



## RESEARCHARTICLE

### CONCEPTUAL MODEL AND DIDACTIC STRATEGY FOR DIFICULTIES REDUCTION BY INTEGRATION OF COMPUTER SYSTEMS ON ANALITICAL GEOMETRY TEACHING AT EDUCATION HIGHER INSTITUT OF CABINDA

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#### ABSTRACT

This article was developed in order to model the integration of computer systems, GeoGebra and MS-Excel, in the teaching-learning process of Analytical Geometry at the Higher Institute of Educational Sciences in Cabinda, in order to reduce the difficulties that appear as, Lack of mastery of the basic concepts of Analytical Geometry, little motivation of students, limited understanding of the concepts of vectors, equations of lines, their representations and graphical interpretations in the plane and space, conic sections, quadric surfaces, poor preparation in the use of software mathematicians, non-compliance with Analytical Geometry programs, among others. For this purpose, a sample of 3 teachers and 154 students was interviewed, selected at random whose opinions processed with the SPSS software allowed the elaboration of a conceptual model and a methodological strategy to guide teachers in reducing these difficulties. The strategy was validated through its implementation with several practical activities developed in the classroom involving teachers Masters and Doctors in Mathematics who favorably rated it very good.

#### INTRODUCTION

Ubirantan (2001, P. 101) states that Mathematics is a satisfaction of the moment and therefore one must follow the changing times, especially the generation of students who have opposite expectations of the groups of experts who dictate the rules. Mathematics is a science consisting of several branches. Among them we highlight: Analytical Geometry, Mathematical Analysis, Number Analysis, Algebra, among others. Analytical Geometry is one of the branches of Mathematics in which algebraic methods and symbols are used to represent and solve geometric problems.

According to Richit (2005, p. 42) the teaching of Analytical Geometry, it should be able to provide the student with the ability to interpret geometrically and algebraically a given problem. This ability can reduce certain difficulties in this Geometry. Thus, it is necessary that the teacher is prepared to provide experiences that may favor students in the development of their abilities to interpret a graphic, geometric and algebraic representation. In Angola, Analytical Geometry is included in the curriculum of the Higher Institutes of Educational Sciences (ISCED) and

Pedagogical Higher Schools, mathematics teaching course and in the programs of high school institutions. To make it more enjoyable, attractive, increase the motivation, arouse interest and curiosity of students of the first year Mathematics Teaching course of these Higher Education Institutions we introduced the mathematical software GeoGebra and Microsoft Excel (Ms Excel) in the learning process of this discipline. The emergence of computer resources has boosted the teaching of Analytical Geometry. According to Santos (2011, p. 135), the teaching of Flat Analytical Geometry with the use of GeoGebra software enables the construction of knowledge related to straights, circumferences and conics. This software allows to create learning environments of the contents of this Geometry, where the role of the teacher is only of advisor, coordinator, plumber, guide and mediator of activities in the classroom. Students should be free to expose their ideas, break down some barriers imposed on them and actively participate in the construction and reconstruction of their knowledge. GeoGebra has become one of the software used in various sciences, such as: Mathematics, Physics, Chemistry, Biology, among others. The inquiries made to students in the first year of Mathematics Teaching at ISCED of Cabinda in the academic year 2019 concerning the use of mathematical software in the teaching-learning process of Analytical Geometry found several difficulties. Among them we highlight:

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Lack of mastery of the basic concepts of Analytical Geometry, little motivation of students in learning the contents of this Geometry, limitation in understanding the concepts of vectors, equations of lines, their representations and graphic interpretations in bi and three-dimensional space and space, conical sections, quadric surfaces, most teachers do not use any mathematical software in their teaching process, little preparation of students in the use of these technologies, non-compliance with the High School Mathematics program by teachers and Analytical Geometry in the Higher Education among others. These and other difficulties found in teachers and students allowed us to identify the following research question:

*How to favor the teaching-learning process of Analytical Geometry, using the mathematical software GeoGebra and MS-Excel in the first year of Teaching Mathematics at ISCED of Cabinda?*

This paper aimed to construct a conceptual model and didactic strategy to reduce difficulties on the teaching-learning of Analytical Geometry at ISCED of Cabinda integrating GeoGebra software and Microsoft Excel.

