

THE USE OF ARTIFICIAL INTELLIGENCE, MATHEMATICAL MODELING AND PROBLEM SOLVING AS ENHANCERS IN THE PROCESS OF TEACHING AND LEARNING MATHEMATICS IN THE SEVENTH YEAR OF ELEMENTARY SCHOOL



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ABSTRACT

The main objective of this article is to verify the potential of the use of Artificial Intelligence, Mathematical Modeling and Problem Solving in the 7th grade of Elementary School. Artificial Intelligence is a current subject and, therefore, it is considered of great importance to verify the possibilities of this tool in the school environment and, in the case of this article, in the learning of Mathematics. To this end, a didactic sequence was elaborated that begins with the presentation to the students of the technological tools, some problems to be solved, some climatic situations that can be modeled and their modeling and presentation of the results. The activity was developed with a group of five students from the 7th grade of Elementary School of a public school in the metropolitan region of Porto Alegre. The option for students at this school level is due to the fact that at this stage the content of Algebra is introduced, a moment of considerable break in conceptual paradigms and mathematical abstraction, this skill is a great challenge for the current generation known as Generation Alpha which is driven by agility, curiosity, independence, difficulty concentrating, surrounded by technology and connectivity and that values experience more than theory. On the other hand, AI can make the student not make an effort to solve the proposed exercises, thus harming their learning. The research resulted in some relevant findings about the use of this tool, encourages student engagement in Mathematics classes, helps the individualization of teaching, supports the transition from the concrete operative stage to the formal operative stage according to Piaget's genetic epistemology, the use in Mathematics classes must be supervised and all results validated, because Artificial Intelligence can make mistakes, and finally, it can cause cognitive dependence due to inappropriate use and without teacher monitoring.

Keywords: Artificial Intelligence. Mathematical Modeling. Equations of the 1st degree.

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INTRODUCTION

Artificial Intelligence (AI) is a subject that is on the rise, it is an opportunity to include it as a teaching and learning tool in mathematics, so that students have contact with this technology in an era contemporary to its emergence, and not in an inopportune way as is common to happen.

Thus, this research aims to verify the potential of using AI in mathematics education for a specific situation, with adolescents who are in the 7th grade of elementary school, a public that does not have full ability to master abstract thinking.

About this phase of teaching, the National Common Curricular Base (BNCC) in its complement called Computing brings the ability "(EF07CO03) Build computational solutions to problems from different areas of knowledge, individually and collaboratively, selecting the appropriate data structures and techniques, improving and articulating school knowledge". (BRASIL, 2022, p. 42)

The mathematical part of this research will deal with algebraic expressions, mainly in the form of 1st degree equations, because it is a subject that is being formally introduced for the 7th grade of elementary school. In order to have practical results that can be applied in daily situations of the students' lives, this theme was worked on using mathematical modeling and problem solving, in addition to working on ideas about the construction of tables and graphs and other subjects that are prerequisites.

To achieve the objectives of this research, five meetings were held with a group of five 7th grade students from a municipal school in the city of Canoas, one of whom was a Haitian immigrant. The final activity was to find a mathematical model in the form of a 1st degree equation that related a certain amount of rainfall to the capacity of a city's drainage pumps.

This article will conclude with the results resulting from the activities and analyses carried out during the work with the students.

ABOUT ARTIFICIAL INTELLIGENCE

There are several definitions of AI across time and space, each shaped to the theoretical interest of the definer. Even today, the definition of AI is not uniform.

A naïve definition is: "the area that is concerned with building artificial artifacts that exhibit intelligent behavior." The difficulty is to define what intelligent behavior is. The definition of "intelligence" is fluid, and human beings have considerable flexibility in relation to the term; We easily accept the limited intelligence of certain

animals, and quickly become accustomed to digital artifacts with clear cognitive limitations. ... Another problem is that there are important differences between reproducing human-like behavior, intelligent by definition, but perhaps not entirely rational based on principles. (COZMAN, NERI, PLONSKI, 2021, p. 21-22)

Another definition that has become popular is that AI is a machine that thinks like a human being, but to make this definition academic, we would have to investigate cognitive science more rigorously. Delving into this area is not the objective of this work, but during the application of the activities with the students, this line of thought cannot be discarded. According to Russel and Norvig (2013, p. 26):

If we want to say that a given program thinks like a human being, we have to have some way of determining how human beings think. The interdisciplinary field of cognitive science brings together computational models of AI and experimental techniques of psychology to try to build accurate and verifiable theories about the processes of the human mind.

Despite significant technological and scientific advances, a general AI has not yet been conceived, with answers for all areas indistinctly. We have found applications and machines making use of AI in specific areas or multiple areas. In addition to the fact that there is no general AI, there is no AI with full knowledge in a certain area, because if we want to obtain a program that thinks like a human being, we have the limitation of human intelligence.

About human intelligence aligned with Wallon's vision, Dantas, Oliveira and Taille (1992, p. 97) wrote, "The ultimate product of the elaboration of an intelligence, concrete, personal, embodied in someone, is a person. The construction of the person is a self-construction".

In the sense of the previous quote, when developing artificial intelligence, part of the construction of knowledge and even intelligence must be carried out by the program itself. In this sense, there is an area of AI called Machine Learning, better known as Machine Learning. In this application, the machine can learn, correct and develop decision-making methods and models.

The importance of these applications in the field of Mathematics Education is relevant, because when implementing these technologies based on the learning of the human mind we have to study how the human being builds mathematical knowledge, ratifying that the development in AI is closely linked to learning theories.

The relevance of this subject made the Ministry of Education in the Complement to the BNCC add AI to the list of Skills and Competencies of the normative document.

Specific Competence: Analyze situations in the contemporary world, selecting appropriate computational techniques for problem solving. Skill EM13CO10: Know the fundamentals of Artificial Intelligence, comparing it with human intelligence, analyzing its potentialities, risks and limits. (BRAZIL, 2022, p. 64)

Therefore, the importance of including this area interrelated with school mathematics is undeniable, so that the new generations of teachers and students are preparing for the current and new moments of the constant technological revolutions that transform the way of thinking about the social space.

