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BEYOND BOOKS: A PRACTICAL EXPERIENCE WITH GEOGEBRA IN THE TEACHING OF GEOMETRY FOR BASIC EDUCATION

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ABSTRACT

This article addresses an exploratory study that analyzes the resolution of geometry problems through the use of GeoGebra software. We explore the role of informatics as a pedagogical resource and the influence of digital media in education since the 1970s, framing our analysis in the theoretical lens of the construct "human-beings-with-media" (Borba; Souto; Canedo Junior, 2021). The main objective of the research was to investigate how the GeoGebra software can be used to solve geometric problems present in mathematics books. The research methodology used was the Exploratory Research because it allows the researcher to develop hypotheses, increase familiarity in a certain subject or intended study and clarify concepts (Marconi, 2008). The results revealed the effectiveness of the GeoGebra software, highlighting its potential to explore mathematical problems of geometry from the perspective of human-beings-with-media, thus expanding the possibilities of investigation in this field.

Keywords: Mathematics. Digital Technologies. GeoGebra Software. Geometry.

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INTRODUCTION

The presence of technologies in Education is not something new. Over time, blackboards, chalks, textbooks and projectors have been considered technologies and used in the teaching and learning process. However, the first experiences of using computers in the school context began in the 1970s, in the United States and France. At that time, the computer began to be introduced in schools as a technological mediator of traditional education, and *software played a significant role in educational advancement (*Valente, 1999; Olive tree; Duro, 2013).

Computers and other digital technologies, such as teaching resources, have become great allies of teachers both in the classroom and outside it, offering a variety of resources, such as sounds, images, and videos, which help in the teaching and learning process. According to Kenski (2012),

> Image, sound, and movement offer more realistic information in relation to what is being taught. When well used, they cause a change in the behaviors of teachers and students, leading them to better knowledge and greater depth of the content studied (KENSKI, 2012, p. 45).

Also in this sense, the computer can offer a great contribution to the teaching and learning process, being considered,

> Powerful in resources, speed, communication and programs, computers allow the creation of a wide space for research, through possibilities of similar situations, test knowledge, dismember contents, discover new concepts, places and ideas. They allow the production of new texts, evaluations, experiences, analyzing something ready, putting the context of the work in shock. In addition to serving as a support to produce other texts, thus creating an individual or collective search (Reis; Saints; Tavares; 2012, p. 223).

According to Oliveira (1997), *educational software can be divided into two categories: applications, which were not originally created for educational purposes, such as databases, word processors, spreadsheets and image editors; and educational software itself, developed especially to assist the construction of knowledge in a specific area, with or without the teacher's mediation. These educational software aims to assist in the teaching and learning process, being characterized by their didactic character.*

Educational *software has demonstrated significant contributions to the teaching of mathematics, providing greater agility in calculations and the creation and manipulation of graphs. These tools allow students to focus more on studying, avoiding the need to perform long and tiring constructions and calculations on paper. In addition, the use of graphs in* *educational software* expands and consolidates conceptual knowledge, facilitating learning (Oliveira; Duro, 2013).

In this context, the objective of this study is to explore two educational technologies: textbooks and *educational software, with a focus on GeoGebra. We intend to verify how the geometry exercises present in the mathematics book can be developed in* the GeoGebra software, expanding the possibilities of visualization, manipulation and solving methods for the chosen problems. For this, we selected the textbook from the collection "The Conquest of Mathematics", authored by José Ruy Giovanni Junior and Benedicto Castrucci, published in 2018 by the publisher FTD. This mathematics book was used in the state school system of the city of Cacoal, Rondônia, during the 2021 school year, where the author resides [2]. The methodology used in this study is Exploratory Research, whose objective is to increase familiarity with the proposed theme. The selected problems will be addressed through an investigation that seeks to expand the possibilities of resolution, exploring the GeoGebra software for its educational characteristics.

In the subsequent sections, we will address the use of information technology as a pedagogical resource and the role of digital media in the Education scenario. Then, the aspects of the research methodology, the results and the discussions about the development of geometry exercises in the *GeoGebra* software will be presented.

THE ADVANCEMENT OF DIGITAL TECHNOLOGIES IN THE EDUCATIONAL SCENARIO

The use of information technology in learning as a pedagogical resource was initially proposed and widely disseminated by countries such as the United States and France in the 1970s. Following the model of digital inclusion in schools, Brazil has initiated an action aimed at improving teachers in the public basic education system and the use of computers in the classroom.

THE INFLUENCES OF THE UNITED STATES AND FRANCE ON THE USE OF INFORMATION TECHNOLOGY AS A PEDAGOGICAL PROPOSAL

In the 1970s, the United States and France had been implementing information technology in Education with the objective of developing pedagogical actions with the use of this technology. In Brazil, university educators began a discussion about what was

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happening in these other countries, with the initial intention of making these machines assume the role of "thinking machines" (Valente, 1999).

Initially, these machines would help teachers in their classroom activities, since the only pedagogical resources available at that time were the blackboard, chalk, textbook and other manipulated materials.

