



ISSN : 2350-0743

www.ijramr.com



International Journal of Recent Advances in Multidisciplinary Research

Vol. 08, Issue 11, pp. 7278-7284, November, 2021

## RESEARCH ARTICLE

### IMPLEMENTATION OF COMPUTER TOOLS IN THE TEACHING OF TRIGONOMETRY IN THE 11<sup>th</sup> GRADE AT LICEU-CABINDA

<sup>1</sup>António Wete da Fonseca and <sup>\*</sup>Marcos João Púcuta<sup>2</sup>

<sup>1</sup>Master in Mathematics Teaching at the Higher Institute of Education Sciences of Cabinda

<sup>2</sup>PhD in Mathematics and Assistant Professor at Mathematics Teaching Department at the Higher Institute of Education Sciences of Cabinda

#### ARTICLE INFO

##### Article History:

Received 20<sup>th</sup> August, 2021

Received in revised form

17<sup>th</sup> September, 2021

Accepted 24<sup>th</sup> October, 2021

Published online 30<sup>th</sup> November, 2021

##### Key words:

Trigonometry Teaching and Geo Gebra  
Mathematical Assistant.

#### ABSTRACT

This article presents the results obtained in the implementation of computer tools in the teaching of trigonometry in 11<sup>th</sup> grade at Liceu in Cabinda. Trigonometry is a branch of mathematics used to calculate the Earth's diameter, river widths, distances to make maps, pyramid measurements, algebraic calculations, among others. In their teaching, students have several difficulties such as: graphical representation of trigonometric functions, solving their equations and inequations, determining the domains of these functions, elaborating the concepts of sine, cosine, tangent, cotangent, secant and cosecant from the right triangle, among others. These difficulties were found by applying questionnaires and interviewing teachers and pre-testing 155 11<sup>th</sup> grade students. Based on this, a didactic alternative was developed in four stages (planning, elaboration, execution and control) using the GeoGebra Mathematical Assistant to favor the teaching-learning process of this content. The evaluation of this Alternative by experts in Mathematics gave rise to satisfactory results that guarantee its validity. These results are the result of the set of activities carried out by students in GeoGebra where more than 70% obtained positive results in the three courses administered at that school.

#### INTRODUCTION

Trigonometry is a branch of Mathematics that contributes to the development of various areas of human knowledge (Architecture, Physics, Topography, Engineering, Electricity, and Medicine) and provides new opportunities to help develop intellectual skills of professionals in construction, education, students among others. In their teaching, teachers play an important role in driving student learning. With the emergence of new technological resources, teachers must opt for active and adequate methodologies as an auxiliary resource in the teaching of trigonometry so that their learning is efficient. For this, it is necessary to constantly update your knowledge. Sousa (2018, p. 9) states that the implementation of new changes in the teaching-learning process helps to develop new pedagogical practices of teaching and learning trigonometric contents with the use of new technologies in order to facilitate students' learning, making the richest and most efficient teaching-learning process. The use of didactic and technological resources allows the construction of a meaningful learning that helps the students' learning. According to Lima's point of view (2013, p.9) the teaching of

trigonometry at the Medium level is taught in classrooms, through the use of a series of formulas, which cause disinterest in students, as they do not understand its importance, its use and its purpose, causing them to become discouraged, making their understanding and learning difficult. In Angola, this theme is included in Secondary School Mathematics Education programs in the 8<sup>th</sup>, 9<sup>th</sup>, 10<sup>th</sup>, 11<sup>th</sup> and 12<sup>th</sup> grade, according to the program of each educational institution. The exploratory study carried out with Mathematics teachers and 11<sup>th</sup> grade students in the Physical and Biological Sciences, Human Sciences and Economic and Legal Sciences courses in Cabinda High School, it can be found several difficulties concerning the conversion of degree, degree and radian, trigonometric relations in a right triangle, concepts of sine, cosine, tangent, cotangent, secant and cosecant of an angle, trigonometric ratios, notable angles, law of sines and cosines, trigonometric identities, which establish relations of equality between the trigonometric functions, equations and trigonometric inequations, reduction to the 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> quadrant, conversion of angle measurement systems, arc addition and subtraction formula, trigonometric functions and their graphical representations, among others. These and other difficulties found in the students and teachers of this Educational Institution allowed us to formulate the following Scientific Problem:

**\*Corresponding author: Marcos João Púcuta,**

PhD in Mathematics and Assistant Professor at Mathematics Teaching Department at the Higher Institute of Education Sciences of Cabinda.