ABOUT MATHEMATICAL MODELING

Mathematical Modeling, as a link between the abstract and the concrete, transcends the limits of mere discipline to become an essential tool in the construction of scientific knowledge and in the formation of conscious and critical citizens. Through the creation of mathematical models, we are able to understand nature, predict future events, and optimize complex processes. In the case of elementary school students, it is possible to develop computational thinking, scientific mindset and comprehension beyond just numbers and formulas with little practical applicability.

According to the ideas of Blum (2000), Mathematical Modeling is the activity of building, analyzing and validating mathematical models as tools to understand, explain and predict real-world phenomena.

A broader concept that encompasses Mathematical Modeling is Mathematical Literacy. Epistemologically, the definition of literacy is broader than that of literacy, because according to the text present in the SAE Digital, "the main difference between both is that literacy teaches how to encode and decode the writing system, while literacy teaches how to master and use language in social practice".

The National Institute of Educational Studies and Research Anísio Teixeira – INEP, through the 2012 Mathematics Assessment Matrix for the Program for International Student Assessment – PISA, brought the following definition:

Mathematical literacy is the individual ability to formulate, employ, and interpret mathematics in a variety of contexts. This includes reasoning mathematically and utilizing concepts, procedures, facts, and mathematical tools to describe, explain, and predict phenomena. This helps individuals to recognize the role that

mathematics plays in the world and so that constructive, engaged and reflective citizens can make well-informed judgments and make the necessary decisions. (BRAZIL, 2012)

Mathematical Literacy is interrelated with the concept of Mathematical Modeling in such a way that PISA, one of the world's main instruments for the evaluation of basic education, includes Mathematical Modeling within its assessments, according to the matrix mentioned above.

The definition of mathematical literacy also seeks to employ the concept of mathematical modeling, which has been a cornerstone of PISA's mathematical assessment since the 2003 edition. The mathematical literacy model in practice offers an overview of this construct and how its parts are related. (INEP, 2012)

The importance of the practical approach to this theme in Basic Education is recognized in the BNCC in different assertions, because the work in Mathematical Modeling tends to represent the best strategy to make school mathematics a learning for life so that the student can translate his spatial, social and cultural reality through mathematical skills. According to the BNCC (2017, p. 261):

Mathematics is not restricted only to the quantification of deterministic phenomena – counting, measurement of objects, quantities – and calculation techniques with numbers and quantities, as it also studies the uncertainty arising from phenomena of a random nature. Mathematics creates abstract systems, which organize and interrelate phenomena of space, movement, shapes and numbers, associated or not with phenomena of the physical world. These systems contain ideas and objects that are fundamental for understanding phenomena, constructing meaningful representations, and consistent argumentation in a wide variety of contexts.

There is even in the BNCC (2017, p. 261) a recommendation to go beyond just proving, deducing or problematizing situations in Mathematics classes, but to make the student create, invent or investigate: "[...] it is also of fundamental importance to consider the heuristic role of experiments in the learning of Mathematics."

Still on the potential of using this tool in the classroom, we have a conclusion that:

Activities that bring real issues to the classroom and that enable the construction and discussion of ideas by students, at different levels of education, are relevant for Mathematics Education to be based on the precepts of meaningful learning and, also, involved with the need for critical and reflective training of the student, who needs to be skilled and competent to live and coexist in the construction of a society in full scientific and human development. (TATSCH; RACHELLI; BISOGNIN, 2016)

In view of the above, Mathematical Modeling is a tool, available to mathematics educators, capable of providing the current pedagogical demands with relevant effectiveness. By modeling, the student is transferring mathematical theory and technique to facts and practical cases, whether everyday or not, including revealing Mathematics beyond a discipline of exact calculations and not susceptible to improvement, because mathematical models are sometimes created in order to adapt the situation to be modeled.

METHODOLOGY AND ACTIVITIES CARRIED OUT

This research incorporates characteristics of the qualitative method, as it seeks to verify subjective issues related to student learning and engagement. To do so, it uses naturalistic observations that cannot be quantified exactly, since they involve personal aspects of each individual, as is typical of the measurement of human cognition. Specifically, this research sometimes adopts a phenomenological approach, which focuses on understanding the lived experiences of the participants and the meanings they attribute to these experiences. Phenomenology allows you to deeply explore students' perceptions and feelings, providing a rich and detailed understanding of their learning and engagement processes.

The activities were developed in five meetings that will be described in the next topics.

FIRST MEETING

In the first meeting, the initial arrangements were made, followed by a survey to verify the level of the students' skills in relation to the use of computer and internet technologies. It was found that students, despite spending too much time connected, do not have basic skills such as using e-mail or even with search tools, especially in the act of verifying whether information is useful or reliable.

Once the deficiencies were verified, activities were developed to remedy these difficulties, starting with the creation of an e-mail account, where each student created his or her own account, emphasizing the importance of keeping the password in a safe place, but accessible to each user. Once this is done, we present tips on how to conduct research and obtain data from the internet in order to mitigate the difficulty of differentiating between useful and useless, true or false information. The report from the Arco Magazine of UFSM was used, which cites five items to check information regarding veracity:

- (1) the choice of the discourse to be analyzed;
- (2) the search for sources with information regarding the topic addressed;
- (3) the reconstruction of the context of the discourse contrasted or corroborated by the information obtained from the sources;
- (4) the classification of the discourse according to the categories elaborated – for example, true, false, inaccurate, exaggerated, among others;
- (5) the graphical representation of the check. (ARCO MAGAZINE, 2020)

After that, the professor conducting the research presented Microsoft's Chat Copilot tool, using simple examples of interaction with Artificial Intelligence, such as requesting the writing of an unpublished poem using specific themes, asking for advice, building tables or requesting explanations about common words in Mathematics. Figure 1 presents one of the examples of a table built by AI with the respective request.

