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GEOGEBRA SOFTWARE APPLICATIONS FOR MATH EDUCATION: AN INTEGRATIVE REVIEW

***Wendel Melo Andrade, Carlos Alves de Almeida Neto, Dalmário Heitor Miranda de Abreu, Rodolfo Sena da Penha, Jorge Carvalho Brandão, Gilberto Santos Cerqueira and Maria José Costa dos Santos**

Graduate Program in Education, Faculty of Education, Federal University of Ceará

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****Corresponding author:***
Wendel Melo Andrade

ABSTRACT

In the modern world, information and communication technologies are increasingly present in our daily lives. With this math teachers have been incorporating the use of software in their teaching practices, an example of this is the use of geogebra. In this context, this paper work aims to investigate the applications of geogebra software in mathematics teaching, identifying in which mathematics contents studied in basic education it can be worked and what the contributions of its use in the learning of these subjects. Therefore, an integrative literature review study was conducted, and nine articles related to this theme were selected and analyzed. The search for articles took place in the databases: Scielo, Periodicals Capes and Google Scholar. Among the criteria adopted for the choice of articles, its relationship with the objective of this research stands out. As a result we found the use of geogebra software in basic math-related content such as the study of fractions; in the area of algebra with functions, including the affine, quadratic and trigonometric function; as well as in the area of geometry, with the study of flat and spatial geometry. From the investigated research we conclude that the geogebra software potentiates the processes of teaching and learning of mathematics mainly regarding the interpretation of the graphic and algebraic properties of the studied content.

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INTRODUCTION

Modernity and technological advances are increasingly present in our daily lives. Computer systems and software are changing people's lives, bringing benefits and facilities to everyday actions. Cell phones and smartphones are devices that are already part of life in society, connecting and expanding beyond communication. An example of this is its use for entertainment and even aiding learning through its educational applications. However, even with this scenario of transformation of society, schools still come slowly in this process of modernization. This is often due to the low investment in educational programs aimed at the implementation, training and use of computerized environments. Gadott (2000), concerned about this situation, warns us that the school cannot be in tow of technological innovations. Because it needs to be a center of innovation. About this Pais (2008) points out that society experiences, in its general context, significant changes in the organization of daily life influenced by technological evolution.

The school, as an institution that forms society and for society, cannot be left out of this evolutionary process and, therefore, must provide students with an interaction with multimedia so that they can dominate and exercise their citizenship in the society that presents itself. computerized. Currently schools are receiving students who were born and live in a computerized environment. Therefore it is up to the educational institutions to consider this context in which students are inserted to foster innovative pedagogical proposals that are closer to the reality experienced by these students in their daily lives, thus contributing to overcome difficulties in learning certain curricular components, such as mathematics. Educators such as D'Ambrosio (2001) and Moran (2004), as they advocate the use of digital resources in mathematics teaching. They claim that these features make it possible to establish relationships between geometry, algebra and the other branches of this science. We realize that the teaching of mathematics throughout history has been inefficient because it requires learners a high capacity for abstraction. The lack of resources that allow the visualization and manipulation of geometric and algebraic relations has