## MATERIAL AND METHODS

**Background to the teaching of Analytical Geometry at the Education Higher Institute of Cabinda:** The Higher Institute of Education (ISCED) of Cabinda is a public institution belonging to the University of November 11 in Angola, located in Cabinda province, founded in 1997 by Decree No. 95/80 on the basis of the combination of articles 7 (c), and 11 (i) of Decree No. 2/95 of the Senate of Agostinho Neto University (UAN). Its fundamental objective is to train qualified teachers in the different areas of Education Sciences, as well as to promote scientific research. Within the curricular conception that enable its operationalization, guiding educational activities, ways of performing them and defining their purposes, the discipline of Analytical Geometry is one of the main curricular plan of Bachelor's Degree in Mathematics Teaching.

In this discipline are used algebraic methods and symbols used in the representation and resolution of geometric problems. Its importance is present in the fact that it establishes a correspondence between algebraic equations and geometric curves. Lima (2005) states that Analytical Geometry is based on the idea of representing the points of the straight by real numbers and the points of the plane by ordered pairs of real numbers. Its importance lies in the fact that we can represent through equations the lines of the plane (straight, circumference, parabole, etc.). This geometry became the basis of large fields of mathematical studies also used in algebraic geometry, differential geometry, discrete geometry, Computational Geometry, Physics, Mathematical Analysis, Engineering, Economics, Civil Construction, Mechanics, among others. It is also used in maps, satellites and the modern Global Positioning System (GPS) used in land, air and sea navigation. They serve as an aid in calculating the diameter of an iron bar or beam that is subject to a force, or even in a column in which the traction it receives for the support of a building, among others, is calculated. At ISCED initially Analytical Geometry was taught by two Licensed Professors, one of whom was a regent from Kuanza Sul province and another Cabinda Natural Assistant.

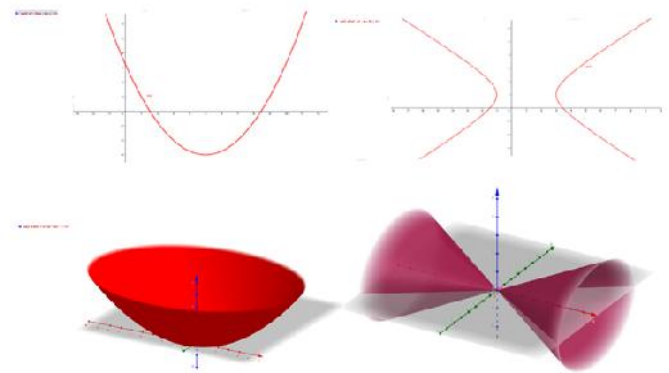
These teachers had deep mastery of the topics we addressed in the classroom and there was little disapproval of the students who attended the 1<sup>st</sup> year in the Mathematics course because 75% of the contents taught were evaluated and 25% not evaluated. Its programmatic content consisted of four chapters: vector algebra, coordinate method, straight in the plane, straight in space and lines of the 2<sup>nd</sup> degree. In the latter, the teachers addressed only the circumference and ellipse and left by treating in depth the parabol and hyperbol. There were no basic bibliography, Internet and computers that could make it easier for teachers and students to consult, deepen and type various themes of the program for investigative work. The analytical geometry discipline is annual with only four hours per week. With the emergence of the new Education System (Educational Reform System) in the country, there was the reformulation of the curricular plan of bachelor's degree in Mathematics and the Analytical Geometry program. Currently Analytical Geometry has been taught by other Professors and Doctors making it difficult. Its program covers the following chapters:

- ) Vector algebra and coordinate method
- ) Straight stowerin
- ) Straight snares in space
- ) 2<sup>nd</sup> degree lines (Conics)
- ) 2<sup>nd</sup> degree surfaces (Quarádrics)