Figure 1 – Construction of tables

Construa uma tabela com a distância de Canoas - RS para outras cinco maiores cidades do Rio Grande do Sul

✓ Procurando por distance from Canoas - RS to other five largest cities in Rio Grande do Sul

✓ Gerando respostas para você...

Aqui está uma tabela com a distância de Canoas - RS para as outras cinco maiores cidades do Rio Grande do Sul:

Cidade	Distância (km)
Porto Alegre	12.6
Caxias do Sul	103.1
Pelotas	232.9
Santa Maria	287.8
Gravataí	18.4

Essas informações foram obtidas usando uma ferramenta de cálculo de distância¹. Espero que isso ajude!

Source: Prepared by the author.

After the activities developed in this meeting, it was found that the students already had enough foundations to start the learning phase using AI.

SECOND MEETING

After a small theoretical review, we started to look for models for some problem-situations, where each student should formulate their question or conversation with the AI so that it returned a correct model for the situation. The main activity was to find a mathematical model for the following problem-situation – to know the net salary of Marcos, who works as a salesman in a store and receives 1600 reais per month in fixed salary plus 3% of everything he sells, however there is a discount of 11% of the gross monthly income for social security.

Figure 2 – Students using AI



Source: From the survey.

After the attempts, at least three different models were found, one of which only calculated the social security discount of the variable part of the salary, excluding the fixed part, that is, one thousand six hundred reais, from the discount. Of the other two models found, one obtained only one equation that generates an inconsistent model:

$$\text{salário_líquido}(\text{vendas}) = 1549,92 + 0,0291 * \text{vendas}$$

This equation does not translate the situation to be modeled, because when trying to validate the model for the situation in which the employee has not achieved sales, we would have to:

$$\text{salário_líquido}(\text{vendas}) = 1549,92 + 0,0291 * 0$$

That is

$$\text{salário_líquido}(\text{vendas}) = 1549,92$$

However, for the situation presented, when the employee does not make sales, he receives only the fixed part of reais, so when applying the discount of , the net salary must be real.1600,00 11%1424,00

One of the resolutions that obtained a consistent model started the resolution by organizing the data of the situation described by the student as shown in Figure 3.

Figure 3 – Data extraction from a situation using AI.

encontrar um modelo matemático para a seguinte situação-problema – saber o salário líquido de Marcos que trabalha como vendedor em uma loja e recebe 1600 reais por mês de salário fixo mais 3% de tudo o que ele vender, contudo há um desconto de 11% do rendimento bruto mensal para previdência.

Vamos criar um modelo matemático para determinar o salário líquido de Marcos.

1. **Salário fixo:** R\$1600 por mês
2. **Comissão sobre vendas:** 3% das vendas totais
3. **Desconto para previdência:** 11% do rendimento bruto

Source: From the survey

Using the data from the situation described, the AI named the variables and developed a model using four equations. He first calculated Mark's commission by the sales made through the equation: $(C)(V)$

$$C = 0,3V$$

Using this result, you can present an equation for gross income: (R)

$$R = 1600 + c$$

For the issue of the social security discount, the equation was presented: (P)

$$P = 0,11R$$

And finishing the model generated by the AI, Mark's net salary can be calculated using the equation: (SL)

$$SL = R - P$$

In figures 4 and 5, the construction of this model by AI is exposed:

Figure 4 – Step by step of the calculation of the net salary by AI

Passo a passo para encontrar o salário líquido:

- 1. Calcular o valor da comissão (C):**
$$C = 0,03 \times V$$

Onde V é o total de vendas no mês.
- 2. Calcular o rendimento bruto (R):**
$$R = 1600 + C$$
- 3. Calcular o desconto para previdência (P):**
$$P = 0,11 \times R$$
- 4. Calcular o salário líquido (SL):**
$$SL = R - P$$

Source: From the survey

In Figure 4, the AI offers an algorithm to find the net salary according to the data of the situation described.

Figure 5 – AI-generated model summary

Modelo final:

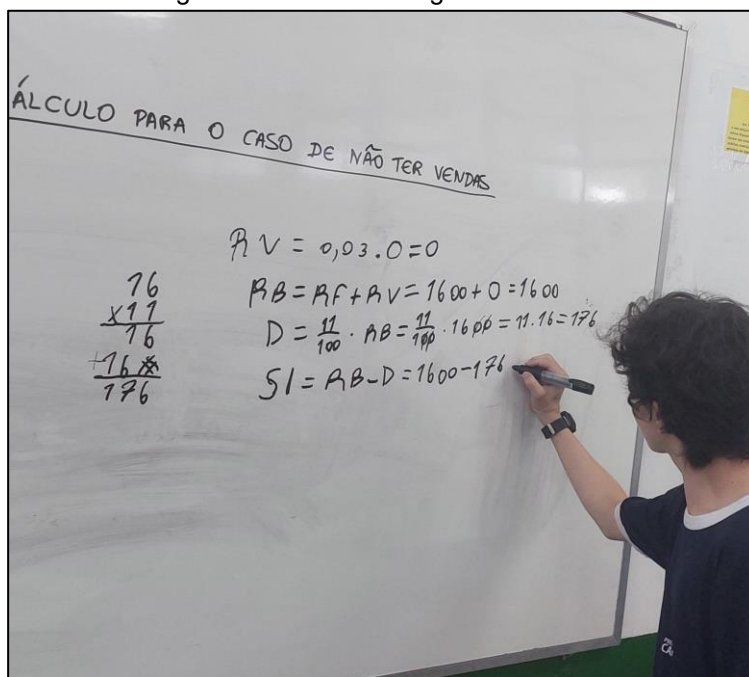
- $C = 0,03 \times V$
- $R = 1600 + C$
- $P = 0,11 \times R$
- $SL = R - P$

Source: From the survey

In Figure 5, the AI summarizes the model by enumerating the equations generated. The students solved two problems applied to this model, in case Marcos did not get sales and the case of having sold 20000 reais.