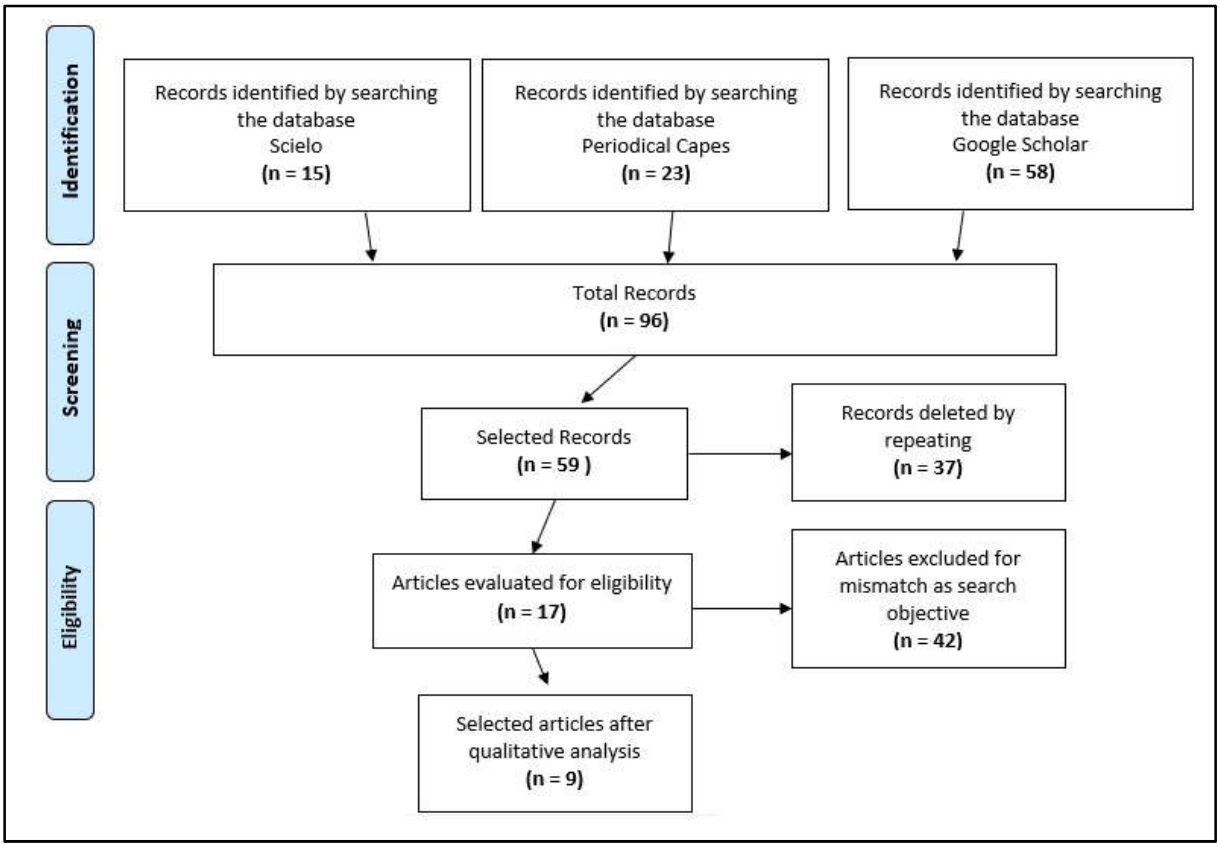

Figure 1. Prisma Flow Diagram

contributed to the deficiency of modern science teaching and learning. The exclusive use of the textbook as a tool for teaching and learning mathematics has also been inefficient, leading teachers to reflect on the need to use technological resources that enable a greater investigation of the geometric and algebraic properties present in mathematics. With the use of educational software, such as geogebra, teachers can provide a dynamic study of mathematics, because it is possible through this application the dynamic visualization and exploration of representations and properties of geometry and algebra. This context leads us to the guiding question of this research, since we want to investigate: How can geogebra software be used in the teaching of mathematics in basic education?

In this perspective, this article aims to investigate the applications of geogebra software in the teaching of mathematics, identifying what content of mathematics studied in basic education can be worked and the contributions of its use in learning this subject.