According to Valente (1999):

> In the early 60s, several *programmed instruction software were implemented on the computer, materializing the teaching machine, idealized by Skinner in the early 50s. Computer-aided instruction (CAI) was born, produced by companies such as IBM, RCA and Digital and used mainly in universities (VALENTE, 1999, p. 03).*

Universities in the United States already used computers aimed at pedagogical practices in the area of technology, but these technological resources took a while to reach the basic level of education. The number of computers was not enough to serve all schools, somewhat delaying the use of information technology in North American Education as a pedagogical resource. The Brazilian reality was not very different in relation to the implementation of computers in schools.

In the early 1990s, Brazilian schools began to receive computers together with the assembly of computer labs. With the insertion of computers in the school, teachers had the opportunity to experience educational informatics. Teachers who ventured into the use of computers in their classes did so mainly in the production of texts, in solving problems related to the discipline of exact sciences, in the manipulation of data, among others (Valente, 1999).

These small advances in education in the area of technology encouraged the Brazilian and international market in the production and diversification of demonstration programs with tutorials, educational games and simulators, having as main aspect activities of the time that related exercise and practice. One of these programs was the Logo language, which is characterized by the representation of a turtle that obeys programming language commands. The "Logo" language was implemented in the United States in 1967, based on Jean Piaget's theory and some ideas of Artificial Intelligence (Valente, 1999).

In 1983, the Ministry of Education and Culture (MEC) started the Computers in Education Project (EDUCOM) through the Special Secretariat of Informatics, where public universities presented their projects called Pilot Centers, which intended to carry out experiments in the area of informatics in education. The projects submitted by public universities that applied for the implementation of Pilot Centers underwent an analysis by the Special Commission on Informatics (CE/IE). The approval of the projects went through a selection of criteria, such as: (a) the use of computers in the teaching and learning process; (b) training of human resources; (c) use in High School. Thus, the Educational Informatics Centers (Cenifor) were created, which had the function of coordinating fundraising and transfer, promoting the integration of Pilot Centers and monitoring the activities developed (Oliveira, 1997).

Oliveira (1997) points out that the approved projects had as their central focus the development of research focused on the intersection between informatics and education, with special attention to the application of these technologies in high school. The Pilot Centers, in turn, have made a commitment to explore various aspects in their trajectories, including the training of human resources, the production and analysis of *educational software, as well as studies related to Special Education.*

In the context of these initiatives, the Pilot Centers have played a key role in training teachers by adopting a self-training approach. In this dynamic, the teachers themselves assumed the responsibility of preparing and producing the didactic material necessary to teach specialization and training courses for both researchers and fellow teachers in the area of Informatics in Education. This approach contributed to strengthening the expertise of educators in the effective use of digital technologies as pedagogical resources, fostering the creation of a more dynamic, innovative educational environment aligned with contemporary teaching-learning demands.

The first public universities that participated in the EDUCOM Project through the Pilot Centers were: Federal University of Pernambuco (UFPE), Federal University of Rio Grande do Sul (UFRGS), Federal University of Minas Gerais (UFMG), University of Campinas (UNICAMP), Federal University of Rio de Janeiro (UFRJ). UNICAMP offered the first specialization course in Informatics in Education, which became known as Formar I. Then, UNICAMP launched Formar II, which trained teachers from several Brazilian cities and states.

In these courses, teachers knew the technological tools and were stimulated to a change in professional practice, which according to Valente (1999)

> The training courses for teachers capable of integrating information technology and the activities they develop in the classroom require a new approach, incorporating pedagogical aspects that contribute to the teacher being able to build, in his

> workplace, the necessary and favorable conditions for changing the current pedagogical practice" (VALENTE, 1999, p. 135).

For Oliveira (1997), teachers and students should position themselves in front of this new educational tool with analytical, critical capacity and construction of the teaching and learning process. For teachers, it would also be necessary to rethink their pedagogical practice and, if necessary, their teaching methodology. This reflection did not have the function of training technicians in Informatics in Education, but educators who would be able to elaborate and propose new teaching activities with the use of this educational technology. The training courses, Formar I and II, intended to encourage the education professional to develop other research on the use of computers as pedagogical resources, integrating new professionals who defend technology in the classroom.

The arrival of computers in schools in the early 1990s provoked in teachers a feeling that the use of this technology would bring a new style of behavior in the classroom, promoting, in a way, a new relationship between teacher and student (OLIVEIRA, 1997). Basic Education teachers took training courses offered by the government in the area of educational informatics, with the objective of training people with consistent and participatory skills. The courses were offered in a group way and trained the teacher to perform new functions in the classroom, such as ensuring training for the use and understanding of technologies by students.

The National Program of Informatics in Education (PROINFO), created in 1997, acted in the coordination and responsibility of the Secretariat of Distance Education (SEED), covering the public network of Basic Education in all school units of the Federation. One of its main objectives of PROINFO was "to promote the development of the use of computer technology as a form of pedagogical enrichment" (Straub, 2005, p. 51).