Figures 6 and 7 show the resolution process of one of the students using the whiteboard in case he did not sell and using pencil and paper in case he sold reais.20000

Figure 6 – Student using a whiteboard.



Source: From the survey

In Figure 6, the student used the equations generated by the AI, he only used other letters to express some of the variables, the commission he called Variable Income (RV) and the income he called Gross Income. In the end, the student found an answer consistent with the model and the given situation. (RB)

$$SI = RB - D = 1600 - 176 = 1424$$

That is, Marcos will receive reais in net salary if he does not get sales. To calculate Marcos' net salary in case he obtained reais in sales, it was decided to use pencil and paper so that manual calculations are not ignored in favor of the use of calculators and other technologies.142420000

Figure 7 – Student's calculations using pencil and paper.

CÁLCULO PARA O CASO
DE TER VENDIDO R\$ 200000

RENDIMENTO VARIÁVEL = $0,03 \cdot 200000$

$0,03 \cdot 20000 = 600$

RENDIMENTO BRUTO = $1600 + 600 = 2.200$

DESCONTO = $\frac{11\%}{100} \cdot 2.200$

SALÁRIO LÍQUIDO = $2200 - 242 = 1958$

RESPOSTA: SI = R\$ 1958,00

Source: From the survey

In Figure 7, the student preferred to use the name of the meaning of the variables instead of the letters in order to give the resolution a more natural aspect and related to daily practices outside the school environment.

THIRD MEETING

In order to collect data to carry out a practical modeling using data from the city of Canoas, a visit was made with the students, subjects of this research, to the Office of Climate Resilience of the city of Canoas – eCLIMA, on the occasion we were received by the Hon. Mr. Municipal Secretary Aristeu Ismailow Duarte who approved the initiative to see students from the municipal public education network participating in research activities in Mathematics using current technologies of multidisciplinary way. Then, an acclimatization was carried out on the premises of the office where the technical team and instructions on the work developed there were presented.

About eCLIMA, in a report in Zero Hora, Duarte (2023) wrote:

As cities face a range of challenges stemming from climate change, disorderly growth, and socioeconomic pressures, the concept of urban resilience is gaining prominence around the world. In general terms, resilience is the ability of a city to resist and recover, quickly and effectively, from the effects of a natural disaster or situations of great risk, such as the heavy rains that hit southern Brazil in recent months.

In this context, a pioneering initiative in Rio Grande do Sul emerges in Canoas with the creation of the Climate Resilience Office – ECLIMA, in May of this year, whose objective is to face these issues in a transversal way, centralizing actions and

permanent dialogue with public power structures, organized civil society and international organizations. By identifying, understanding, and using current and future scenarios to assess the risks to which the municipality is exposed, the municipal administration develops strategies to mitigate them.

[...]

EClima has been looking for answers and developing joint actions between public authorities, private initiative and the population in general.

Resilient cities need to be able to resist and recover after adverse situations – of a natural, social or economic nature – using the past to create a future action plan.

In this context, when visiting the site, students were able to have access to real-time satellite images with vector graphs indicating multiple climatic variables that can offer data susceptible to being modeled linearly, we mention linear models because seventh grade students, for the first time, are in contact with equations of the 1st degree and are discovering the formal environment of algebra. Thus, the visit was important in several aspects: in the psychological field, the students had the perception of doing something relevant through their studies in order to feel motivated to understand the relationship between Mathematics and the real world, in contact with various technical areas that use Mathematics to perform their functions; In the cognitive field, they were able to improve the mathematical abstraction that is required in this type of activity, in the social field, they were able to get in touch with people from different social niches outside the formal learning environment so that, by socializing with people from different areas of knowledge, they can add values and more professional possibilities.

FOURTH MEETING

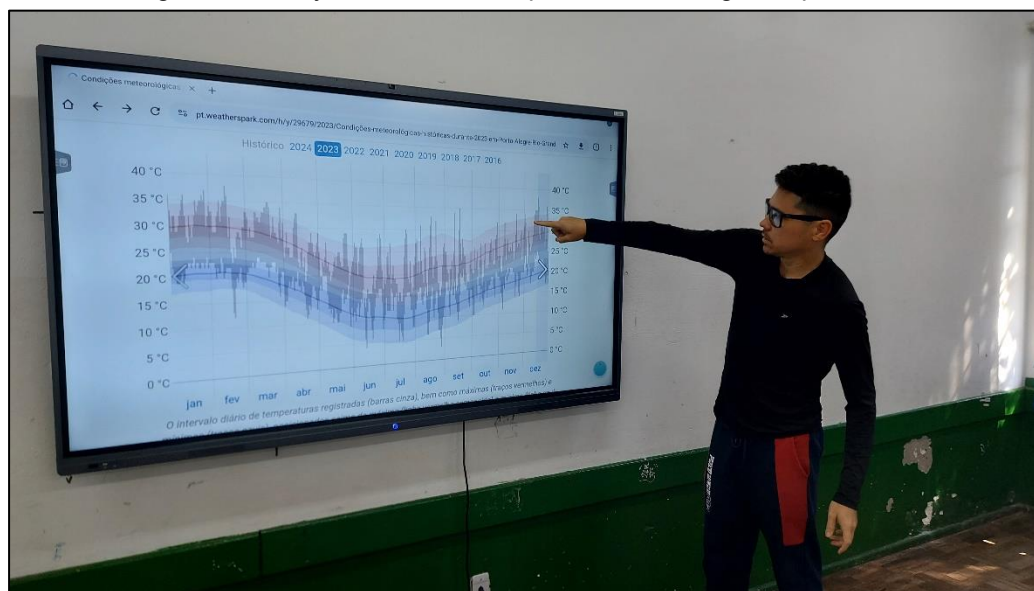
Based on the practices, shared knowledge and data collected in previous meetings, we began the work by discussing which data can provide subsidies for a modeling that meets what the BNCC preaches about a seventh year. Thus, it was decided to use something that could be translated through a first-degree equation.

