

STUDYING MATHS WITH A.I.: A TROUBLE LIAISON FOR BLIND STUDENTS

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Abstract

Mathematic language has always posed a complex problem for students with visual impairments. Accessibility difficulties generally concern: semantic aspects, such as understanding symbols and the statements of theorems and problems; syntactic aspects, such as transcribing mathematical language into accessible languages (e.g., braille); and spatial aspects, such as graphical representation. Over the years, numerous measures have been adopted in terms of accessibility: from the possibility of linearizing formulas with dedicated interfaces, to accessibility standards for major application software and the web (W3C et al.). In recent years, the presence and use of generative AI represents a new frontier: through its use, it is possible to generate alternative texts that help simplify syntactic and semantic decoding and replace the use of images with effective descriptions.

However, there are evident limitations that students and teachers themselves are not yet fully aware of: through this research, we aimed to show the characteristics and limitations of mainstream AI tools in the study of mathematics. With a working group of twenty-five specialized high school teachers, three types of mathematical problems were selected: an algebraic equation containing an error, a Euclidean geometry problem with a construction defect, and a geometry problem that requires different solutions, asking to justify the choices. The questions were proposed to about ten of the most popular and freely accessible AI platforms, and the results were extremely heterogeneous: each platform suggested different interpretations and versions, proposing mathematically unacceptable solutions; some isolated cases highlighted the error, but not in all questions; the same platform provides different interpretations and solutions a few hours after the first submission.

This presents a certainly promising picture for the future, but not yet currently reliable as a study tool for students, blind or not, in high school and university: AI provides partial but not holistic support for the study of mathematics.

Keywords: Technology, special education, mathematics.

1 INTRODUCTION

In his 1998 essay, "The Language of Mathematics," Keith Devlin defines maths as "what makes the invisible visible" (Devlin, 1998). In a contribution where we will try to understand more about the mathematical difficulties of blind students (and, more generally, the difficulties of teaching mathematics in high schools), the expression "making the invisible visible" seems promising. Devlin's essay, a successful attempt to make the essence of mathematics understandable to non-experts, was not an isolated case; within a few years, on the shelves of bookstores around the world, we find: from the same year (1998) *Le théorème du perroquet* and, subsequently (2003) *Les cheveux de Bérénice* by the French mathematician Denis Guedj, two novels in which the plot revolves around the knowledge of mathematics; across the ocean, in Brazil in 1996, the mathematician Malba Tahan (pseudonym of Júlio César de Melo e Sousa) publishes *O Homen que Calculava*, an epigone of "One Thousand and One Nights" in a mathematical key; a few months later, in 1997, Hans M. Enzensberger publishes *Der Zahlenteufel*, a story for children about the magic of mathematics; more serious, but no less interesting, is the 1997 neurobiological study by Stanislas Dehaene (a student of the famous Jean-Pierre Changeux) "The Number Sense." What is happening? At the end of the 20th century, popular interest in mathematics "explodes" in numerous successful editorial cases, publications to which many others have followed; mathematics is no longer confined to the "ivory tower" of the Academies: all these books have a single purpose, that of making a science considered "invisible" to non-experts "visible."

This research starts from there, from when the author of this article begins to address the difficulties in mathematics faced by blind students. For many blind teenagers, mathematics is an impenetrable wall: various attempts to make it "popular" and "visible" do not lead to any stable results, and there is still no consistently effective teaching method or approach. What is wrong? The idea of making something "visible" to those who cannot see is not the right approach: those who cannot see are not interested in

“seeing the invisible,” but in understanding the deep meaning of mathematics. Mathematics cannot be “vision” (an egocentric perspective from those who see, just because they are in the role of teacher), but must be “language,” a “coherent expression” of a thought that only mathematics can express through its structures. There is only one book, in those years (1996), that treats mathematics in this way, and it is written by a blind person: José Enrique Fernández del Campo, *La enseñanza de la matemática a los ciegos*. There are no images (very few!), but phrases and logical constructs expressed with clarity and coherence. This is what blind people ask for: mathematics is like a language and is learned like a second language with its symbols, grammar, syntax, and logic. Mathematics should not “show,” it should “speak”: images are just a “prosthesis” that sighted people have invented to try to understand it through a shortcut. But what happens when mathematics expresses concepts that are not visually representable (its *invisible*)? It happens that sighted people are often misled and confused: imagining is approximate and misleading. Understanding means deeply reading a message in mathematical language, and making others understand means knowing how to write mathematics coherently. And those who are not bound to a visual expression are advantaged.

Studying mathematics with blind students subverts the logic of traditional teaching: mathematics “speaks” about reality with its own language, and creating images is just one of the possible consequences. This study aims to focus on two objectives: a) when expressing a part of reality through a symbolic language, errors can occur: what tools does mathematics provide to new educational technologies, primarily AI, to understand these errors? b) Can we conceive of a more inclusive and effective mathematics education through the tools of Artificial Intelligence?