PROINFO's primary objective was to improve the quality of Education, concentrating its efforts on improving teaching and learning processes. To achieve this goal, the program emphasized the stimulation of scientific and technological development, while promoting the continuous and permanent training of computer teachers and technicians. This training process occurred in two distinct stages: initially, through a specialization course for teachers, known as multipliers, who were responsible for disseminating the knowledge acquired to other teachers selected in the schools that benefited from the implementation of computers (Straub, 2005). After the conclusion of the training by PROINFO, new training courses were conducted in the Educational Technology Centers (NTE), operating at two different levels: the multipliers, specialists in training other teachers in the use of telematics in the classroom, and the teachers of the schools themselves. The figure of the teacher-multiplier assumed an essential role in the process of disseminating knowledge, ensuring that the benefits of technology effectively and comprehensively reached all the schools involved (Straub, 2005, p.52).

This two-level approach ensured that education professionals were adequately prepared to incorporate digital information technologies into their pedagogical practices, maximizing their potential for enriching the educational process. However, Straub (2005) stated that the presence of computers in the school does not guarantee quality education; It is necessary to adequately train teachers capable of using digital information technologies to teach and, thus, avoid the underuse of laboratories. Computer labs need to be seen as a space for teaching and learning, considering that Digital Technologies (DT) have been gaining more and more space in the lives of teachers and, especially, students. Therefore, the need to cross the boundaries of conventional education is urgent.

Some researchers in Brazil, based on the immersion of DT in the educational scenario, proposed to investigate and, for didactic purposes, classify the phases with which these technologies act in this scenario.

THE PHASES OF DIGITAL TECHNOLOGIES IN THE EDUCATIONAL SCENARIO

Digital Technologies (DT) are present in our private lives, in the social world and in the development of knowledge in our time. However, the focus here is to highlight the key role of these technologies in the education landscape. To this end, we will delve into the contributions of Borba, Scucuglia and Gadanidis (2014), presented in the work entitled "Phases of Digital Technologies in Mathematics Education", in which the authors offer an overview of research on technologies and bring to light the discussion of the four phases of technologies. In addition, Borba, Souto, and Canedo Júnior (2021), in their work "Videos in Mathematics Education: Paulo Freire and the fifth phase of digital technologies", advance by proposing a fifth phase of digital technologies, which, according to them, emerges as a response to the demands brought about by the SARS-CoV-2 virus, a non-human actor. In this context, it is crucial to understand how these phases of digital technologies impact and influence the educational scenario, especially in the context of teaching and learning Mathematics.

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Still in the first four phases of digital technologies, the authors show this panorama to describe the movement of transformation of the classroom. In a brief explanation, we can highlight that the first phase, which began in the 1980s, discussed the use of calculators, computers, and *software. The term used was information technologies (IT), but this phase was characterized by* the use of the LOGO software, which emphasized the use of computer language, programming, and mathematical thinking. At this stage, there was concern with the implementation of computer labs, with the training of teachers with this specialty, and computers were considered catalysts for pedagogical changes in the classroom.

The second phase began around the 1990s. At this stage, there was a very large movement in relation to the development of *educational software, of which Winplot*, *Graphmatica*, for the teaching of functions and *Cabri Géométre, Geometricks*, for the teaching of geometry, stood out. The didactic-pedagogical possibilities that these *software presented awakened in some teachers and researchers ideas that worked on the manipulation, combination and visualization of the construction of mathematical objects. There was a concern about how educational agents saw the role of computers, both personally and professionally. Many teachers had not yet used computers, "[...] still others, because they perceived the cognitive, social and cultural transformations that occurred with the use of IT, sought to explore didactic-pedagogical possibilities" (Borba; Scucuglia; Gadanidis, 2014, p. 22).*

The third phase began with the advent of the internet, in 1999. In education, the internet is beginning to be used as a source of research, information and communication. The term used is Information and Communication Technologies (ICT), characterized by the beginning of continuing education courses for teachers, via e-mail, chats and forums.

In 2014, with the emergence of fast internet and greater dissemination of cell phones, computers and tablets, the term used becomes Digital Technology (DT). With this phase, initial distance learning courses also gain strength.

At the end of 2019, a Covid-19 pandemic ravaged the world, and this brought sudden changes, the need for social distancing, the use of masks and other means that could contain the proliferation of the virus. In education, there have also been considerable adaptations and changes; the social distancing caused by Covid-19 meant that teachers at all levels of education had to improve and look for alternatives to teaching, which was called remote. In Mathematics Education, digital videos were an alternative that gained strength

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during the pandemic, and along with the growing search for videos and video production, as well as live streams, the authors Borba, Souto, and Canedo Junior (2022) defend the fifth phase of digital technologies. "Finally, the 'boom' of the lives, as well as the expansion of pedagogical approaches based on the production of videos and the growing popularization of video festivals, constitute events that, among others, announce the fifth phase of DT" (Borba; Souto; Canedo Junior, 2022, p. 43).