Among the main analyses carried out, a model of future projection of the increase in the average annual temperature in the metropolitan region of Porto Alegre stands out, carried out largely manually and using only school materials that students can easily access.

Initially, we analyzed graphs from the Weather Spark website, which contains historical and current weather reports on the weather with intervals in hours, days, and months. The constant scatter plot model was explained to the students in Figure 8, where

the tracing of the maximum and minimum temperature averages throughout the months of the chosen year is evident and intuitive.

Figure 8 – Analysis of the scatter plot of the average temperatures.



Source: From the survey

From the data obtained through these data, the students began to tabulate on graph paper the maximum monthly averages of temperature in Greater Porto Alegre and then calculated the annual average of the last eight years using the simple arithmetic mean. Figure 9 shows a table made by a student, which contains the monthly temperature averages and the respective annual averages with rounding in hundredths.

Figure 9 – Data table prepared by the research student.

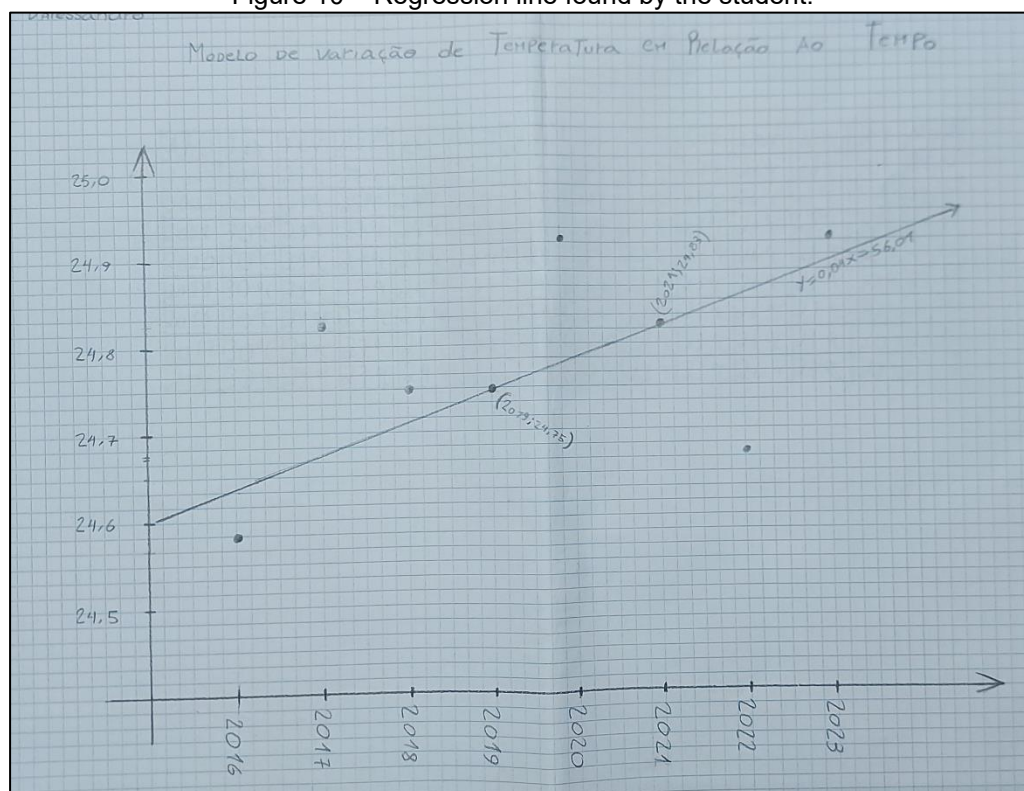
ANO	JAN	FEV	MAR	ABR	MAIO	JUN	JUL	AGO	SET	OUT	NOV	DEZ	MÉDIA ^{oC}
2023	30°C	29°C	27°C	24°C	21°C	19°C	20°C	22°C	23°C	26°C	28°C	30°C	24,92
2022	30°C	29°C	25°C	24°C	20°C	19°C	20°C	22°C	23°C	26°C	28°C	30°C	24,67
2021	30°C	29°C	27°C	24°C	20°C	19°C	20°C	22°C	23°C	26°C	28°C	30°C	24,33
2020	30°C	29°C	27°C	24°C	20°C	19°C	20°C	22°C	24°C	26°C	28°C	30°C	24,92
2019	30°C	29°C	27°C	24°C	20°C	19°C	20°C	22°C	23°C	26°C	27°C	30°C	24,75
2018	30°C	29°C	27°C	24°C	20°C	19°C	20°C	22°C	23°C	26°C	27°C	30°C	24,75
2017	30°C	29°C	27°C	24°C	20°C	20°C	20°C	22°C	23°C	26°C	27°C	30°C	24,33
2016	30°C	29°C	27°C	24°C	20°C	19°C	20°C	21°C	23°C	26°C	27°C	29°C	24,58

Source: From the survey

With this data, the students built a scatter plot, where they were asked to use the coordinate for the year in relation to another coordinate with the average annual temperature. After marking the points, the students should draw a line that best suits the points found. It was recalled that two points define a line, and based on this information, it was discussed with the group that, in order to find an equation of the line more easily, it would be interesting for the regression line to contain at least two of the points found. As it is a seventh-grade class, the technical terms used in the study of the equations of the line, scatter plot and linear regression were not used because it was not the ideal time foreseen in the BNCC. However, through the research, I was able to verify that the general ideas were well received by the students so that, when they formally study these subjects in later years, they will have an easier time understanding.

Figure 10 contains the graph constructed by a student who responded to the suggestion of plotting his regression line through two points of the data set itself.

Figure 10 – Regression line found by the student.