With an increase in the academic levels of professors of the Department of Mathematics Teaching and Research in several countries of the world such as Brazil, Cuba, Spain and Portugal who teach these disciplines application of various strategies, techniques and teaching methods by these teachers, there was a significant change in terms of academic performance of students in the 1<sup>st</sup> year of this course, although it did not introduce Information and Communication Technologies in their teaching-learning that could increasingly motivate and disperrate interest of students. According to Douady (1993), a teacher's goal is to teach and create the conditions for students to produce knowledge and knowledge. In this research we selected the mathematical software GeoGebra as one of the most suitable computer bells for the teaching of Analytical Geometry in the 1<sup>st</sup> year teaching of Mathematics of ISCED-Cabinda.

**The use of GeoGebra Mathematical Software:** The software is a set of computer programs with procedures, equipped with rules, documents and associated data. It is a tool that can be used in the educational field, through the various technological means, that makes analytical geometry classes more dynamic, attractive and interesting. According to Gladcheff, Zuffi and Silva (2001), the use of software can be an important ally in the cognitive development of each student facilitating a work that adapts to different learning rhythms and allows students to learn from their mistakes. These authors affirm that the use of software in mathematics classes can consent to several objectives: to be a source of information, to assist teachers in the construction of knowledge, to expand the autonomy of reasoning, reflection and the creation of solutions. GeoGebra is a dynamic mathematics software that brings together Geometry, Algebra, Spreadsheet, Charts, Probability, Statistics and Symbolic Calculations in a single easy-to-use package. This software puts students in situations that allow the exploration of tools according to their need (discovery of menus, commands, navigation bar modification / color overlap or changes in the configurations of the axes, among others).

Romero (2006) highlights the role of the use of technology, specifically educational software, by providing motivational opportunities and higher rate of appropriation of content in the classroom. In this aspect, Púcuta (2016) highlights the impact of technology as an element of extreme importance in the development of teaching of Analytical Geometry, and can contribute to quality teaching and improve the learning of its contents in university students. It also helps students visualize mathematical and geometric ideas, allowing them to perform calculations efficiently and accurately. Púcuta (2016) states that GeoGebra has become one of the most widely used dynamic geometry software in the teaching-learning process of Mathematics, Physics and Engineering on all continents of the world.



Source: Author, plotted from GeoGebra software

Figure 2. Graphic representation in GeoGebra of Parabol, Hiperbol, elliptical paraboloid and Two-leaf cone

- Open the GeoGebra computer program.
- Enter the equation in the *input or command bar*.
- Give an Enter so that the equation appears immediately in the algebraic zone and its graph sketch in the graph zone.

**The use of Microsoft Excel**

Microsoft Excel can be used to obtain analytical expressions or calculus that is not possible with Geo Gebra. For example, distance between two different points and the line equation that passes two different points.

- For the distance between two different points in the plan, A(2;4) and B(-3;1) we can:
- For each point, insert the value of x and y in the correspondent cells;
- Insert the formula of the distance  $d(A; B) = \sqrt{(x_B - x_A)^2 + (y_B - y_A)^2}$  using Ms-Excel function SQUART ((D3-B3)^2+(D4-B4)^2) = 5.83 as shown in the Figure 2.

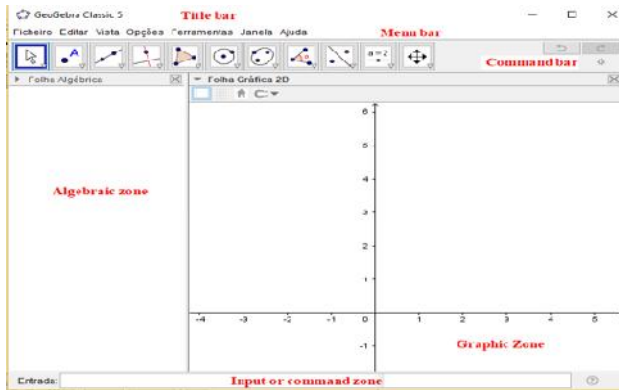
SOMA				
A	B	C	D	E
1 Distância entre dois pontos A(2;4) e B(-3;1) do plano				
2 A		B		
3 x=	2	x=	-3	
4 y=	4	y=	1	
5				
6	d(A;B)	=RAIZQ(((D3-B3)^2+(D4-B4)^2)		
7		RAIZQ(núm)		
6	d(A;B)	5,830952		