How to favor the teaching-learning process of trigonometry in 11<sup>th</sup> grade at Liceu-Cabinda?

The present research aims to propose a didactic alternative that favors the teaching-learning process of trigonometry with the use of GeoGebra Computer Assistant in the 11<sup>th</sup> grade at Liceu-Cabinda.

**The teaching of trigonometry in the 11<sup>th</sup> grade in Angolan curriculum parameters:** Trigonometry is a branch of Mathematics dedicated to the study of triangles, in a plane where one of the angles measures  $90^\circ$  in the case of the right triangle and relationships between the sides and their angles. This theme is addressed in several Educational Institutions from the 1<sup>st</sup> Cycle of Secondary Education, High School to higher education. In this regard, Lima (2013, p.9) states that the teaching of trigonometry in high school is taught in classrooms, through the use of a series of formulas, which cause disinterest in students, as they do not understand its importance, its use and its purpose, making them discouraged. According to Pescarolo (2018, p.23) the teaching of trigonometry in schools has often proved to be uninteresting for students and it is of great importance in various areas of daily life, the teacher must establish diversified ways of teaching so that learning is meaningful, awakening the creativity and interest of the student. In Angola, the theme "trigonometry" appears in the Mathematics programs of the I Cycle of Secondary Education 8<sup>th</sup> and 9<sup>th</sup> grade and in High School in the 10<sup>th</sup>, 11<sup>th</sup> and 12<sup>th</sup> grade, according to each educational institution program. These programs address several subtheme: angle, sexagesimal system (unit of degree), circular system (unit in radian), degree conversion, gradation and radian, main trigonometric relations in a right triangle, concepts of sine, cosine, tangent, cotangent, secant and cosecant of an angle, metric relations in the right triangle, trigonometric ratios, notable angles, law or theorem of sines and cosines, fundamental relations between them, trigonometric identities, which establish relations of equality between the trigonometric functions, equations and trigonometric inequalities. The basic operations that make up the skills of trigonometric calculation, use of tables, reduction to the first quadrant, conversion of angle measurement systems, addition and subtraction of arcs are introduced and fixed, where skills in solving trigonometric equations and inequalities.

The six trigonometric functions mentioned are defined as angle functions. The starting point for defining them is the trigonometric cycle and the determinations of the positive and negative directions of an arc. These are defined using another function that associates each real number with a point on this cycle. In 11<sup>th</sup> grade teachers cover the following sub-themes: Measuring an angle, generalizing the notion of an angle, trigonometric ratios for acute angles, solving triangles, trigonometric functions

$y = \sin \alpha$ ,  $y = \cos \alpha$ ,  $y = \tan \alpha$  for any angles, trigonometric functions in the trigonometric circle, trigonometric functions in a frame where the angle amplitude is the abscissa (sine function, cosine function, tangent function), transformations of the graphs of trigonometric functions, trigonometric equations of the type  $\sin x = a$ ,  $\cos x = a$ ,  $\tan x = a$  and reduction to the 1<sup>st</sup> quadrant.

Its teaching has caused many difficulties for students due to the fact that there are formulas that lack demonstrations and graphics that many teachers cannot explain to students, reduction of angles, trigonometric identities, graphical

representation of functions, solving equations and trigonometric inequalities. Mathematics teachers do not motivate classes, do not explain the importance of their study and its applications in different areas, nor do they use appropriate methods that facilitate their learning. In this regard, Catharina (2017) and Oliveira (2015) state that trigonometry and its applications history in everyday life is a source of motivation for students. History becomes indispensable in the Mathematics teaching, as it reveals its pedagogical role, as it brings the mathematical content studied in schools closer to the reality of students, revealing to them how each concept was formed, the historical moment in which they emerged and in which circumstances, favoring the formation of the concept of each mathematical content studied in its daily life. Oliveira (2015) recognizes the impact of its applications and states that in trigonometry classes, the approach to its applications in everyday life plays an extremely important role as it serves as one of the alternatives to awaken students' interest in learning these contents. Trigonometry is used to calculate the Earth's diameter, distances to make maps, river widths, adjustment of characteristic acoustic curves, measurements of inaccessible distances, such as the heights of mountains, towers, trees, buildings, pyramids, algebraic calculations, functions, definition of polar coordinates, limits, derivatives, integrals, representation of a complex number, slopes of lines, among others. It is also used in Mechanics, Physics, Topography, Engineering, Electricity, Medicine, Economic Sciences, Electro-technics, Biological Sciences, Geosciences, among other areas. This content allows students to understand some periodic phenomena of daily life interpreted and graphically represented, creating strategies for solving problems in their day-to-day. In its approach it is necessary that teachers use teaching material such as: ruler, compass, protractor, square, computer tools, etc. Ausubel cited by Oconha (2016, p.30) highlights the importance of using this tools in the teaching process and states that the teaching material should be potentially significant and allow the association of the contents with students' prior knowledge, that is, the teaching material needs contain information already known by the students and the latter, in turn, must be willing to use their previous knowledge as a basis for expanding their repertoire as it is based on already known concepts.