Source: From the survey

After the above sketch, the Microsoft Copilot AI was asked to find the equation of the line sketched in the figure containing the points (2019; 24.75) and (2021; 24.83), because at this stage students do not yet know the algebraic tools to find the equation of the line

that passes through two points. However, you already know the concept of equation. Thus, the equation below was generated.

$$y = 0,04x - 56,01$$

In the equation above, the term (independent variable) refers to the year and the term (dependent variable) refers to the average maximum temperature for the year.

The student was asked to use their model to predict how many degrees the temperature would increase in 100 years, where they only had to use the number instead of , finding the answer °C. As in the year of this research, , the average annual temperature was °C, we have a forecast of an increase in the average annual maximum temperature of °C.

As a final part of this meeting, a survey of the official scientific projections of the temperature increase for 100 years was carried out, and the result was surprising, because the models generated in a semi-artisanal way by the 7th grade students of Elementary School are in the range of increase of the best current technical forecasts. According to the Intergovernmental Panel on Climate Change, the average global temperature will increase in the next 100 years between 1.8 °C and 4.0 °C:

Projections by the Intergovernmental Panel on Climate Change (IPCC) indicate that in the next 100 years there could be an increase in the global average temperature of between 1.8°C and 4.0°C, and an increase in the average sea level between 0.18 m and 0.59 m, which could significantly affect human activities and terrestrial ecosystems. (BRAZIL, 2023)

Performing the comparison, it is perceived that the model found by the student is reasonable, because $1,8^{\circ}\text{C} < 3,99^{\circ}\text{C} (\text{aluno } 1) < 4,0^{\circ}\text{C}$

A positive factor when using this type of approach in class, whether using AI or other technology, is the possibility of working in a short period, 1 hour and a half in this case, several skills provided for in the BNCC itself. Evidently, when working together, several skills may not cover the theory expected of each one of them, however, following the philosophy of our current educational legislation, practical understanding must be privileged at times, as is the case with this activity. Chart 1 lists some of them worked only in this meeting.

Chart 1 – BNCC skills worked on in the fourth meeting of the research

Skill	Description
EF07MA10	Compare and order rational numbers in different contexts and associate them with points on the number line.
EF07MA12	Solve and elaborate problems involving operations with rational numbers.
EF07MA13	Understand the idea of variable, represented by letter or symbol, to express the relationship between two quantities, differentiating it from the idea of unknown.
EF07MA18	Solve and elaborate problems that can be represented by polynomial equations of the 1st degree, reducible to the form $ax + b = c$, making use of the properties of equality.
EF07MA29	Solve and elaborate problems involving measures of magnitude inserted in contexts arising from everyday situations or other areas of knowledge, recognizing that every empirical measure is approximate.
EF07MA35	Understand, in meaningful contexts, the meaning of statistical average as an indicator of a research trend, calculate its value, and intuitively relate it to the breadth of the data set.
EF08MA06	Solve and elaborate problems involving the calculation of the numerical value of algebraic expressions, using the properties of operations.
EF08MA07	Associate a linear equation of the 1st degree with two unknowns to a straight line in the Cartesian plane.
EF08MA08	Solve and elaborate problems related to their immediate context, which can be represented by systems of equations of the 1st degree with two unknowns and interpret them, even using the Cartesian plane as a resource.
EF07CI07	To characterize the main Brazilian ecosystems in terms of landscape, amount of water, soil type, availability of sunlight, temperature, etc., correlating these characteristics to specific flora and fauna.
EF07CI13	Describe the natural mechanism of the greenhouse effect, its fundamental role in the development of life on Earth, discuss the human actions responsible for its artificial increase (such as the burning of fossil fuels, deforestation, fires, etc.) and select and implement proposals for reversing or controlling this situation.
EF08CI16	Discuss initiatives that contribute to restoring environmental balance by identifying regional and global climate changes caused by human intervention.
EF06GE11	Understand what global warming is and its consequences for life on Earth.

Source: BNCC

Interdisciplinarity is a major hallmark of the BNCC, encouraging the use of cross-cutting themes and new technologies in all areas of knowledge. The second general competence present in the aforementioned normative document states that:

Exercise intellectual curiosity and use the approach of the sciences, including research, reflection, critical analysis, imagination and creativity, to investigate causes, elaborate and test hypotheses, formulate and solve problems and create solutions (including technological) based on knowledge from different areas. (BNCC, 2018, p. 9)

In the moments of final reflections of our fourth meeting, we were able to discuss our model in the light of what is happening in the frequent floods in the city where we carried

out this research. It was possible to talk about specific details of our mathematical model, explaining, for example, that these prognoses are based on the current conditions of which human beings have interacted with nature, so that the model depends on other variables, such as the direct relationship of proportionality of the predictions being better or worse, in the sense of social well-being, with the human attitude being better or worse towards the environment.

FIFTH MEETING

With the experience gained in previous meetings, it was possible to expand the level of modeling work with AI. Thus, it was decided to model something related to some climatic event that was the cross-cutting theme that permeated our activities. The activities began with the presentation of some data about a fictitious city that has a water pumping system to transfer the water from the floods caused by the rains to appropriate places. At a certain point in this city there is a river that rises 10 cm for an average amount of rain of 20 mm per hour. For the river to reach the flood level, it must rise 2 meters or 200 centimeters from the initial level 0 cm. The flow of the pumps in this place is 10 mm of rain per hour.

Based on this knowledge, the following activities were requested to be carried out with the help of AI:

1. Find a mathematical model that expresses this situation (a function or equation).
2. Ask to express the variables with letters.
3. Based on this model, find an equation that calculates the time it takes for the river to reach a height from the current height of the river? h

This activity aims to instigate students to use AI to recognize the school mathematics of their year in practical situations that can occur in the most diverse human activities. Despite being careful not to exaggerate the informality of the technical terms of Mathematics, Hydrology, Meteorology and related areas to the given situation, it is not the focus of the research to evaluate the students' learning beyond what their school year predicts, at some moments during the modeling more complex subjects such as integrals and derivatives emerged, however, the final model was always expressed in a linear equation.