Source: Calculated in MS-Excel

Figure 3. Calculation of the distance between two points by MS-Excel

- For determination of the line equation that passes the points A(2; 4) and B(-3; 1), we can:
- Type the values of x column and y column in the correspondent cells;
- Go to Menu DATA and click on *Data analysis Tool*. Click on *Regression* in the dialog box;
- Enter the input values in x and y intervals;
- Active output option and chose the print interval

Ms-Excel will print the regression results. The line parameters (coefficients) will be “Intercept = 2.8” and “Variable x = 0.6” as shown in the last step of the Figure 4. The line equation will be  $y = 0.6x + 2.8$



Source: Created by GeoGebra /2020

Figure 1. GeoGebra interface

The first zone called *input or command zone* which is the space where algebraic expressions that you want to graph are entered from the keyboard. The second is called *algebraic zone* where the algebraic characteristics of objects entered in the graphical or command window appear (coordinates and equations including variables). In this zone objects are divided into two parts: free that can be moved and dependent, which depend on the free objects. The third called *Graphic Zone* is the space where all objects appear graphically, allowing to make geometric constructions of points, straightlines, polygons, functions, among others. The following exercises (in the plan and in the space) were solved by this mathematical software.

In the plan: Represent graphically the following conical sections

) Parabol:  $(x - 5)^2 = 4(y + 3)$

) Hiperbol:  $\frac{(x-1)^2}{4} - \frac{(y-1)^2}{2} = 1$

) In the space: Represent Graphically the following Quadric surfaces

) Elliptical paraboloid:  $\frac{x^2}{1} + \frac{y^2}{9} = z$

) Two-leaf cone:  $z^2 = \frac{x^2}{9} - \frac{y^2}{4}$

To represent graphically these curves using the mathematical software Geo Gebra it is necessary that students follow the following methodological steps:

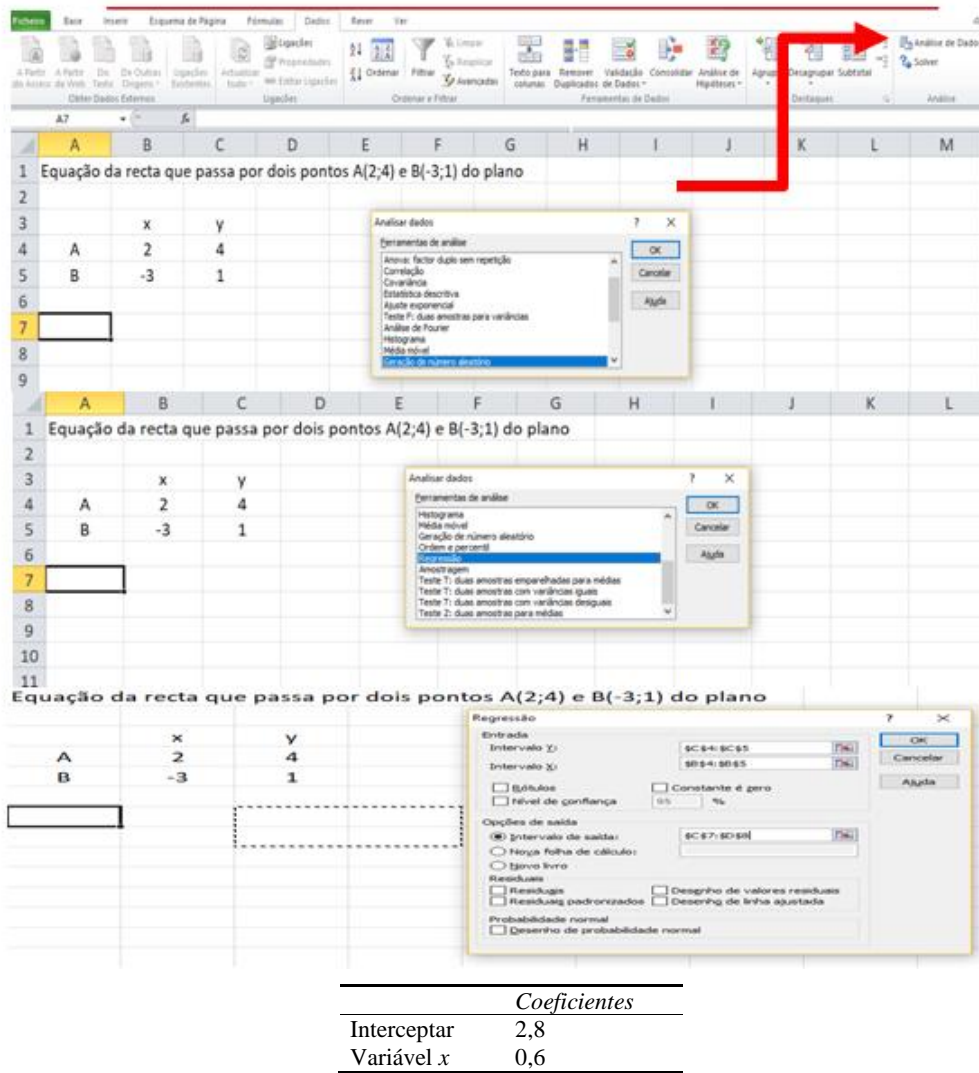
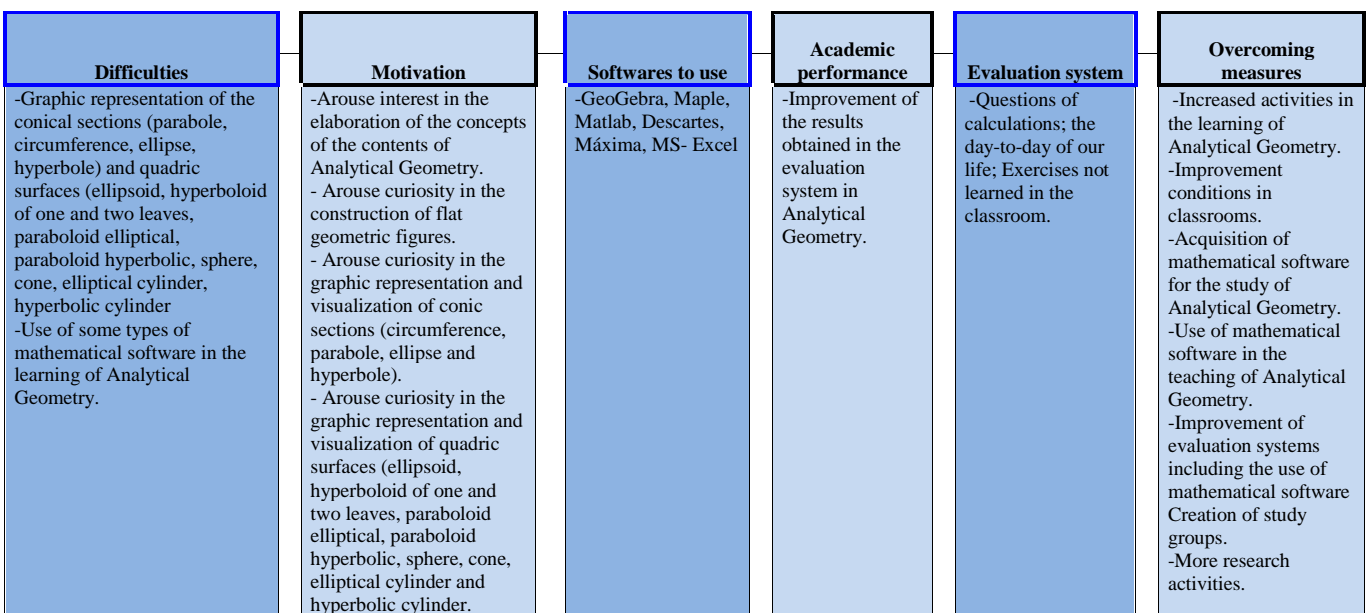