METHODOLOGY

An integrative literature review study was conducted on the theme of this work in order to identify articles that portray the use of geogebra software in teaching and learning mathematics. The integrative review consists of a methodological approach that has the general purpose of systematically gathering works, articles and scholarly works on a specific topic, in order to gather knowledge on a topic to be investigated. For the elaboration of this review we will follow the phases of its elaboration process, which are: (1) elaboration of the guiding question, already presented in the introduction of this article; (2) search or sampling in the literature; (3) data collection; (4) critical analysis of included studies; (5) discussion of the results and (6) presentation of the integrative review. (SOUZA; SILVA; CARVALHO, 2010) Regarding the literature search and data collection, we surveyed the articles investigated in the following databases: Scielo, Periodicals Capes and Google Scholar. Being used, for the search of the articles, the following descriptors and their combinations in the Portuguese language: "geogebra software", "mathematics", "teaching", "learning", and "basic education". The inclusion criteria defined for the selection of articles were: (1) articles published in Portuguese; (2) Articles published in national and international journals; (3) articles related to the purpose of this paper; (4) article published from 2015 to 2019. In figure 1, we can see the Prisma Flow diagram of the database search. Prisma Flow consists of a flow diagram that describes the systematic steps of directory searches highlighting the adoption of article selection criteria in their different phases. It maps the number of records identified, included or excluded, and the reasons for the deletions. In our research we adopted as exclusion criteria: (1) Repeated records in different directories; (2) article that presents incompatibility with the objective of this research and (3) reading and qualitative analysis of the abstracts of the articles.

RESULTS AND DISCUSSIONS

Geogebra is a dynamic math application that combines geometry and algebra with the same degree of importance. It was developed by Markus Hohenwarter together with an international team of programmers and is intended to assist in teaching and learning mathematics. It is a free software that is easy to install, has a simple interface and is available in 22 languages (HOHENWARTER and HOHENWARTER, 2009). The application can be accessed online either directly from its official website (www.geogebra.org) or via the downloadable installation available on the same site as a multiplatform program as it can be run on Windows operating systems,

Table 1. Analysis chart of selected articles

AUTHOR (YEAR)	GOAL	RESULTS	CONCLUSIONS	PERIODIC	QUALIS BRAZIL	DATA BASE
Zampierie Javaroni (2018)	Discuss about continuing education actions focused on carrying out experimental activities with geogebra software.	It was found that the teachers who participated of these actions recognized geogebra as a learning enhancermathematics.	It is concluded that the software features enhance the teaching and learning processes of Mathematics within the different contexts.	Bolema	A1	Scielo
Azevedoe Alves (2019)	Present an experience report involving the teaching of trigonometry and the use of geogebra software in a 2nd year high school class.	It was observed that with the use of geogebra software, in the topics of Trigonometry, there was a greater participation and interest of the students for the subject, with this we had a better understanding of the conceptsstudied.	It was found that geogebra software contributed to a better articulation of mathematical logical reasoning in the search for solutions of the proposed activities, becoming an articulator between theory and practice.	Tangram - Journal of Mathematical Education	A4	Google Scholar
Santana, *et all* (2019)	Addressing pedagogical strategies applied in the discipline of Linear Algebra using geogebra educational software to innovate the process of teaching and learning mathematics.	It was found that geogebra software can be used in working with algebra, especially in studies involving minimum and maximum of a function.	It has been found that the use of software in algebra teaching has helped students to better understand some concepts worked in the classroom, besides making the study more enjoyable and interesting.	Brazilian Journal of Development	B2	Google Scholar
Amado, Sanchez e Pinto (2015)	Identify the contributions of geogebra software in the study of demonstrations of the properties related to the notable points of the triangle.	The results point to the importance of the activity with geogebra, in the construction and manipulation as a starting point for the demonstration.	It is concluded that students recognize the importance of geogebra in its activity as a motivating factor and, above all, for allowing to experiment and manipulate figures.	Bolema	A1	Scielo
Urdaneta, González e Castilho (2017)	Describes the design of a feature developed with geogebra software and its application in a didactic sequence involving the concepts of sine, cosine and tangent from an angle.	Among some results, it was possible to realize that the geogebra software favors the understanding of trigonometric ratios allowing the determination of certain characteristics of the Sine, Cosine and Tangent.	It is concluded that teachers can count on these new didactic alternatives as tools that complement your practice so that you can meet learning expectations proposed in Mathematical Education.	Amazônia - Journal of Science and Mathematics Education	A2	Periodical Capes
Domingues, Sturion e Carvalho (2019)	Application analysis of geogebra software as an alternative methodological approach to teaching and learning problems involving compound functions.	It was observed that the students still present many difficulties, and some mathematical concepts have not yet been fully understood.	It is concluded that a large part of the collegiate had difficulty with regard to studied content, what helped was the software, which allowed the students to visualized both the algebraic and the geometric format (graph of functions).	REnCiMa.	A3	Google Scholar
Trentin e Bitarello (2018)	To study the use of Geogebra software in the teaching of spatial geometry to high school students from a municipality whose economy is based on family farming, in order to verify their contributions in the learning process.	Was it is possible to observe a strong interaction between the students in the discussion of the problems as well as their autonomy and protagonism when constructing the geometric shapes and interacting with the software resources.	With the application of the didactic proposal it was possible to conclude as positive and relevant the contributions of geogebra, especially because it is a versatile tool for the construction, visualization and movement of geometric figures.	Tecné, episteme y didaxis: ted.	A2	Google Scholar
Beltrãoan d Barbosa (2017)	Describe results from a software use study geogebra as a teacher's auxiliary tool in teaching complex numbers.	The results indicate the need to use mathematical software continuously in class, as a way to teach content in a logic that integrates theory and practice in teaching.	The use of geogebra enabled the student the use of strategies, leading him to engage in mathematical applications, developing and improving logical thinking skills and providing moments of interaction, exchange of experiences and discussions.	Journal of Studies and Research on Technologica l Education	A3	Periodical Capes
Cardoso (2019)	Identify ways to use geogebra software in teaching and learning mathematics, with regard to algebra as well as geometry, for meaningful learning.	It was found that the software can be used in the teaching and learning of functions, as well as understanding the behavior of their graphs, such as the Quadratic Function.	It is concluded that through geogebra software we can create, build and develop learning objects, as well as manipulate them to better obtain mathematical knowledge.	IDEAS-Ideas&Innova tion	B3	Google Scholar