One of the research students decided to use Gemini AI, and started the activity by formulating the initial conversation he would have through the Gemini chat. Figure 11 shows part of the conversation between the student and the AI.

Figure 11 – Data analysis by AI

Novo Modelo:

- Chuva por hora P :**
$$P = 2 \text{ cm/hora}$$
- Vazão das bombas V :**
$$V = 1 \text{ cm/hora}$$
- Aumento líquido no nível do rio por hora:**
 - A cada hora, o rio sobe 5 cm (já que as bombas removem 1 cm de água a cada hora).
$$\Delta R = 5 \text{ cm/hora}$$

Source: From the survey

In Figure 11, the AI calculated the rate of variation of the height of the river waters in relation to the data initially presented. For this, a detail must be carefully explained to students in a 7th grade of Elementary School, the conversion of to and from . This detail is important because we are using a unit of length to measure the amount of liquid volume. There can also be confusion of this measurement with the measurement of the height of the river. This observation may seem irrelevant to those who naturally understand this system of measurements, but for students at this level of maturity and learning, it can generate enormous difficulty in understanding the model. 20mm 2cm 10mm 1cm

Next, the AI was asked to find the model's equation. Figure 12 presents the model found by the AI.

Figure 12 – Model found by AI.

Para encontrar o tempo t necessário para o rio atingir a altura h a partir de R_0 :

$$t = \frac{h - R_0}{\Delta R_{\text{liquida}}}$$

Source: From the survey

To redo the model, the AI used only the knowledge of proportionality and basic properties of fundamental operations. Figure 12 presents the model for the time for the river to reach a certain height from an initial height.

In Figure 13, we have that the equation that models the situation we are analyzing is: $\Delta R_{\text{líquida}} = 5\text{cm/h}$

$$t = \frac{h - R_0}{5}$$

Figure 13 – Calculation of the $\Delta R_{\text{líquida}}$

3. Aumento líquido no nível do rio por hora:

- A cada hora, o rio sobe 5 cm (já que as bombas removem 1 cm de água a cada hora).

$$\Delta R = 5\text{ cm/hora}$$

Source: From the survey

Using the model equation and the data initially arranged, the students were asked to solve the following problem: What is the flood time for a constant rainfall of , a pumping system with the ability to extract water from the system, knowing that the flood level is and initial height? Also solve for the case that the initial height is in .20mm/h10mm/h2m0m20m

One of the students of the research directly applied the equation found by replacing it with , for the first part and for the second part. Figures 14 and 15 show the student's resolution on the whiteboard. $h2m = 200\text{cm}$ $R_0 = 0\text{cm}$ $R_0 = 20\text{cm}$

Figure 14 – Student solving a problem using an equation found by the AI.

$$t = \frac{h - R_0}{5}$$
 CALCULE O TEMPO DE ENCHENTE A PARTIR DO NÍVEL INICIAL $R_0 = 0\text{cm}$ e $R_0 = 20\text{cm}$.

$$= \frac{200 - 0}{5}$$

$$= \frac{200}{5} = 40\text{h}$$

$$T = \frac{200 - 20}{5}$$

$$T = \frac{180}{5}$$

Source: From the survey

At first glance, the activity that the student is performing in Figure 14 may seem simple. However, it is evident to the teacher when the student is able to perform this activity after understanding the entire process that led him to solve it. This is due to the fact that the student is not just performing a calculation of an algebraic expression in a mechanical way and without practical applicability. In this context, the student can work with equations that he himself contributed to the construction, in a practical situation.

Figure 15 – Problem resolution by a research student.

$$t = \frac{h - R_0}{5}$$
 CALCULE O TEMPO DE ENCHENTE A PARTIR DO NÍVEL INICIAL $R_0 = 0\text{cm}$ e $R_0 = 20\text{cm}$.

$$T = \frac{200 - 0}{5}$$

$$T = \frac{200}{5} = 40\text{h}$$

$$T = \frac{200 - 20}{5}$$

$$T = \frac{180}{5} = 36\text{h}$$

Source: From the survey

Figure 15 shows that the results found by the student are consistent with the initial data of the situation presented.

At the end of the work with the students, reflections were made on our model and the following conclusions were reached:

- It is important to know the initial height of the river (R_0) to get an accurate result;
- We assume that river rise and pumping rates are constant over time, which may not be entirely accurate in reality;
- We did not consider other factors that can influence the river level, such as evaporation, soil infiltration, or the contribution of tributaries; and
- Pumping capacity can vary over time due to a variety of factors, such as failures, maintenance, or increased demand.

However, it was explained to the students that the model they found is not useless, as it has several practical applications, including the author of this research asked the AI if there is real use in this model, the answer in Figure 16 demonstrates that the model is viable in some situations.

Figure 16 – Practical applications of the student model according to Gemini AI.

Aplicações Práticas:

Este modelo simples pode ser utilizado para:

- **Previsão:** Estimar o tempo que leva para o rio atingir o nível de enchente em diferentes cenários.
- **Planejamento:** Auxiliar no planejamento de ações de emergência, como a mobilização de mais bombas ou a evacuação da área.
- **Otimização:** Avaliar a eficiência do sistema de bombeamento e identificar possíveis melhorias.