Figure 4: Line equation that passes two points calculated by MS-Excel

Diagram 1. Conceptual model for problems mitigation of the ICT use in the Analytical Geometry teaching-learning



Source: The author, based on Main Component Analysis Matrix

**Conceptual model of problem mitigation of the ICT use in the teaching-learning of Analytical Geometry:** The conceptual model is a set of assumptions based on a real world that indicates the rules of a system. It is the description of a proposed system in the form of a set of integrated ideas and concepts about:

- What should the system do?
- How should he behave?
- How should it appear?

The purpose of establishing a good conceptual model is that it must be understood by the user in an intended way. Helps clarify important connections in real-world processes and systems and can be enriched with more specific features from generation and development of more complex models. It is represented through a graphical interface, as illustrated in Diagram 1. Based on the Scheme 1 model, it is observed that the teaching-learning of Analytical Geometry in ISCED-Cabinda should be accompanied by the use of IT, motivate students, identify teaching-learning difficulties, improve students' academic performance, improve the evaluation system, and adopt separation measures. For the use of ICTs in the teaching of Analytical Geometry in ISCED-Cabinda, the mathematical software GeoGebra, Maple, Matlab, Descartes, Máxima, MS Excel, among others should be incorporated.

The motivation of the students should arouse interest in the elaboration of the concepts in the contents of Analytical Geometry; arouse curiosity in the construction of flat geometric figures; arouse curiosity in the graphic representation and visualization of the conical sections (circumference, parabola, ellipse and hyperbola); arouse curiosity in the graphic representation and visualization of the quadric surfaces (ellipsoid, hyperboloid of one and two leaves, hyperbolic paraboloid, elliptical paraboloid, paraboloid, sphere, cone, elliptical cylinder, hyperbolic cylinder and cylinder). Work towards reducing the difficulties identified in (ISCED-Cabinda), with regard to the teaching of Analytical Geometry on everything in the graphic representation of the conical sections (parabola, circumference, ellipse, hyperbola); quadric surfaces (ellipsoid, one- and two-leaf hyperboloid, hyperbolic paraboloid, paraboloid, sphere, cone, elliptical cylinder, and hyperbolic cylinder); and the use of some types of mathematical software in their learning. In order to have a good academic performance, we must observe an improvement in the results obtained in the systematic evaluations of students in Analytical Geometry. Improve the evaluation system by introducing: calculation questions; day-to-day questions of our lives and questions with unlearned exercises in the classroom. For overcome the difficulties of students, the following measures must be made: increased activities of learning analytical geometry; improving classroom conditions; acquisition of mathematical software for the study of Analytical Geometry; use of mathematical software in the teaching of this geometry; improvement of evaluation systems including the use of mathematical software; creation of study groups and more research activities.

### Didactic Strategy for difficulties reduction

**Strategy steps:** The strategy developed in this paper comprises four stages, each of which contains three steps:

#### *Planning stage:*

is the process of determining what should be done in the research. In this stage we have the following phases: diagnosis, structuring and awareness, and control.

**Diagnostic phase:** It is the initial phase of the didactic strategy where we detect the difficulties of the teachers and students of the first year of the Mathematics Teaching course at Education High Institute in Cabinda concerning the teaching-learning process of Analytical Geometry. These difficulties were verified through the application of questionnaires, pre-test and post-test, bibliographic survey, observation of some classes, revision of the curricular plan and Analytical Geometry program, the conditions of the classrooms, technological availability and use of the mathematical software GeoGebra and MS-Excel.

**Structuring and awareness phase:** In this phase, we analyze the textbooks and the Analytical Geometry program, used by teachers with the purpose of structuring the system of knowledge and skills, specific objectives, methodological suggestions, methods, means of teaching, forms of organization and evaluation in correspondence with the objectives in general, we prepared some Analytical Geometry manuals to later elaborate an exercise system that allows students interactivity, dynamism and visualization of mathematical concepts and figures in two and three dimensions.

