient solved and proposed exercises regarding indefinite integrals; lack of adequate didactic and bibliographic material for the teaching-learning of these integrals, lack of mastery of the rules and techniques of integration in their learning; non-use of Information and Communication Technologies in the teaching of Indefinite Integrals, among others.

Questionnaires and interviews applied to bothteachers and students during the research, and from the diagnostic test administered to these students of Mathematics Teaching course at ISCED- Cabinda, referring to the calculation of indefinite integrals involving the integration methods that are one of the key contents of Mathematical Analysis I, we can say that the percentage of unfit is higher than 70%. To overcome students'difficulties through new methodologies, we propose the following scientific question:

How to favor the teaching-learning process of indefinite integrals using the Maple Mathematical Assistant in the 1st year of Mathematics Teaching at ISCED-Cabinda?

The teaching-learning process of indefinite integrals: The teaching-learning process is a system where teaching and learning, as subsystems, are based on a developmental education, which implies intentional communication and activity, whose didactic action generates learning strategies for the development of an integral personality and student self-determination, within the framework of school as a social institution that transmits culture (ADDINE, 2013, p. 41). Given the importance that this bilateral process represents for school success and for improving the quality of teaching, it requires increased attention to some contents considered as key, such as the indefinite integrals that constitute the focus of this same research and the basis for understanding several subjects in the higher education (Analysis Mathematics I, II and III, Complex Analysis, Numerical Analysis, Differential Geometry, Ordinary Differential Equations, Differential Equations in Partial Derivatives, among others. This content begins to be studied in high school in 12th or 13th grade on the topic Differential and Integral Calculus according to Mathematics program of each educational institution. It is considered complex by some Mathematics teachers and most students. For their study they begin with a function primitive, primitives rules, indefinite integral, its properties, geometric interpretation of its concept, table of immediate integrals, definition of the definite integral and its properties, fundamental theorem of integral calculus, Barrow formula or Newton-Leibniz, areas of plane figures, area under the curve and applications of definite integrals. In addition, it is also included in the programs of Higher Education Institutions, namely Higher Institutes of Educational Sciences, Higher Pedagogical Schools, Higher Polytechnic Schools, Faculties of Science and Engineering of Public and Private Universities.
Regarding his concept, Stewart (2006, p.403) states that an indefinite integral represents a whole family of functions (an anti-derivative for each value of the constant c). An indefinite integral $\int f(x)dx$ is a function (or family of functions). Integration methods are analytical procedures used to find anti-derivatives of real functions of real variable. The methods used at this level of education are: substitution method, integration by parts, integration of trigonometric functions, integration of functions that contain a square trinomial, integration of rational functions by partial fractions, integration of irrational functions and integration technique of differential binomials. The substitution method consists of changing a new variable in the initial integral and deriving both variables from the substituted expression to later substitute again in the original integral, so as to obtain a new integral with a single variable. Batista et al (2012, p. 50) state that the variable change technique is a powerful tool to calculate indefinite integrals, which allows replacing a relatively complicated integral with a simpler one.

Integration by parts expresses the integral of a product of functions of different types (logarithmic, inverse, polynomial, trigonometric, exponential) in another integral, one of which is easy to integrate and the other is easy to derive. This method aims to choose u which we consider primitive function and dv as differential in order to obtain a new integral, that from the new variables to obtain $du$and v in such a way that u facilitates the derivation and $dv$is easier to integrate to find v. From this method, the following formula is deduced, known as part-integration formula for indefinite integrals.

$$\int udv = uv - \int vdu$$

The method or technique of integration of trigonometric functions is basically used as a product of trigonometric powers. For its use it is necessary that students have a deep mastery of trigonometric identities, and some mathematical formulas. Some authors, such as Stewart (2006, p. 80), César and Panchana (2017, p. 186), in their works, present strategies for the integration of these functions. Stewart (2006, p. 478) uses trigonometric identities to integrate certain combinations of trigonometric functions, starting with the powers of sine and cosine, and presents strategies when evaluating integrals of the form $\int sen^m x cos^n dx$, where $m \geq 0$ and $n \geq 0$ are integers. The technique of integrating functions that contain a second-degree trinomial $ax^2 + bx + c$consists of reducing it to the form:

$ax^2 + bx + c = \frac{1}{a}\left[\left(x + \frac{b}{2a}\right)^2 \pm k^2\right]$, onde $a, b, c \in \mathbb{R}$ e $a \neq 0$.