What motivates our investigation is mainly the second and fourth phases of DT, because, as Borba, Souto, and Canedo Junior (2022, p. 22) point out, "fast internet allows quick updates of GeoGebra Online", and GeoGebra is an essential part of this research.

EDUCATIONAL SOFTWARE: GEOGEBRA

From the moment a teacher decides to use digital technology as a pedagogical resource, he searches among the *software available on the internet for those that best adapt to his lesson planning (Tajra, 2001). Sometimes, the teacher does not evaluate the software* as a pedagogical resource according to his objectives, analyzing from a didactic point of view if it meets his class needs, if it is in accordance with his target audience, offers feedback, if it is interactive or even if graphics and texts are adequate. Tajra (2001) draws our attention to the fact that:

"Planning educational activities with the support of computers requires more time and greater creative capacity from the teacher. The teacher must investigate and know well the purpose of the *chosen software* and be aware of the appropriate time for its introduction. The class should be dynamic and the *software* used should be related to the curricular activities of the projects to stimulate problem solving" (Tajra, 2001, p. 84).

The adequacy of digital media to classroom actions should not be limited only to the use of some educational *software*, hoping that this will make the teaching proposal in a certain area of knowledge be considered a computer practice in Education (Tajra, 2001). The pedagogical practice with the use of digital media goes beyond a class involving student and computer/cell phone/tablet; It requires creativity, interactivity with new dynamic challenges, which stimulate students to new discoveries and, above all, can contribute to the objectives proposed by the teacher in the teaching of scientific concepts.

Before selecting an educational *software*, it is necessary for the teacher to know the pedagogical proposal, to be aware of how he is basing his teaching practice with the use of the computer (Valle, 2002). The search for educational materials and resources for the teaching of Mathematics, for example, requires the teacher to reflect on his own teaching practice and the student's practice with regard to the teaching and learning process with the use of educational *software*. Thus, it is essential for the teacher to reflect on the contribution that educational *software* can offer to the teaching and learning process of Mathematics, how this material can be used and when it should be used (Valle, 2002).

Therefore, when we think of educational *software* as a pedagogical resource, it is necessary for the teacher to reflect on the use of information technologies and how they contribute to their pedagogical practice in the classroom. When we select educational *software* as a pedagogical resource, it is necessary that this *software* is in accordance with the pedagogical project, which can be considered as a tool to support the teaching work. It is worth remembering that the use of *educational software in the classroom as a pedagogical resource requires reflection on the teaching practice itself, so that the teacher seeks new ways to lead students to achieve the objectives proposed in the pedagogical project.*

RESEARCH METHODOLOGY

The objective of this study is to investigate the development of geometry exercises present in the Mathematics book, by means of the GeoGebra software. To achieve this purpose, we based our research on the Exploratory Research approach proposed by Marconi (2008), characterized by its empirical investigation and emphasizing the formulation of questions or problems. In this context, Exploratory Research seeks to develop hypotheses, increase familiarity with the subject under study and clarify concepts. The data collection in this research can be carried out both through a qualitative and quantitative interpretation of the object of study, allowing the researcher to search for conceptualizations of the interrelations present in the properties of the observed phenomenon (MARCONI, 2008). For this study, content analysis was chosen, justified by the analysis of the potential of the GeoGebra software in the teaching modality of the discipline of Mathematics, with a specific focus on the concepts of Geometry.

In the course of this investigation, two educational technologies will be explored: textbooks and educational software. The selected textbook was "The Conquest of Mathematics", by José Ruy Giovanni Junior and Benedicto Castrucci, published in 2018 by the publisher FTD, which was used in the state education network of the city of Cacoal, Rondônia, during the 2021 school year, the author's place of residence [2]. The selected

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problems were based on the experience of one of the authors as a teacher-trainer of Mathematics teachers at the Federal Institute of Rondônia (IFRO), Campus Cacoal, Rondônia, Brazil. To solve these problems, the GeoGebra Classic 5 software was used. This version was chosen due to the authors' familiarity with the software and the possibility of using the Geogebra.org Platform as a means for the reader to manipulate and appropriate the solution presented.

RESULTS AND DISCUSSIONS

The discussion proposed in this study is to analyze the possibilities of solving the geometry problems that are in the textbook of Elementary School II of the collection "The Conquest of Mathematics" from the use of the GeoGebra software, enhancing possible developments of the solution with the manipulation of the *software.* It is important to emphasize that the National Common Curriculum Base (BNCC) highlights the use of digital technologies in its general competencies, aiming to promote a more comprehensive teaching and aligned with the demands of contemporaneity, by proposing that

> Understand and use digital information and communication technologies in a critical, meaningful, reflective and ethical way in the various social practices (including school ones), to communicate through different languages and media, produce knowledge, solve problems and develop authorial and collective projects (BRASIL, 2018, p. 65).