**The Algebraic Calculation Systems:** Currently, the traditional methodologies used by teachers in the Mathematics teaching have created problems to students from primary Education and 1<sup>st</sup> and 2<sup>nd</sup> Cycle of Secondary Education, causing some organizations such as: United Nations Educational Organization, Science and Culture (UNESCO), European Organization for Economic Cooperation and Development (OECD) and the Organization of Iberoamerican States (OEI) carry out investigations and studies in order to contribute to the Mathematics curriculum design improvement and introduction of Systems of Algebraic Calculus in the teaching-learning process of this discipline. Algebraic Calculation Systems are a powerful computer tool to perform symbolic operations that allow students to manipulate non-numeric objects, operate and carry out transformations with mathematical symbols. Authors such as: Guzmán (1991), Llorens (1993), Landay (1999), among others, claim that these systems cause enormous changes in the teaching and learning of Mathematics. Within the CAS we have: COPLOT, DERIVE, EURECA, GRAPHER, MAPLE, MATHCAD, MATHEMATICA, MATLAB, THE MATH Utilities, among the commercials.

Other Free and/or Open Source Computational Algebra Systems with GNU-GPL license are ARIBAS, AXIOM, GAP, GRAPHER, JASYMCA, MAXIMA, NUMPY, OCTAVE, PARI/GP, SINGULAR and JAZA. Commands are essentially entered with the keyboard. The following are some of the Computer Assistants most used in solving exercises and mathematical problems.



**The integration of GeoGebra Math Assistant into Trigonometry Teaching:** GeoGebra Math Assistant is a technology resource that provides students with learning opportunities. GeoGebra has several geometric tools that help the teacher's work in the classroom, giving them possibilities to make their classes more attractive and motivating, where students are curious to learn mathematical content. This computer tool contains three different areas of mathematical objects (the input area, graphical, algebraic or numerical), which display objects in three different representations: Graphical, algebraic and in the cells of the spreadsheet. Its commands are used in the construction of flat geometric figures, trigonometric circle, graphical representations of trigonometric functions, calculation of derivative functions, definite integrals, among other mathematical contents covered at all levels of education. The graphical interface consists of an initial window that displays the upper part, the main menu, the toolbar with various commands, the algebraic window on the left side, the right side of the graphical window and the input field at the bottom. According to Lopes (2013) the GeoGebra Mathematical Assistant enables the movement of objects that allows the student to investigate what happens with their construction. This was created with the aim of developing geometric contents in Primary and Secondary Education. Citing Sousa (2018, p.59), Lopes (2013) and Toledo (2015, p.31) recognize its usefulness in the Mathematics teaching and learning process. Sousa (2018, p.59), for example, defines GeoGebra as an educational tool that facilitates students' learning through a creative and constructive mechanism, minimizing their difficulties, increasing their interest and motivation, expanding their possibilities of understanding the concepts inherent to trigonometry.

It offers a possibility for teachers to use as a resource that helps to improve their teaching practice, developing more interactive lessons, to provide students with moments to create mental mechanisms that allow Mathematical understanding, leaving the traditional teaching modality and expanding their capacity to treat Mathematics with a new perspective of positive learning, as it is an important element for conducting research at home or in the classroom, strengthening the teaching of Trigonometry, with multiple constructions of Mathematical objects, such as creating points, straight lines, geometric solids and all conics, but it also stands out as a powerful tool for the study of trigonometric functions. Costa (2017, p.60) affirms that GeoGebra works as a teaching tool, which allows enhancing the understanding of the certain figures properties that remain invariant in dynamic geometric constructions. All potentialities presented through investigative activities are

mainly the construction of graphics, their dynamism and visualization. Its use in the teaching-learning process of trigonometry allows a better visualization and dynamism in working with trigonometric functions, especially sine and cosine when there is variation in their parameters, thus providing high school students and teachers with an environment in which learning can be stimulated through the union of computer resources aimed at teaching trigonometry. It also allows the practices of social relationships and their interactions, facilitates the exchange of information about trigonometry to solve various problems, making the student participatory, active and creative in the development of their learning process.