The technique of integrating rational functions by partial fractions consists of writing the rational function as a sum of simple fractions.

f$f(x) = \frac{p(x)}{q(x)}$ where $q(x) \neq 0$, $p(x)$, and $q(x)$are polynomials. If the degree of $p(x)$is less than the degree of $q(x)$, then $f(x)$will be a proper rational function, otherwise $f(x)$ will be called an improper function. The technique of integrating irrational functions consists in reducing these functions by means of the corresponding variables, the integrals of rational functions. Below are three cases that illustrate how to integrate these functions.

1st Case: Integrals of the type

$\int R\left(x, x^{\frac{m}{n}}, \ldots x^{\frac{r}{s}}\right)dx$, where R is a rational function of its arguments and k is the common denominator of $\frac{m}{n}, \ldots, \frac{r}{s}$
Putting $x = t^k$and deriving we have: $dx = kt^{k-1}dt$ Each fractional power of $x$can be expressed through a power of t and consequently becomes a rational function of the variable t .

2nd Case: Integrals of the type

$$\int R\left[x, \left(\frac{ax+b}{cx+d}\right)^{\frac{p_1}{q_1}}, \left(\frac{ax+b}{cx+d}\right)^{\frac{p_2}{q_2}}, \ldots\right]dx$$

Where R is a rational function and p_1, q_1, p_2, q_2...are integers. Integrals of this type are reduced to a rational function by substituting $\left(\frac{ax+b}{cx+d}\right) = z^n$ Where n is the common denominator of the fractions $\frac{p_1}{q_1}, \ldots\ldots \frac{p_2}{q_2}$ where q_1e $q_2 \neq 0$ and q_1 and $q_2 \neq 0$

3rd Case: Integrals of type $\int R\left(x, \sqrt{ax^2+bx+c}\right)dx$

The integrals of the differential binomials are of the type $\int x^m(a+bx^n)^p dx$

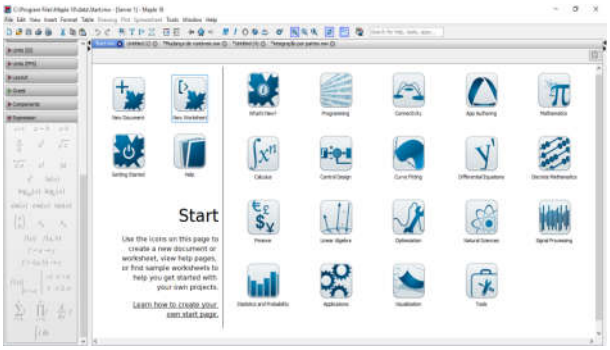
Where $m,\ n$ and p are rational numbers.

The integral $\int x^m(a+bx^n)^p dx$ can be reduced to the integral of a rational function if $m,\ a,\ p$ are rational numbers, and therefore it can be expressed by means of elementary functions. Due to the complexity of these methods, many students have had difficulties in identifying the rule or method to use in solving exercises and problems that involve indefinite integrals in order to develop basic thinking skills: creativity, strategy and visual skills, and for the development of logical-mathematical reasoning. These abilities make students stimulate new learning strategies by mastering the content provided to them. The content is a set of knowledge, skills, habits, evaluative ways of social action, pedagogically and didactically organized by the teacher, with a view to the active assimilation and application by students in their life practice. (LIBÂNEO, 1992, p. 27). In addition to the aforementioned aspects, students are discouraged in relation to the mathematical content taught in the traditional classroom; failure to achieve the intended satisfactory results in their learning; misunderstanding of the concept of indefinite integral; the teachers do not mention the application and the relationship between these integrals and the daily problems of society; limitation of this content in some Mathematics manuals, insufficient solved and proposed exercises; lack of didactic material and adequate bibliography for teaching and learning.