The chosen textbook collection features a variety of math exercises and problems that are related to the study of geometry. Analyzing the chapters of the book that involve the study of geometry, it is possible to verify a series of problem situations that can be explored with the use of *mathematical software. The authors highlight sections of the book that emphasize the use of technologies, where they explain how to use technological tools to solve mathematical problems or questions. In chart 1, we present the number of problems and exercises on geometry that we found in the books analyzed.*

Table 1 - Number of Mathematics problems/exercises

Book	Number of mathematical exercises/problems
The conquest of Mathematics - 6th grade, 2018	159
The Conquest of Mathematics - 7th grade, 2018	140
The conquest of Mathematics - 8th grade, 2018	128

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The conquest of Mathematics - 9th grade, 2018	229

Source: The authors.

The problems in each book are divided into didactic units that are related to geometry, as shown in chart 2, and represent the geometry contents of elementary school II that should be explored in this segment of education.

Table 2 - Distribution of Sections that have geometry

Book	Textbook Units
The conquest of Mathematics - 6th grade, 2018	Geometric figures; Angles and polygons; Length and Area; Mass, volume and capacity
The Conquest of Mathematics - 7th grade, 2018	Geometric transformation and symmetry; Plane geometric figures; Area and volume
The conquest of Mathematics - 8th grade, 2018	Angles and triangles; Polygons and plane transformation; Area, volume and capacity
The conquest of Mathematics - 9th grade, 2018	Relations between angles; Metric relations in the right triangle and the circumference, Flat, Spatial Figures and Views

Source: The authors.

The problems selected for presentation in this article are questions that arose in Mathematics teacher training courses offered to academics at the Federal Institute of Rondônia, Cacoal Campus. The main questions asked at the time of the courses were: How many Plans are there for a cube? How and what are the transformations of a geometric figure? These questions will be partly contemplated by the selected problems, due to the fact that the statements of the problems explore this theme and have the ability to be analyzed and explored with the use of the GeoGebra software beyond what is suggested in the statement.

The first problem explores the transformations of a geometric figure, more specifically reflection and magnification by a factor. The second problem explores the flattening of a cube. The problem that appears in chart 3 is presented in the book "The conquest of Mathematics - 7th grade".

Chart 3 - Problem on geometric transformation

Starting from a polygon with the vertices at points (2,2), (6,2), (6,5), (4,6) and (2,5), make two transformations: a magnification of factor 2 of the original polygon and then a reflection of this image in relation to the origin.

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a) What are the coordinates of the vertices of the polygon obtained? b) Draw the final polygon and the original polygon on the same Cartesian plane.

Source: Giovanni Júnior and Castrucci, 7th year, (2018, p. 82).

Before presenting the possibility of solving with the use of GeoGebra software, it is necessary to emphasize that the use of graph paper, pencil, or other technologies, does not make solving the problem less captivating. The knowledge produced in the presence of pencil and paper tends to be qualitatively different from that produced in collectives using *software* and applications (BORBA; CANEDO JÚNIOR, 2020).

To solve the problem in GeoGebra, the points presented in the problem must be plotted (chart 3). To do this, it is necessary to insert the coordinates , , , and , in the GeoGebra input field, to facilitate the construction and identification of terms. Thus obtaining the points that will be the vertices of the polygon. In order to be able to make the transformations with a few commands, you must create a list with the points, for this, write in the GeoGebra input field L_1={A,B,C,D,E}$A = (2,2) B = (6,2) C = (6,5) D = (4,6) E = (2,5)$[5]. The Polygon command (<Point List>) creates a polygon. In the GeoGebra input field, typing Pol1=Polygon(L_1) the initial polygon is created and will have the name Pol1 in GeoGebra. The points created as shown, as well as the Pol1 polygon, create an effect that allows manipulation at the points of the plane and allows you to build other shapes of polygons, simply by dragging the points with the help of the mouse over the Cartesian plane in which Pol1 is being built. In order to explore possibilities for solving the problem, the next step is to build a slider that will be called , with the parameters of a minimum value of -5, a maximum value of 5 and an increment equal to 0.5. These values will have the function of transforming the polygon by means of a factor . The k*L_1 operator creates the desired magnification points. You should then create a list of new points that will be called L_2. The command Pol2=Polygon(L_2) creates the polygon with factor magnification, leaving the slider with the value , is part of the solution to the problem. To obtain the expected response, it is necessary to reflect the polygon Pol2 in relation to the origin, this is done using the command Reflection (<Object>, <Point>), where the term <Object> is Pol2 and <Point> is the point of coordinates (0,0). The composition Reflection (Pol2, (0,0)) gives the expected result, which will be called Pol2' in GeoGebra, reflection polygon with respect to origin with a factor magnification. If we manipulate the dots or the slider, we will have

[5] The words, variables and mathematical operators that appear in bold in section 4 of this article refer to programming commands that must be used in *the GeoGebra* software.