**Motivating and increasing the curiosity of 11<sup>th</sup> grade students in the courses:** Physical and Biological Sciences, Human Sciences and Economic and Legal Sciences, the following activities were developed in the use of GeoGebra in trigonometric contents:

- Construction of the right triangle from the trigonometric circle;
- Determination of trigonometric ratios from the right triangle;
- Construction of the sine function graph;
- Construction of the graph of the cosine function with parameters  $a$ ,  $b$ ,  $c$  and  $d$ .
- Construction of the graphs of the sine and cosine functions from the trigonometric circumference;
- Construction of the graph of the tangent and cotangent, secant and cosecant function;
- Solving Trigonometric Equations.

These activities were carried out over a period of ten days, in which, in addition to the students, some Mathematics teachers who did not know how to use the GeoGebra Mathematical Assistant in teaching Mathematics and trigonometry in particular took part. They demonstrated satisfaction and motivation in learning to use technological tools and developed their skills and abilities in solving exercises and trigonometric problems through this Computer Assistant. At the end of these activities, the following problem was introduced, which served to assess the students:

A plane takes off at an angle of  $30^\circ$  after traveling  $10,44 \text{ km}$ . Determine the height where the plane is located. In solving this problem, the students built the scalene triangle formed when the plane took off. To facilitate this construction in GeoGebra, the following steps should be taken into account:

**Step 1:** Open the GeoGebra Math Assistant.

**Step 2:** Score three points. Click on the arrow of the new point tool and select new point, activate and go to the 2D graphic sheet at the origin of the axes click marking point  $A$  then on the horizontal axis mark point  $B$  above the number  $9$  and on the vertical axis mark the point  $C$  above the number  $5,5$ .

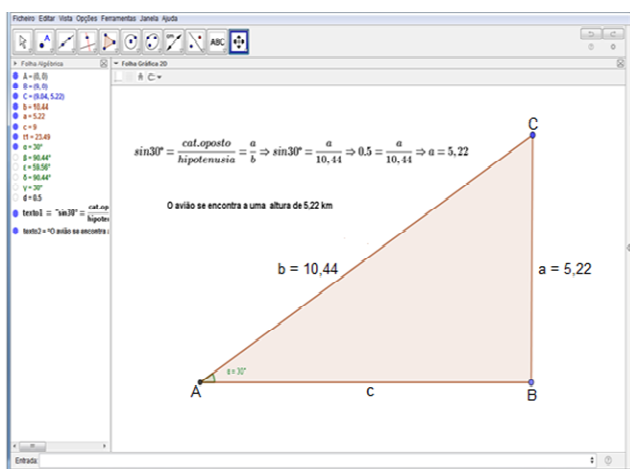
**Step 3:** Click on the arrow of the polygon tool and select polygon, activate it and then click on the three points.

**Step 4:** Deactivate the axes and grids. Click the arrow on the move tool and select move and enable, then go to the arrow on the 2D graphics sheet and disable the axes and grids.

**Step 5:** Draw the  $30^\circ$  angle between the line segments  $[A, B]$  and  $[C, A]$  and the length of the line segment  $[C, A]$ . Click the arrow of the angle tool and select distance or length, then click on the line segment  $[C, A]$ . Then click on the angle tool and select angle then click on the line segments  $[A, B]$  and  $[C, A]$ .

**Step 6:** Determine the height of the plane by entering the function  $\text{sen}(30^\circ)$  in the input bar and pressing Enter, the letter  $d = 0,5$  will appear on the Algebraic sheet, which corresponds to the value of  $30^\circ$  sine then select insert text and give an Ok a dialog box will appear where you type the definition of the sine. Activate the Latex formula, click on its arrow and choose the option roots and fraction in the same dialog box by typing para (sine,  $\text{sen}30^\circ = \text{cat Op/hipotenusa}$ ).

Following these steps results in the figure presented below:



**Conceptual model for mitigating ICT use problems in teaching trigonometry:** The conceptual model is a block diagram that demonstrates all the relationships between entities, their specializations, their attributes and self-relationships.