Integrals are used in approximate solutions of equations, in methods such as Newton's, fixed-point interaction and linear approximation, in the determination of velocity, acceleration, in the subfields of electricity and magnetism, to find the total flux of electromagnetic fields, in Maxwell's electromagnetism theoryand Einstein's theory of general relativity, determining the variation in the rate of reactions, radioactive decay, determining the angle in the branching of blood vessels to maximize circulation, determining the maximum size of molecules that are capable of crossing the plasma membrane in a given normal or induced situation in cells, study of function graphs, determination of the maximum bending moment of a beam at any point, the maximum profit providing a formula to easily calculate both marginal cost and marginal income.

The use of Maple Mathematical Assistant in the teaching-learning process of indefinite integrals: Today's society is increasingly involved in technological tools in the most diverse sectors such as: Industrial, Health, Education, Agriculture, among others. People are concerned with updating what is happening in the world in general and in the country in particular. This reality is no different from those who enter Higher Education, as the consistency of the facts shows that students follow technological evolution and in their day-to-day make frequent use of available computer resources. The introduction of technological tools in classrooms is an essential factor to motivate students to learn certain contents and solve various mathematical problems. Today, the impact of calculators, computers and other technological elements are useful resources that can carry out the proposed tasks more quickly and efficiently, that is, they can be a valuable instrument for self-assessment, verification of results, and correction of errors. In addition, students save time in performing calculations (SANTOS et al 2007, p. 13). In this perspective, in order to facilitate and streamline the teaching-learning process of some contents considered difficult by the 1st year students of Mathematics Teaching course at ISCED-Cabinda such as indefinite integrals, the Mathematical Assistant Maple was implemented in order to provide agreater interaction environment of classes, enabling numerical experimentation, dynamism and more comprehensive visualization of these contents both to teachers and students. According to Rodriguez (2010), dynamism is the arbitrary transformation of a geometric figure, determined by the possibility of obtaining multiple representations of objects, through the continuous transmission of states and processes to which it is submitted. Visualization allows the achievement of goals as important as the motivation of students in learning mathematical content. Maple Mathematical Assistant is a general-purpose Algebraic Computing program that has been developed since 1981 at the University of Waterloo, Canada, and the ETH Institute, Zurich, Switzerland, consisting of an algebraic, numerical and graphical computing system, intended for professional use in solving problems that require mathematical methods.

Sangoi and Isaia (2011, p. 103) highlight the importance of their use as basic tools in the Engineering disciplines, Mathematics and Computer Science, as it helps in understanding the contents alluded to these courses, achieving a learningquality termed as significant. This Mathematical Assistant allows you to solve problems in several areas, namely: Mathematics in contents such as differential and integral calculus, differential equations, Complex analysis, algebraic equation systems, among others, it has tools that visualize results of the elaborated data used in the calculation of indefinite integrals, in such a way to avoid wasting time with algebraic manipulations. For the calculation of these integrals, it is necessary to enter the data through the worksheet, and graphs can be drawn up in two and three dimensions; in addition to containing a fast and easy-to-use programming language. Thus, in the worksheet view you can see the Maple tools as shown in the figure below:



Source: Generated Maple AM

Figure 1. Maple Math Assistant worksheet

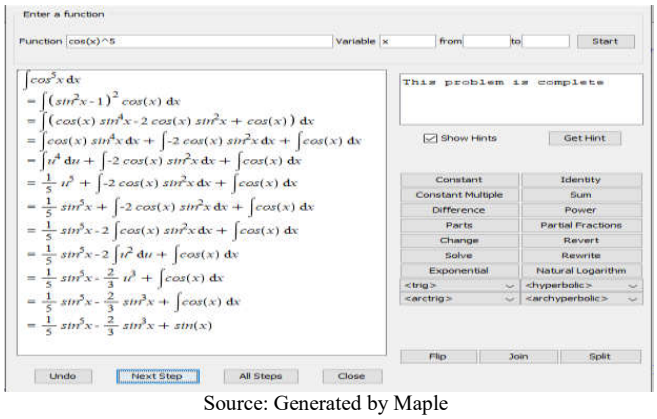
The tools above indicate that Maple facilitates, in a practical and simple way, the understanding of the concepts of the subjects previously mentioned, and making use of the large amount of functions available for the most diverse purposes in the Mathematics area, in addition to functioning as a programming language. It enables the student in these areas and in the graphical representation of various functions (polynomial, exponential, logarithmic, rational, irrational, trigonometric and modular) mastering syntaxes for the use of integration techniques; beyond the understanding of concepts such as function, limit, derivative, definite integrals, indefinite integrals, among others, developing various mathematical skills (calculate, represent, identify, observe, interpret, analyze, synthesize, among others).