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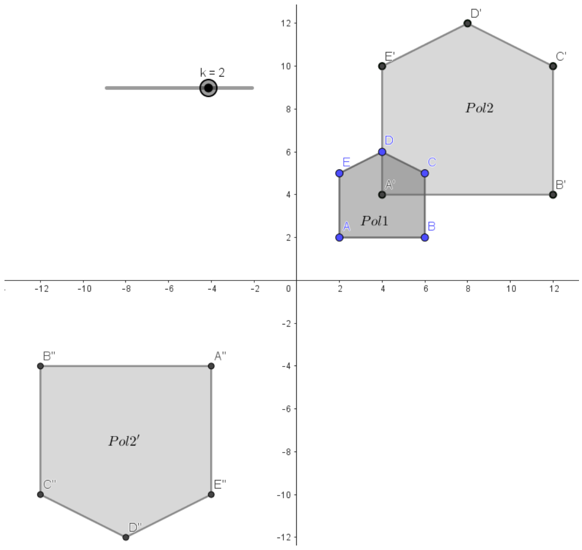
different results, which expands the observation and the power to analyze the problems of reflection and magnification. Observing the polygon Pol2', as shown in figure 1, the result of this transformation, it is possible to perceive the new coordinates of the vertices of the generated polygon, which are represented by A" = (-4,-4), B" = (-12,-4), C" = (-12,-10), D" = (-8,-12) and E" = (-4,-10). The visualization of this resolution, as well as the manipulation of the points of the initial polygon can be found on the Geogebra.org platform through the link $kkkk = 2k$https://www.GeoGebra.org/m/ab76jckd

Figure 1 - Geometric transformation made in GeoGebra



Source: The authors.

As a way to present the possibilities of transformations of the initial polygon, we present a transformation with factor with the initial polygon modified its vertices, see figure 2.$k = 3$

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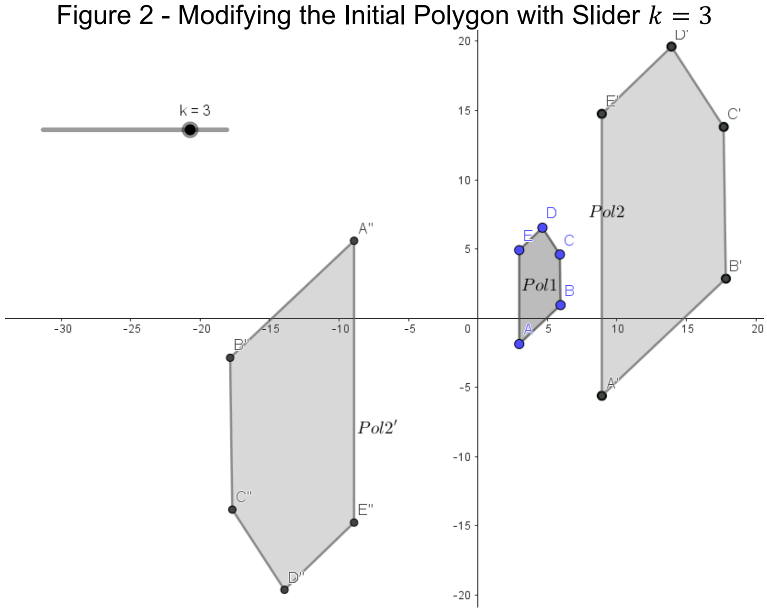
Figure 2 - Modifying the Initial Polygon with Slider $k = 3$

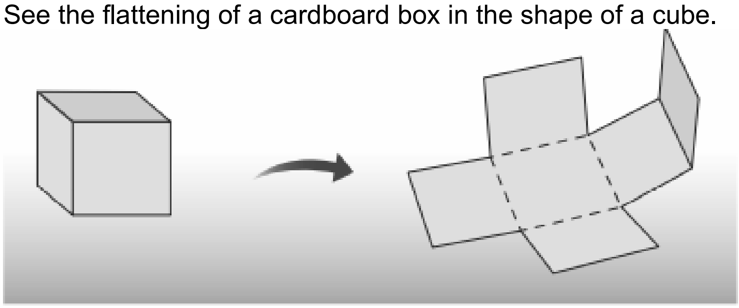


Source: The authors.

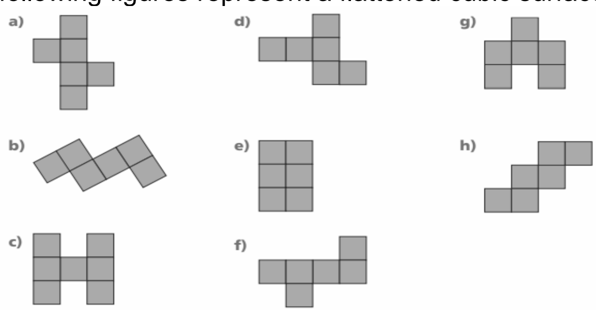
The second problem (chart 4) developed with the help of GeoGebra was based on the exercise proposal of the book "The conquest of Mathematics, 6th grade, 2018" (GIOVANNI JUNIOR; CASTRUCCI, 2018).