Source: From the survey

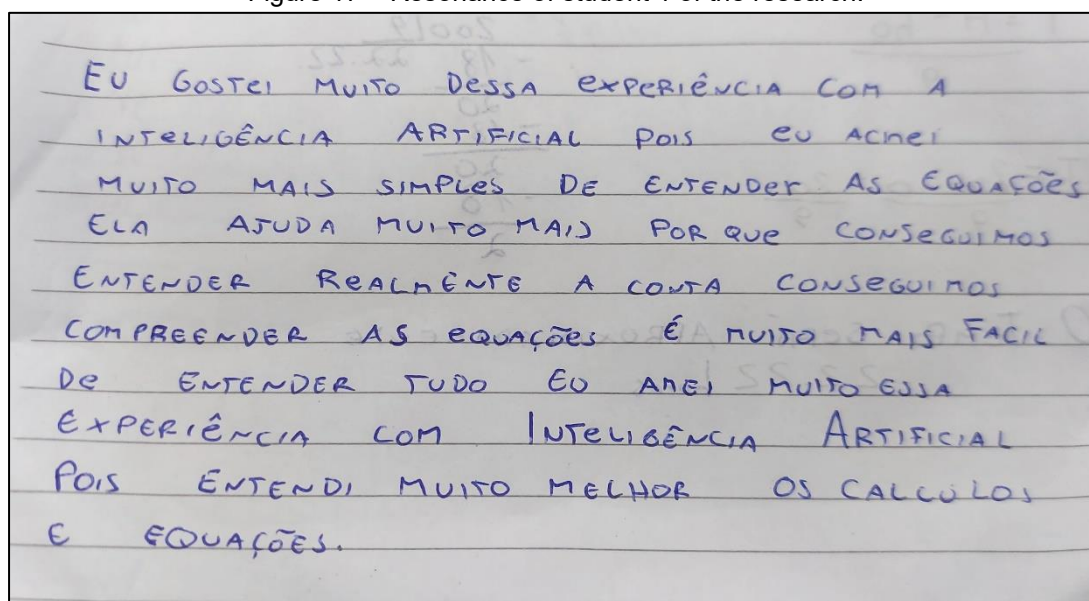
RETURN OF STUDENTS

At the end of the work with the students who were the subjects of this research, care was taken to listen to them, frankly and openly, without directions, so that they have the reality of the students' perception of self-knowledge. A listening practiced, not in any way, but the listening advised by Paulo Freire (1996, p. 20):

There is no intelligence – except when the very process of understanding is distorted – that is not also communication of the understood. The great task of the subject who thinks right is not to transfer, deposit, offer, give to the other, taken as a patient of his thinking, the intelligibility of things, facts, concepts. The coherent task of the educator who thinks right is, exercising as a human being the irrefutable practice of understanding, challenging the student with whom he communicates and to whom he communicates, to produce his understanding of what has been communicated. There is no intelligibility that is not communication and intercommunication and that does not merge into dialogicity. Right thinking, therefore, is dialogical and not polemical.

Among the moments of written dialogic communication with the students, they were offered the opportunity to write about their real impressions about the style of class, about learning and whether this type of activity arouses interest in Mathematics. Figure 17 shows the written report of one of the students.

Figure 17 – Resonance of student 1 of the research.



Source: From the survey

Despite the grammatical inconformities that are also subject to the intervention of the Mathematics teacher, it is evident, in Figure 17, the degree of excitement of the student for the use of AI in the learning of equations through modeling, as he perceived a purpose for the study of equations.

FINAL CONSIDERATIONS

Some reflections were made and their results, which although not exhaustive, were relevant and significant, especially for a study carried out with adolescents from a seventh-

grade class, the fruits of these reflections will be described below, seeking to present the positive aspects, negative aspects and recommendations for improvement.

The main reflection carried out on the use and epistemological issues of the use of AI in basic education helped to build part of the understanding of how AI can transform the way mathematical knowledge is acquired and understood. During the activities, the possibility of AI allowing the personalization of teaching, adapting the content to the individual needs of each student, was noticeable. Some tools were able to identify specific difficulties and offer targeted explanations, promoting more effective learning. It was also observed that by offering corrections immediately, helping students to correct errors in real time, it provided a better understanding of mathematical concepts, increasing student motivation and engagement. In a particular and punctual way, during the integrated work between mathematics education and AI, it was possible to observe the usefulness of this tool in the transition from the concrete operational stage to the formal operational stage, according to Jean Piaget's (1971) theories of cognitive development, a moment in the transition from childhood to adolescence in which they go through a paradigm break when they start the journey of abstract thinking that they did not have in the previous stage, instigating students to create hypothetical theories when faced with the problems presented.

On the other hand, the excessive use of AI can lead to a technological dependency, where students become less able to solve mathematical problems without the help of digital tools, hindering the development of student autonomy. The collection and analysis of students' personal data to personalize learning can raise fears about the privacy and security of this data, as in many cases it is not possible to be sure that it will be used ethically.

Thus, through this reflection, it is necessary to invest in the Continuous Training of teachers so that they can effectively integrate AI into their pedagogical practices so that they can optimize the benefits of AI and mitigate the challenges of misuse of this technology. Another recommendation is that strict data privacy and security policies should be implemented to protect student information, so that educators and parents can have confidence when handling this and any other type of digital technology. While AI can democratize access to educational resources, it can also exacerbate existing inequalities, as there are still schools that do not have access to these technologies, creating a difference in learning and experiences; and to address this situation, governments and

educational institutions must work to ensure that all students have equitable access to AI technologies, and for this, investments in digital inclusion programs must be made.

Concluding this reflection, we can infer that the use of AI in the mathematics education of elementary school students presents both opportunities and challenges. By carefully addressing epistemological issues and implementing effective strategies, it is possible to harness the benefits of AI while minimizing its risks. The key lies in a balanced and ethical approach, which puts students' learning and well-being first.

Keeping up with technological advancements is essential for teachers, as technology has significantly transformed education. The integration of new technological tools into pedagogical practice offers numerous advantages, both for educators and students. Technology facilitates access to a vast array of educational resources, allowing teachers to diversify their teaching methodologies. Another important aspect is the preparation of students for the future, as we live in a digital age, where technological competence is essential for professional success. Constantly updating in relation to new technologies also benefits the teachers themselves, providing them with opportunities for professional development and career growth. In short, keeping up with technological advances is crucial for teachers to be able to offer a quality, personalized education in line with the demands of this century. This not only enriches the learning experience of students but also contributes to the ongoing development of educators.

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