Linux, MacOsx, and recently on Android and iOS tablets and phones for iPads and iPhones. In it can be made geometric constructions (points, vectors, segments, conic sections, lines and functions in general) allowing the active manipulation by changing their coordinates, besides constructing graphs of functions and can identify their fundamental points by exploring more dynamically. all behavior curve of the function. The geogebra software environment provides three different views of mathematical objects: the graphics zone, the algebraic, or numeric zone, and the spreadsheet. They allow to

show mathematical objects in two different representations: (i) graphically, through points, function graphs and others; (II) Algebraically, through Cartesian coordinates, equations and others. So all representations of the same object are dynamically linked and automatically adapt to changes made to any of them, regardless of how they were initially created. (HOHENWARTER and HOHENWARTER, 2009). The geogebra also enables the construction of flat and spatial geometric figures, as well as the identification of segments, points, coordinates, vectors and graphs of various functions, as well as the dynamic modification of these constructions. With geogebra you can also enter equations and coordinates directly in the command input box. In addition, it can handle variables of numbers, vectors, and points, as well as determine derivatives and integrals of functions. Based on the analyzed articles, we identified applications of using geogebra software in basic education contents related to: (1) Basic knowledge of arithmetic as in the studies pointed out by Zampieri and Javaroni (2018) with fractions; (2) Algebra, such as affine, quadratic and trigonometric functions, present in the articles by Azevedo and Alves (2019), Santana, et al (2019), Amado, Sanchez and Pinto (2015) and Urdaneta, González and Castilho (2017); (3) Flat and spatial geometry, present in the works of Trentin, Bitarello (2018); (4) Problem solving, quoted in research by Domingues, Sturion and Carvalho (2019); (5) The complex numbers highlighted in the article by Beltrão and Barbosa (2017); besides (6) other contents such as probability, statistics and vectors, cited in Cardoso's work (2019). Zampieri and Javaroni (2018) highlight the importance of teacher education for a good use of software in mathematics teaching, they affirm that the realization of activities with geogebra, within an experimental approach, promotes rich reflections, allowing teachers to collaboratively analyze them and make their criticisms, aiming at the learning of their students. In their work, they point out that geogebra can assist teachers in teaching content ranging from basic fractions to the study of functions.