Table 4 - Cube planning challenge

See the flattening of a cardboard box in the shape of a cube.



There is more than one cube flattening. Find out and record in the notebook which of the following figures represent a flattened cubic surface.



Source: Giovanni Júnior and Castrucci, 6th year, (2018, p. 95).

This challenge is interesting from the point of view of the visual perspectives that students need to be able to compose the cube presented in the problem in the form of

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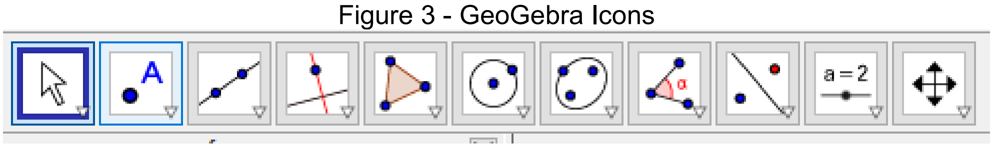
plans. One way to explore the challenge is to propose to students the preparation on paper of the options contained in the problem in chart 4, this idea can lead students, as well as the resolution through the imaginary, to identify which plans form a cube. For the authors, the correct answers are the alternatives: a, b, d, f and h. A question that may arise is: are there only these flattenings for the cube? One way to analyze and explore this activity is to propose a resolution through the GeoGebra software. It is worth mentioning that even using GeoGebra, the resolution is not so trivial from the point of view of building the eleven possibilities of flattening a cube.

GeoGebra presents a resolution in a simplified way with a few commands for a single plan. For clarification and better monitoring of the commands indicated here, the GeoGebra *classic* 5.0 version for computers will be used and then the file will be made available on the GeoGebra.org platform. We must initially make the algebra window, the 2D viewing window and the 3D viewing window available for viewing to perform the activity.

First, a square will be made using the regular polygon option, by the command Polygon(<Point>, Point>, <Number of Vertices>) or by selecting the regular polygon icon, which is represented by a triangle, as shown in figure 3, and you must click on the arrow in the lower right corner of the icon to access the desired option, clicking on the grid of the 2D viewing window at points (0,0) and (1,0) and number of sides 4.

Figure 3 - GeoGebra Icons



Source: The authors

This command will guarantee the properties of the square and, in general, GeoGebra will name Pol1 and present the value of the area of this square in the algebra window, becoming Pol1=1. Now with the Cube (<Square>) command, we type the expression Cube (Pol1) in the GeoGebra input command. GeoGebra will automatically name the cube by the letter . A slider must be constructed, which we can name it, with parameters of minimum value at zero, maximum value at 1 and increment 0.1. This slider will determine the stages of the cube flattening, the maximum being 1.am

To flatten the cube, simply enter the command Flattening(<Polyhedron>, <Number>). In this command the term <Polyhedron> should be replaced by the cube name, polyhedron in question, and the term <Number> by the name of the slider. Thus, the Planning

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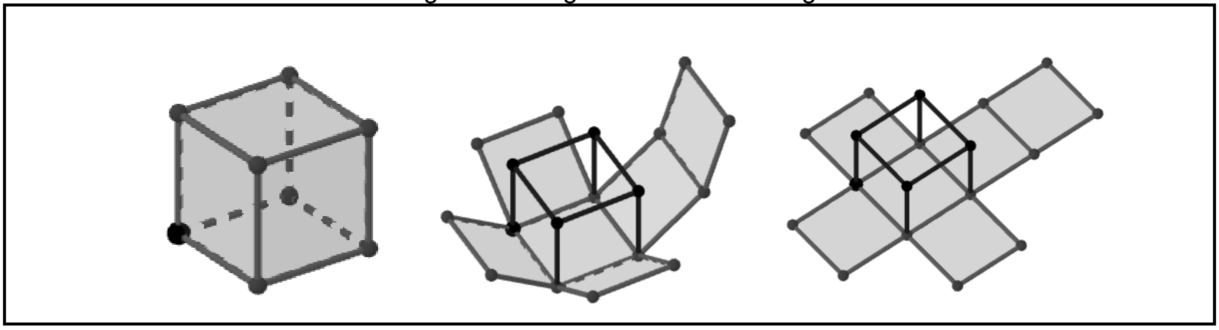
command (a,) will give a single possibility to flatten the cube. In this construction, the slider () makes it possible to view the cube in different planning stages. When , the cube will be completely closed. When , the cube opens its faces. In figure 4, we have , respectively.$ammmm = 00 < m \leq 1m = 0, m = 0.7\ e\ m = 1$