As an example we have: Calculate the following indefinite integral by the method of integration of trigonometric functions:

$$\int cos^5 x dx$$

To calculate this integral by the method of integration of trigonometric functions, the following steps are followed:

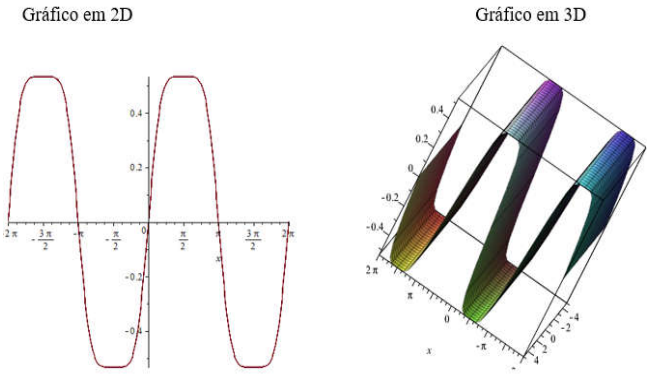
- Open the Maple 18 program and when viewing the home page click on Neworksheet to get a new spreadsheet;
- Click on the toolbar on the tools option, then click on tutors, on calculus single variable and on Integration methods;
- Wait until the calculation window opens where you must insert the function you want to calculate in the function section;
- Then Click on start, then on next step and so on until you get the desired result and finally click on close to finish and thus show the solved exercise in the worksheet page.
- To obtain the graph, just insert the function in the worksheet sheet, then click on the function with the right button of your mouse, choose the option plot then in 3D for the graph in 3 dimensions.



Source: Generated by Maple

Graphic 1. Graphical representation of the Trigonometric Function Integration technique

However, this Mathematical Assistant exerts great influence on the intellectual development of students at any level of education, providing a different view and knowledge related to the learning method, greater understanding of indefinite integrals without having to waste time with exhaustive algebraic manipulations. Hence the need for its implementation in the teaching-learning process of these integrals in the 1st year of Mathematics Teaching at the Higher Institute of Education Sciences (ISCED) in Cabinda.



Source: Generated by Maple

Graphic 1. Graphical representation of the Trigonometric Function Integration technique

Methodological alternative: The alternative is one possibility among others that face didactic and pedagogical issues in the teaching-learning of Mathematics considered as insufficient or problematic. The scheme in figure 1 illustrates, in a global way, the proposal of the methodological alternative elaborated for the realization of this research.