**Didactic alternative:** alternative is one possibility among others that allows the teacher to face didactic and pedagogical issues of teaching-learning.

**Planning:** Is a process that implies guiding the actions to be developed before, during and after teaching practice, reflecting the decisions taken by the teacher. Ferreira (2014) defines planning as a didactic and specific activity developed by the teacher, based on disciplinary programs, in which the teacher must select and design learning experiences, in order to respond to the needs and interests of their students, with the objective to lead to the success of the teaching-learning process.

**Elaboration:** is a fixed model to be followed with a coherent sequence and necessary elements for the teaching and learning process. (HENZ, 2009).

**Execution:** is the stage of carrying out the planned and elaborated actions, where the teacher puts the students to practice everything they think is important in order to check whether the objective of the class was achieved or not.

**Control:** consists in checking the actual activities, if they are according to plan. Oliveira (2005, p. 427) states that to control

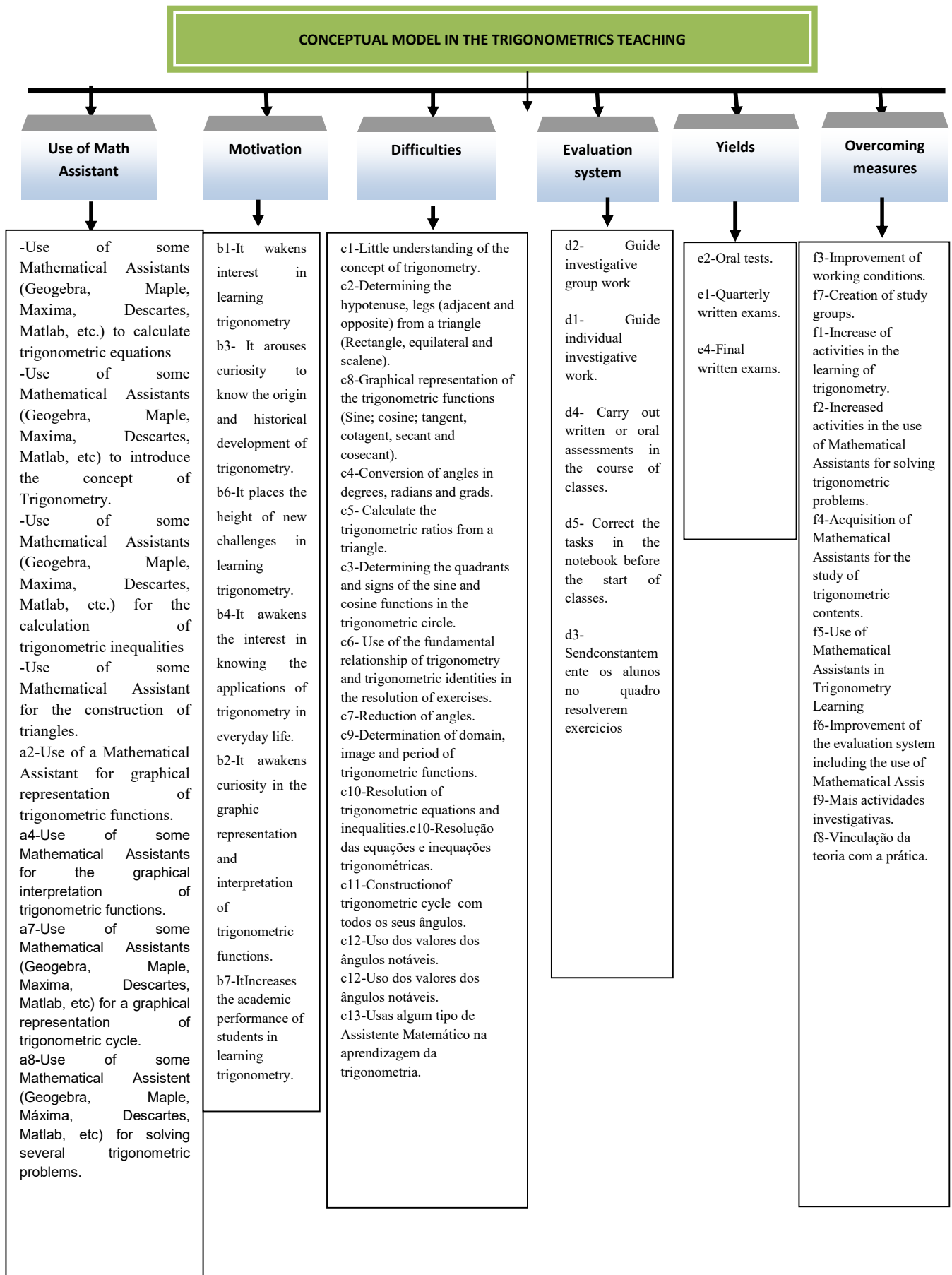
is to compare the result of actions, with previously established standards, in order to correct them if necessary.