It was also evidenced the use of geogebra software as an aid in the interpretation of graphs of algebraic functions, such as affine, quadratic and trigonometric functions. Azevedo and Alves (2019) highlight in their research that the geogebra favors the understanding of trigonometric functions, since students clearly understand their graphical properties. They point out that a class using the software goes beyond a traditional class, because it draws attention as it allows to present practical applications of the knowledge studied. Urdaneta, González and Castilho (2017) point out that the software also helps in understanding and interpreting the relations of sine, cosine and tangent in the trigonometric circle. Amado, Sanchez and Pinto (2015) bring a valuable application of geogebra software in mathematical demonstrations performed in the classroom, especially in the field of geometry, where the dynamic characteristics of the application favor the construction and application of motion of geometric shapes, but preserving its graphical properties. An interesting aspect identified in the work of Domingues, Sturion and Carvalho (2019) is the difficulty still present in many students with the basic concepts of mathematics. In their research, they point out that many students present had difficulties in performing simple calculations (basic operations), such as multiplication and division. The authors also noted some students' difficulties with understanding the concept of function and interpreting the graph for identifying the root of a related function. Nevertheless, the authors still argue that geogebra is an application that can help to overcome these difficulties (DOMINGUES; STURION; CARVALHO, 2019). Santana et al. (2019) studied the applications of geogebra software in linear algebra and found that it is a powerful tool for graphically illustrating problem solutions involving matrix and linear system operations, and performing complex calculations simply and safely makes more attractive and interesting teaching.

Trentin and Bitarello (2018) found that the use of 3D features of geogebra software, associated with active methodologies such as Problem Based Learning - PBL, are versatile tools for the construction, visualization and movement of spatial geometrical figures, helping to learn this content. from highschool. Also for high school, the work of Beltrão and Barbosa, (2017) evidenced contributions of the use of geogebra software in teaching and learning content related to complex numbers, mainly in the geometric interpretation of a complex in the Argand-Gauss plane. Furthermore, the authors point out that the dynamism provided by the software helps the math teacher in his practice and motivatesstudents in the process of learning this content. (BELTRÃO; BARBOSA, 2017). In Cardoso's research (2019) we find examples of the use of geogebra software in various mathematical contents in basic education and also in higher education: such as flat and spatial geometry, algebra, probability, statistics and the study of vectors. The author points out that, using the software, we can create, build and develop objects, as well as manipulate them for a better understanding of their geometric and algebraic properties. Thus favoring the learning of the contents highlighted by him. Based on the precepts of the integrative review, the chart below was organized based on a critical analysis of the selected articles, in which we summarized the objectives, results and conclusions of the researched articles.

Final Considerations

Based on this research, systematized by an integrative review, we found the geogebra software enhances the processes of teaching and learning mathematics in various contents, ranging from the study of operations with fractions in the early years of elementary school to working with numbers. complex in the high school, passing mainly by the field of algebra with the study of the functions, among them the affine, quadratic and trigonometric function, and by the field of the plane and spatial geometry. Thus, we identified positive and relevant contributions about the use of geogebra software in mathematics teaching, highlighting its dynamic and versatile ability to construct and move flat and spatial geometric shapes, preserving the geometric characteristics of the figure, as well as helping to understand of graphic properties an algebraic function. Despite the findings of this research, we are convinced that this theme is not yet exhausted. With this, we hope that further research will be carried out adding new discoveries and bringing more contributions about the use of geogebra software in mathematics teaching. Therefore, we understand that in the process of teaching and learning mathematics there is no unique and perfect didactic tool, because there are still many obstacles to be overcome. However, we believe that the well-planned use of learning resources such as geogebra software is always valid when the goal is to improve the quality of teaching.

Conflict of interest: No

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