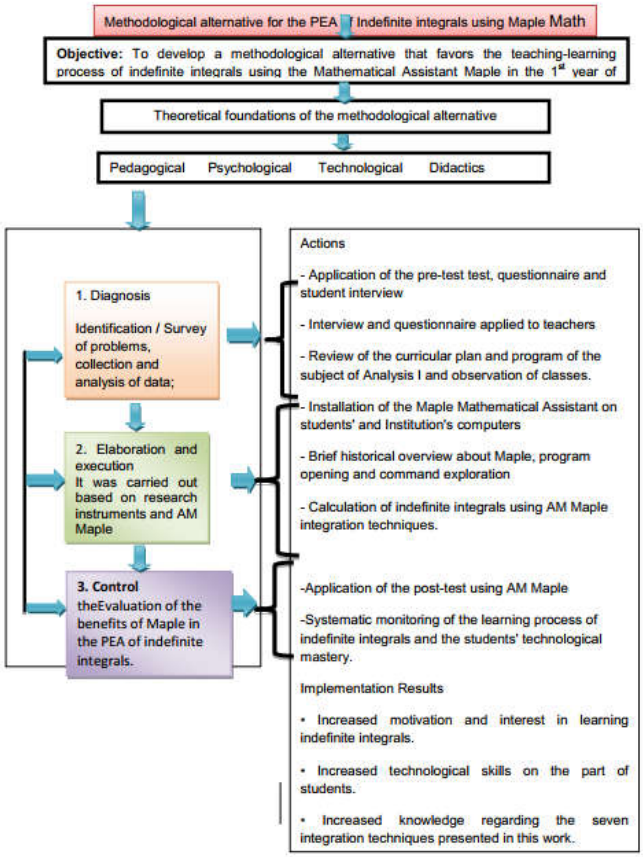


Figura 1. Diagram of methodological alternative for the teaching-learning process of indefinite integrals

Diagnosis phase: consisted of exploring the environment in order to raise and define the problems related to the teaching-learning process of indefinite integrals. To make this diagnosis, it was necessary to define criteria and work instruments. For this it was necessary to carry out the research in a clear way, thus highlighting the logic and coherence between the obtained statistical data.

Elaboration and execution phase: there was the practical application of teaching-learning of indefinite integrals through the use of the Maple Mathematical Assistant, where there was a need to contextualize the students through a class on the historical aspects, commands and importance of Maple , where activities were carried out with different exercises and graphs related to indefinite integrals, applying the integration methods, with a post-test later being carried out to assess the degree of accessibility of knowledge by the students.

Control phase: consisted of evaluating the relevance of implementing the mathematical assistant in practice, thus investigating the extent to which students have skills and mastery of it in order to facilitate the resolution of indefinite integrals.

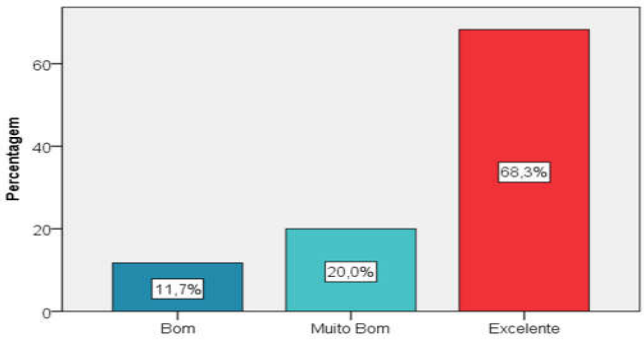
METHODOLOGICAL RESULTS

Population, Sample and Data Processing: As a result of this research, from the information collected, the sample is of 5 teachers and 145 students, 69 from the regular period and 45 from the post-work period, aged between 18 and over 30 years. A questionnaire and interview were applied to these teachers and students. The questionnaires were elaborated according to seven dimensions (socio-demographic data, use of Information and Communication Technologies in teaching-learning of indefinite integrals, motivation for teaching-learning of indefinite integrals, teaching-learning difficulties of indefinite integrals, evaluation system , academic performance of students in indefinite integrals and measures of improvement of teachers and students) with their respective indicators and using the Likert scale. The researchers have processed these data later in the SPSS statistical software.

Results of the implementation of methodological alternative: The results obtained in this research based on the implementation of the methodological alternative in the 1st year of Mathematics teaching at ISCED-Cabinda, had rise to positive results, namely increased motivation and interest in learning the indefinite integrals of technological skills on the part of the students, of knowledge regarding the seven integration techniques presented in the work, elaboration of an exercise system and problems solved with the Mathematical Assistant Maple that contributes to the enrichment of the students' knowledge in visualization, dynamism and numerical experimentation, the that favors the learning environment, easy resolution of exercises considered difficult to understand, establishment of teacher/student/group communication for the exchange of questions/answers and other materials, using MAPLE Mathematical Assistants, electronic mail, chat, social networks and internet t. Taking into account the reliability of the above-mentioned statistical data, through the use of Cronbach's alpha coefficient, the degree of reliability of the same results obtained in applying the questionnaire to students was evaluated; it is worth mentioning that the Cronbach's alpha value of 0.883 for decent and 0.768 for students demonstrates that the instrument used for data collection is valid and also the existence of an internal consistency of these data.

RESULTS

Graph 2 shows that the results achieved by the students were based on three indicators where 11.7% had a good result, 20% very good and 68.3% had an excellent result, which demonstrates that the use of Maple in the process teaching-learning of indefinite integrals, will provide satisfactory results.