**Control phase:** In this phase, we process the results obtained in the technological and pedagogical diagnosis made, as well as the levels reached by the first year students to establish the levels of necessary help, plan new actions, determine methods and resources that allow the transition to the second stage.

**Elaboration stage:** This stage comprises the following phases: selection and configuration, verification and control.

**Selection and configuration phase:** In this phase we elaborate a system of exercises that include the equations of the line in the bi and three-dimensional space (vector equations, systems of parametric equations of the line, symmetric, reduced, general and segmental equations of the line), graphical representation of the plane equations, conic sections (circumference, parabola, ellipse and hyperbola) and quadric surfaces (ellipsoid, sphere, one and two-leaf hyperboloid, elliptical paraboloid, hyperbolic paraboloid, cone, elliptical cylinder, hyperbolic cylinder and parabolic cylinder) using the GeoGebra mathematical software and MS-Excel for overcoming first year students in the Mathematics Teaching course at Education High Institut in Cabinda.

**Verification phase:** In this phase, we check if the exercise system developed is well defined, its objectives, contents, methods, means, forms of organization and evaluation, using the GeoGebra mathematical software and MS-Excel. This system must respond to the model designed to enhance the interactivity, motivation, dynamism and interest of students in the first year of Mathematics Teaching at Education High Institut in Cabinda.

**Control phase:** It is the phase of valorization of the levels reached by the students of the first year in the fulfillment of the

planned actions, the suggestions and necessary actions to guarantee the passage to the next stage.

**Implementation stage:** This stage comprises the guidance, execution and control phases.

**Orientation phase:** It is the phase in which each teacher, starting from his mission and function that is entrusted to him, guides the indications to follow, for the fulfillment of the teaching objectives of Analytical Geometry.

**Execution and control phase:** It is the phase in which MS-Excel was explored and the installation of the GeoGebra mathematical software Setup on the Laptop computers of the regular and after-work periods selected in the sample, having explained its operation and how the distance between two points in the plane is calculated.

**RESEARCH METHODOLOGY**

**Population, Sample and Data collection:** In order to carry out the research, information was collected data from 4 teachers who teach the discipline of Analytical Geometry and 154 students of the first year of the Regular and Post-Work courses Mathematics Teaching of ISCED-Cabinda and we directed two questionnaires and a diagnostic test to these students to learn about the current state of the teaching-learning process of this discipline. The questionnaires were elaborated according to seven dimensions (socio-demographic data, use of ICT in the teaching-learning of Analytical Geometry, motivation, teaching-learning difficulties, evaluation system, academic performance and measures to overcome teachers and students) with their respective indicators as nominal variables, using the Likert scale.

**Data analysis and Model construction:** Conceptual model was designed using IBM-SPSS software after the treatment of questionnaire data of professors and students, with the reliability of 88.4 and 84.0 respectively of Cronbach's alpha, thus being within the admissibility range, with reasonable internal data consistency. In the diagnosis, the respondents' opinions were extracted based on the analysis of normality of the data and of the Main Components. The variables did not have a normal behavior, they had distributions around their median because the p-values were below 0.05 and the answers stood very often on the extremes. For the extraction of the variables with the highest weight, they were extracted based on the admissible values of the Kaiser-Meyer-Olkin sample adequacy coefficient and the Bartlett sphericity test. In the case of students, this measure was 76.4% with a p-value of 0.0 for the Bartlett test. For the experts, this measure was 60% with a pvalue of 0.0 for the Bartlett test.

**RESULTS AND VALIDATION**

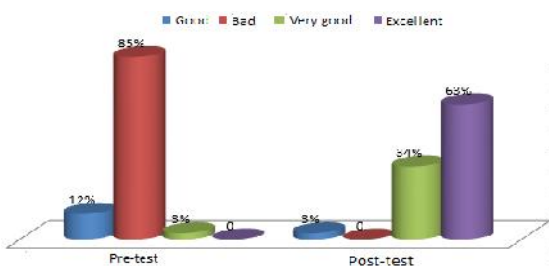


Figure 5. Results of the tests

Figure 5 is the graph of the results obtained in the pre-test and post-test applied to students of the first year Mathematics teaching course. The post-test results showed us improvements in terms of students' academic performance in the use of Geogebra mathematical software and MS-Excel in the learning of Analytical Geometry.