## METHODOLOGICAL RESULTS

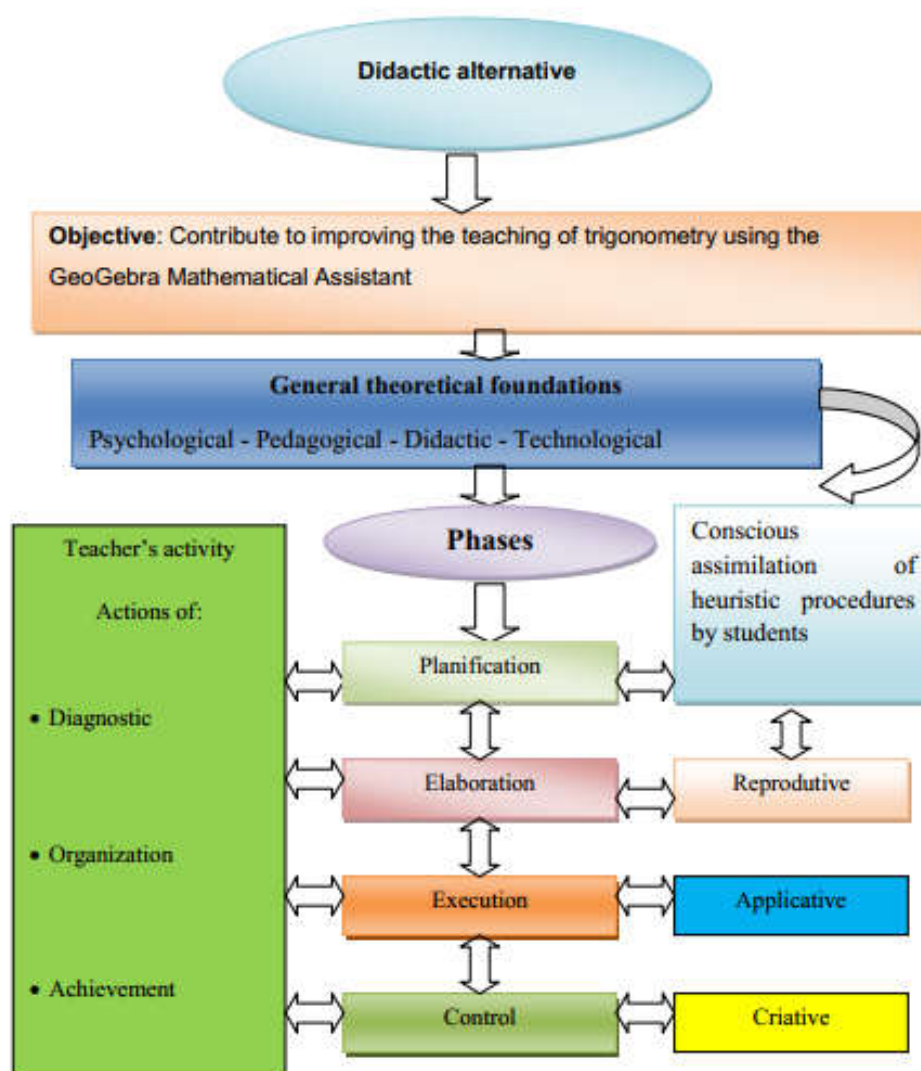
**Population, Sample and Data Processing:** In this research, 159 elements were selected, including 4 Mathematics teachers and 155 11<sup>th</sup> grade students at Liceu-Cabinda from Physical and Biological Sciences (PHBS), Economics (ELS) and Legal Sciences and Human (SH) Sciences courses, of which 64 are male and 91 female respectively. A questionnaire and interview were applied to these teachers and a Test to the students. The questionnaires were elaborated according to three dimensions (teaching of trigonometry, learning of trigonometry and integration of Information and Communication Technologies in the teaching of trigonometry) with their respective indicators. The data obtained were processed by the SPSS statistical software.