Source: Generated by SPSS Software

Graph 2. Result of the Post - test applied to 1st year students of ISCED-Cabinda

Validation of the methodological alternative by the specialists: For the validation of the methodological alternative, five professors from ISCED-Cabinda and one professor from the Faculty of Economics of 11thNovember University, with an academic Master's degree and a Doctor's scientific degreewho teach the subjects of Mathematical Analysis I and II were selected in order to respond a questionnaire and be interviewed. These professors have enough skills and experience about the use of Information and Communication Technologies; where 40% claimed to have more than 20 years working in Higher Education Institutions. This validation was based on a script of questions formulated in a questionnaire with the following indicators (design and implementation of the methodological alternative, phases of the methodological alternative, methodology used for the integration of the Maple Mathematical Assistant, relevance of the methodological alternative in ISCED-Cabinda, feasibility of applying the methodological alternative at ISCED-Cabinda) based on the scale below:

B- Bad, S-Sufficient, G- Good, VG-Very Good and E-Excellent.

Taking into account the above indicators, the result obtained in the validation of the implementation of the methodological alternative by the experts was excellent.

DISCUSSION

The implementation of the MAPLE Mathematical Assistant, in the 1st year of Mathematics Teaching at ISCED-Cabinda, had satisfactory results, which can be supported by the ideas of Souza and Mesquita (2011, p.1) who state that when we use new methodologies in classes of Mathematics, we realized that the teaching-learning process becomes more pleasurable for the student, as he/she can understand what is being proposed in the classroom. Thus, software, in the case of Maple, exerts a great influence on the students' intellectual development. It was found that the inclusion of the Maple Mathematical Assistant in the teaching-learning of indefinite integrals contributed to the reduction of students' difficulties and increased their motivation and interest in their learning. The students were able in less time to calculate all the integrals that were proposed to them with different integration methods, having developed their mental faculties and various mathematical skills, such as: calculate, interpret, observe, analyze, distinguish, define, select, explain, control , modeling, solving, among others. As stated by Santos et al (2007, p. 13), the impact of calculators, computers and other technological elements are, today, useful resources that can carry out the proposed tasks more quickly and efficiently, this can be a

valuable instrument for self-assessment, verification of results, correction of errors. In addition, students save time in performing calculations. Thus, society expects teachers to have other skills that enable the autonomous children training, capable of reading different forms of representation and developing ideas for new problems, in addition to activities carried out in the classroom. Thus, it is evident that the Maple Mathematical Assistant provides students with greater interaction in the process of learning indefinite integrals. It allows them to better understand the mathematical concepts, namely the solving of exercises, in which the integration techniques are applied.

CONCLUSION

The results obtained with the proposal of the methodological alternative for the implementation of the Maple Assistant allowed us to conclude the following: 1) Historically, indefinite integrals and their learning process are content considered complex, and that requires teachers who use strategies, appropriate techniques and methodologies in their teaching; 2) The diagnosis performed shows that, taking into account the current state of the teaching-learning process of indefinite integrals, there are many difficulties for students, such as understanding the concept of the indefinite integral, its geometric interpretation, use of integration techniques, and assistants Mathematicians, among others; 3) Regarding the questionnaires and interviews applied, teachers and students registered their concerns, perceptions and suggestions regarding the indefinite integrals. The data obtained confirm the need for these contents to remain in the curriculum in the Mathematics Teaching course, and revealed that teachers and students are engaged in contributing to improving their teaching and learning; 4) The methodological alternative elaborated is pertinent and guarantees the implementation of the Maple Mathematical Assistant in the teaching-learning process of the indefinite integrals in ISCED-Cabinda. It has a set of practical activities, where numerical experimentation, interactivity and visualization stimulate students to understand, graphically represent and use integration techniques in the calculation of indefinite integrals; 5) Furthermore, we observe that the implementation of Maple in the Mathematics teaching course is a motivational factor and significantly contributes to learning, serving as a facilitator in the construction of knowledge of various contents, making classes more dynamic by providing students with an interaction of contents in which one can build their own concepts.

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