**Validation of the methodological strategy by the experts:** The integration of the mathematical software GeoGebra and Ms-Excel in the teaching-learning process of Analytical Geometry stimulated and motivated the teachers and students of the first year course Mathematics Teaching of ISCED-Cabinda. The system of exercises presented to students and others solved using GeoGebra software and Ms-Excel in the implementation of the methodological strategy allowed visualization, dynamism and numerical experimentation favor students in the development of their skills and mathematical skills. The strategy allowed the establishment of teacher/student/group communication for the exchange of questions and answers related to the use of GeoGebra software and Ms-Excel in the teaching-learning process of Analytical Geometry. The elaborated strategy was reviewed and validated by Masters and Doctors who have been working on Mathematics in different countries of the world (Brazil, Cuba and Spain) with a lot of experience in these contents and in use of Information and Communication Technologies and GeoGebra mathematical software in particular. The levels of reliability statistics of the questionnaires directed at the protagonists of the process are quite good according to Cronbach's alpha 81.2 and 84.0, respectively. These statistical data allow us to state that the levels achieved are satisfactory and the instruments used in data collection are very efficient.

**DISCUSSION**

According to Richit (2005, p.42), the teaching of Analytical Geometry, should be able to provide the student "with the ability to interpret geometrically and algebraically a given problem". This ability could reduce certain difficulties in Analytical Geometry and Algebra. Thus, it is necessary that the teacher is prepared to provide experiences that may favor students in the development of their ability to interpret a graphic, geometric and algebraic construction. An important feature of GeoGebra is the possibility of interaction between the user and the objects that are on their desktop. Santos (2011, p.135) states that the teaching of Flat Analytical Geometry with the use of GeoGebra software enabled the construction of knowledge related to straights, circumferences and conics. The environment privileges the visualization of these concepts and contributes to the realization of experimentation, emphasizing the interpretation of geometric constructions that are difficult to be worked on in the classroom. This Mathematical software allows students and faculty to visualize the contents of Analytical Geometry which is one of the aspects of extreme importance in the teaching-learning process. According to Paul Klee (2010, p.23) viewing is not only seeing the visible, it is mainly making visible. Goldenberg (1998, p.37) defends the idea that there are two types of visualization that students need, both in mathematical contexts and in others. These concern the ability to create, manipulate and "read" mental images of aspects common to reality; visualize spatial and quantitative information, and visually interpret the information presented to it; review and analyze steps previously taken as objects that

could touch, draw, and interpret, or make appear. Ms-Excel allows obtaining the equations of the line in the plane and space, distance between two points and vector coordinates. The results of the diagnostic test or pre-test showed and allowed us to verify students' difficulties regarding the use of the mathematical software GeoGebra and Ms-Excel in the teaching-learning process of Analytical Geometry. As a result, we elaborated a conceptual model and methodological strategy using the GeoGebra mathematical software and Ms-Excel and proved to be more efficient, increasing student performance, eliminating bad students and standing between good and excellent according to the Figure 5. The presented strategy and conceptual model can be adopted to mitigate the failure in teaching-learning of Analytical Geometry at Education High Institut of Cabinda.

## CONCLUSION

The results obtained in the implementation of methodological strategy allow us to infer the following: 1) The use of GeoGebra mathematical software and Ms-Excel in the teaching of Analytical Geometry made classes more dynamic, attractive, participatory and favored the experimentation, dynamism and visualization of the concepts having increased the ability of analysis, geometric and algebraic interpretation of a given problem, easy motivation, the curiosity dispersion and interest increasing of students; 2) The system of exercises solved with the mathematical software GeoGebra and another proposed according to the needs of students of the first year mathematics course favors the learning of Analytical Geometry at Education High Institut of Cabinda; 3) The proposal conceptual model helps professors to choose the best strategy according to him for increasing his own performance when teaching Analytical Geometry.

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