**The implementation of didactic alternative Results:** The results obtained in the implementation of the didactic alternative in the 11<sup>th</sup> grade at the Liceu-Cabinda were satisfactory. These results are the result of the set of activities carried out in GeoGebra where most students showed that through this computer tool they overcame the difficulties concerning the definition of trigonometry, its importance in daily life, the problems they solve in Mathematics and in other fields such as: Physics, Astronomy, among others, the use of the Pythagorean theorem, conversion of degree, gradation and radian and vice versa, determination of domain, image and period, aspects related to the pre-test applied in the initial phase of this research. In addition, it established teacher/student communication, increased motivation, curiosity and their interest in learning trigonometric contents. Graph 1 shows that there was greater academic of students' performance in the Post-test, where the percentage of these in the three courses are respectively 93, 100 and 96%, while in the Pre-test students obtained a very high negative percentage, that is, 64, 77, and 72% respectively. These statistical data demonstrate that there is a need to implement Information and Communication Technologies in the teaching of Mathematics and trigonometry in particular. The GeoGebra Mathematical Assistant made the trigonometry teaching-learning process more dynamic, attractive, fun and meaningful, arousing the curiosity and students' interest in the three courses.

**Didactic alternative validation by the experts:** For the didactic alternative validation, 4 Mathematics experts were selected. The validation was based on the analysis of the conceptual mitigation model of problems in the use of ICTs in the teaching of trigonometry, Didactic alternative for its teaching using the GeoGebra Mathematical Assistant, bar graph that illustrates the comparative results of tests applied to 11<sup>th</sup> grade students from different courses at Liceu-Cabinda and in the script of questions formulated in the questionnaire with five indicators, as shown in the table below, based on the scale: B- Bad, S- Sufficient, G- Good, VG- Very Good and E- Excellent. The statistical data illustrated in this table indicate that the didactic alternative presented in the trigonometry teaching using GeoGebra Mathematical Assistant was rated Excellent. The Computer environments bring in teachers and students a new change, new dynamism and visualization of mathematical content.



Scheme 1. Conceptual model of mitigation of problems in the use of ICTs in the teaching of trigonometry



Source: Prepared by the author

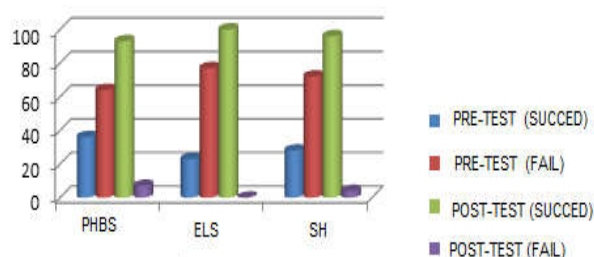
Diagram 2. Didactic alternative for teaching trigonometry using GeoGebra Mathematical Assistant in 11<sup>th</sup> grade at Liceu-Cabinda

Table 8. Indicators evaluated

Indicators	B	S	G	VG	E	Total
1.Design and implementation of the didactic alternative.				1	3	4
2.Didacticalalternative					4	4
3.Methodology used in the integration of the GeoGebra Math Assistant			2	2		4
4.Relevance of the Didactic Alternative at Liceu- Cabinda		3	1			4
5.Feasibility of applying the didactic alternative at Liceu-Cabinda				4		4

The implementation of the GeoGebra Mathematical Assistant in the trigonometry teaching in the 11<sup>th</sup> grade at Liceu-Cabinda produced satisfactory results that demonstrate the advantages of its use by students. GeoGebra is a technological resource that many authors have used in recent years to motivate the teaching of Mathematics and trigonometry due to its potential and dynamism in the construction and visualization of flat figures and geometric solids, attractiveness of students' attention, stimulates learning and pique your curiosity. Santiago (2015, p.30) states that the use of GeoGebra in the trigonometric teaching functions, specifically: sine and cosine, allows for better visualization and dynamism of the figures, especially when there is a variation in their parameters. This computational resource provides students and teachers with an environment in which learning can be stimulated, through the union of computer resources aimed at teaching Mathematics.

According to Sousa (2018, p.59) the GeoGebra Mathematical Assistant is an educational tool that facilitates student learning, through a creative and constructive mechanism, minimizing their difficulties, increasing their interest and motivation, expanding their possibilities of understanding the concepts inherent to trigonometry.