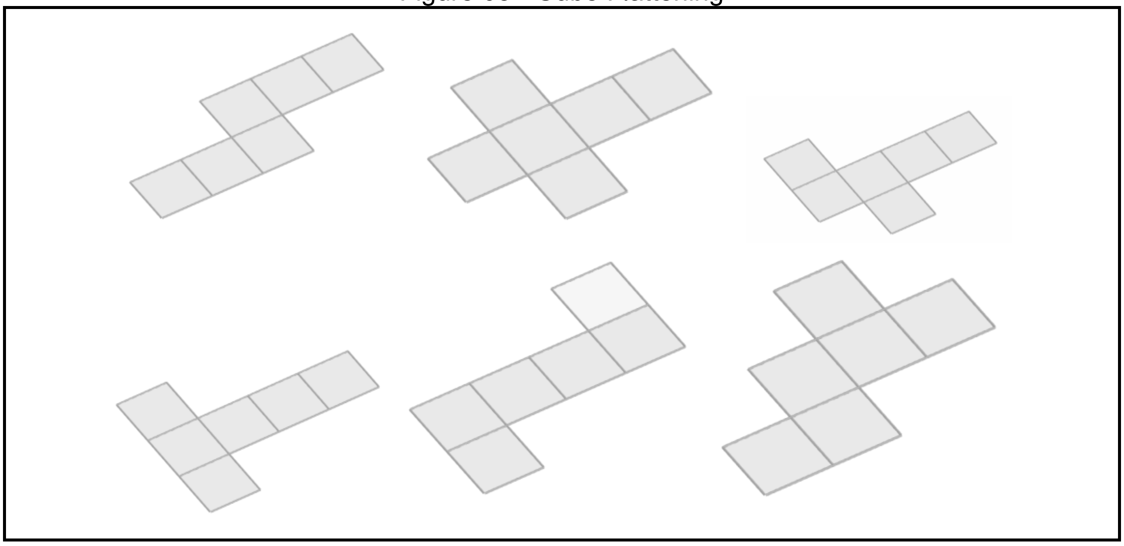
Figure 4 - Stages of cube flattening



Source: The authors.

The eleven forms of planning can be viewed and manipulated through the GeoGebra.org platform (https://www.GeoGebra.org/m/ab76jckd). In the flattening it is possible to manipulate the sliders that have the function of choosing the type of flattening among the eleven possible and the slider that has the function of controlling the stage of opening these flattenings. The control keeps the cube closed and keeps the cube flat in its entirety. In addition to the possibilities given in the problem by the answer options of items a, b, d, f and h, other forms can be analyzed, figure 5, which complement the answer options of the proposed challenge.$n\alpha\alpha = 0\alpha = 90$

Figure 05 - Cube Flattening



Source: The authors.

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For the problem proposed in chart 4, GeoGebra software technologies were used to expand the possibilities of visualizing and solving a mathematical problem. In this case of expanding possibilities, the GeoGebra software facilitates the manipulation of plane or spatial figures, encourages the creation of other answers that go beyond what is proposed in the textbook, promotes creativity and values the student's independence by making him venture into other paths.

The discussion to solve this problem (chart 4), as well as the way to manipulate a possible solution through the GeoGebra.org platform is in line with the second and fourth phases of the development of Digital Technologies and permeates the theoretical construct of human beings-with-media (BORBA; SOUTO; CANEDO JÚNIOR, 2021), as we understand that the construction of problem solving involves "[...] actions of a thinking collective composed of human actors and media" (BORBA and CANEDO JÚNIOR, 2020, p. 178). The media are understood as non-human actors, and not an apparatus of human actions, assuming a role of action in this process of knowledge construction. ,

FINAL CONSIDERATIONS

After a careful analysis of the collection of the textbook "The Conquest of Mathematics", by José Ruy Giovanni Junior and Benedicto Castrucci, published in 2018 by FTD, we found that the work offers a variety of mathematical problems and exercises that can be enriched with the use of digital technologies. The selection of the problems to be analyzed with the GeoGebra software derived from the authors' discussions about the possibilities of some problems exceeding the limits established by the statement. The problem presented in chart 4 clearly illustrates this perspective of expanding discussions and resolutions by incorporating technological resources. Our research revealed that solving a textbook problem through digital technologies significantly expands the possibilities for solving, discussion of magnification, and conceptualization compared to the traditional pencil-and-paper approach. By transposing the exercises from the book to the GeoGebra software, we identified, in practice, the influence of phases 2 and 4 of the digital technologies described by Borba, Souto, and Canedo Júnior (2021). The second phase addresses the creation and elaboration of specific software for educational purposes, and in this context, the use of GeoGebra as a technological resource is in line with this stage of Digital Technologies (DT). The possibility of sharing the resolution through the

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Geogebra.org platform allows the reader to interact and manipulate the proposed solution, aligning with the fourth phase of DT, also presented in the same book.

The primary objective of this study was to verify how the geometry exercises present in the mathematics book could be approached and developed with the help of the GeoGebra software. In this sense, we present our own approaches to the two highlighted problems and argue that the solutions offered by the authors are not unique. In the context of knowledge mediated by technologies, the possibilities are expanded, providing multiple paths to solve the same problem, which contributes significantly to student learning and fosters the production of knowledge. The GeoGebra software stood out as a powerful digital media by enabling visualization, dynamicity, interaction and an environment conducive to the production of mathematical knowledge.

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