## CONCLUSION

- The diagnosis made in this research regarding the teaching of trigonometry allowed to identify several students difficulties, such as: Little mastery of trigonometric concepts (sine, cosine, tangent, cotangent, secant and cosecant of an acute angle) and of trigonometric functions, their applications, resolution of trigonometric equations and inequalities, graphical representation of these functions, determination of domains and their images, lack of material conditions, among others.
- The proposal of the didactic alternative presented was developed in four stages (planning, elaboration, execution and control) where the trigonometric contents were approached using GeoGebra Mathematical Assistant in order to make teaching more attractive, dynamic and fun.
- The evaluation of the Didactic Alternative proposal by experts in Mathematics gave rise to satisfactory results that guarantee its validity. These results are the result of the set of activities carried out on GeoGebra where most students showed that through this computer tool they overcome the difficulties concerning trigonometric contents.

## REFERENCES

- Almeida, D. et al. *Aplicação do coeficiente alfa de cronbach nos resultados de um questionário para avaliação de desempenho da saúde pública*. 2010, p.1
- Catharina, C. R. M. *Uma Proposta para a Aprendizagem de Conceitos trigonométricos no Ensino Fundamental*. Dissertação apresentada ao Centro de Ciências e Tecnologia da Universidade Estadual do Norte Fluminense Darcy Ribeiro, como parte das exigências para obtenção do título de Mestre em Matemática. 2017.
- Costa, A S. M. *A utilização do GeoGebra como ferramenta para o ensino de trigonometria*. Dissertação apresentada para a obtenção do título de Mestre em Matemática. 2017. Pág. 60
- Ferreira, I. M. M. *A planificação como prática de uma professora em processo de formação*. 2014.
- Guzmán, M. de G. *“Para pensar mejor”*, Labor, Barcelona, La última edición: *“Para pensar mejor. Desarrollo de la creatividad através de los procesos matemáticos”*, Pirámide, Madrid, 1991
- Henz, C. C. *O uso das tecnologias no ensino-aprendizagem da matemática*. erechim. 2009
- Landay, S. *Compute and Conjecture Notices of the A.M.S.*, Febrero 1999, pág. 189.
- Lima, N. J. *A aprendizagem significativa em trigonometria sob o ponto de vista de quem ensina e de quem aprende*. In«VI Congresso Internacional de Ensino Da Matemática» Período: 16, 17 e 18 de Outubro. 2013. Pág.4-9
- Llorens, J. L. *“Introducción al uso de DERIVE: aplicaciones al álgebra lineal y al cálculo infinitesimal”*, Dpto de Matemática Aplicada E.U.I.T.A., Universidad Politécnica de Valencia, 1993.
- Lopes, M. M. *Sequência didática para o ensino de trigonometria usando o software GeoGebra*. Bolema. Vol. 27, n.46, 2013. Pp. 631-644.
- Ocanha, M. *Uma Introdução à Trigonometria com Aprendizagem Significativa. Dissertação de Mestrado em Matemática*. 2016. Pág.30
- Oliveira, E. G. *Uma abordagem da trigonometria no ensino fundamental, tendo a história como recurso didático. Dissertação de Mestrado em Matemática*. 2015.
- Oliveira, P. D. P. R. *Sistemas, organização e métodos: uma abordagem gerencial*. 15ª Edição. São Paulo: Atlas, 2005, p. 427. ISBN 85-224-4185-5
- Pescarolo, H. M. *Uma Proposta de ensino aprendizagem de trigonometria em triângulos por meio do Software GeoGebra*. Trabalho de Conclusão de Curso de Graduação para a obtenção do título de Licenciado. 2018. Pág.23
- Santiago, E. *O ensino da trigonometria usando o software geogebra como ferramenta de ensino-aprendizagem*. Dissertação de Mestrado. 2015. pág. 30
- Sousa, F. D. R. B. *Software GeoGebra no Ensino da trigonometria: Proposta metodológica e revisão da literatura a partir das produções discentes nas dissertações do PROFMAT*. Dissertação de mestrado apresentada para a obtenção do título de Mestre em Matemática. 2018. Pág. 9 -59
- Toledo, B. de S. *O uso de softwares como ferramenta de ensino-aprendizagem na educação do ensino médio/técnico no Instituto Federal de Minas Gerais*. 2015, pág.31

\*\*\*\*\*