The first AI Platform accessible to everyone appeared on the web in the mid-2010s: IBM Watson in 2011 and, subsequently, Google AI in 2015, followed by many others. In principle, AI platforms can be divided into “probabilistic” and “deterministic”: the latter are less known to the general public and were created for specific purposes, such as Sat Solvers, a computer programs designed to solve Boolean satisfiability problems (Dean and Naibo, 2024). Generative AI is a distinct class of probabilistic AI and an incredibly powerful technology: generative AI can be defined as a technology that leverages deep learning models to generate human-like content (e.g., images, words) in response to complex and varied requests (e.g., languages, instructions, questions). It is also important to distinguish generative AI from related concepts: it has the unique ability not only to provide an answer but also to generate the content in that answer, going beyond human-like interactions in conversational AI. Furthermore, generative AI can generate new responses beyond its explicit programming, while conversational AI typically relies on predefined responses. However, not all generative AI is conversational, and not all conversational AI could generate content. Augmented intelligence models, such as ChatGPT, combine generative and conversational AI to enhance their capabilities (Lim et al, 2023). Therefore, generative AI constantly renews the content of its responses, but it is not guaranteed that the response given at a certain moment is the definitive one. Paradoxically, it can be innovative in creating entirely new constructs but unreliable when the rigor of a mathematical proof is required or when applied to finding a logical error within a procedure: exactly what we encountered in explaining mathematical or procedural errors during problem-solving. As if to say: if in mathematics there is only one correct way to proceed (even this statement is only partially true, as we will demonstrate in the article), there are infinite ways to make mistakes, and generative AI is not always able to provide a coherent explanation.

What is the current function of generative AI in the study of mathematics in high schools? What role can it play in the implementation of inclusive education? The scientific debate is completely open, between proponents and detractors: there is no unanimous perception because the presence of generative AI highlights some paradoxes. As astutely pointed out by Lim and colleagues (Lim et al, 2023), AI is a “friend but an enemy”: it facilitates access to knowledge but does not necessarily create new content, so much so that it has been branded by an intellectual like Chomsky as “high-tech plagiarism”; secondly, it is “capable but dependent”, in that the content strictly depends on the correctness of the prompts provided, and it does not exempt from the critical judgment of the people using it; thirdly, it is “accessible but restrictive”: the interfaces of the various AI platforms do not have a common and harmonious architecture, and often are little or not at all accessible to people with visual impairments (Adnin & Das, 2024); finally, it perfectly impacts the adolescent tendency of the “allure of the forbidden” whenever it is banned from school study for reasons of improper use (“popular when prohibited”). Specifically, blind and visually impaired students face accessibility issues, inaccuracies, hallucinations, and idiosyncrasies associated with GenAI and develop interesting (but often imperfect) mental models of how these tools work (Adnin & Das, 2024).

Regardless of any possible considerations, the presence of generative AI is a fact, therefore: demonizing its presence is completely useless. Looking closely, it is producing the same effect, a few decades later,

as the revolution brought by the introduction of the scientific calculator: the possibility of automating some calculation procedures was seen as an undue facilitation of students' mental calculation abilities; on the other hand, it has allowed to remove (useless) effort from performing some procedures to free up mental resources for more abstract and complex cognitive processes. And: if the presence of generative AI were an "evolution" of the calculator presence? Research by Lagrange and collaborators (Lagrange et al, 2023) seems to go in this direction: analyzing various generative AI platforms in high schools reveals a massive presence of tools for the study of Geometry, primarily GeoGebra. The gain, in metacognition terms, is significant: teaching of geometry, when students have automatic demonstration tools at their disposal, is no longer a mere repetition of the traditional curriculum; geometry, with these tools, becomes a richer context for the development of human reasoning. But very little research has been conducted in mathematics education: students in the approach to mathematical functions lack algebraic manipulative skills: the main problem is that they cannot make sense of the objects they have to manipulate. Even if they are skilled in using formulas, graphs, and tables, the x in the notation $f(x)$ has very little meaning for them. The missing step is quantification: students understand a covariation between geometric objects, but generally do not see that x and $f(x)$ represent covariable quantities (Lagrange et al, 2023, p. 10). So, despite the progress, the problem of the inaccessibility of mathematics for the blind reappears as we defined it at the beginning of this paper, only more complicated. The fundamental error is epistemological: mathematics education still seeks the path of visibility when it should seek the path of semantic understanding. Blind students adapt to it, once again, reluctantly: this is demonstrated by the numerous distortions produced by generative AI in the production of alternative text for image explanations (Adnin & Das, 2024).

What would it be sensible to do, so as not to miss another opportunity to rethink mathematics education? There are principled reasons to believe that solving open questions in mathematics will remain difficult for computers essentially for the same reason it is difficult for humans, namely because it is an inherently difficult task for any computational system: the discovery of proofs can be considered a decision problem with an infinite number of instances, and deciding the truth in mathematics is a completely different matter from mere provability (Dean & Naibo, 2024). Some GenAI platforms take these reasons into account, and the results regarding their use are still timid but promising. QED-Tutrix is a tutoring system based on logic programming and provides mathematical elements (such as results or properties) that are relevant to the proof: it implies that the software must be able to evaluate, on the fly, the validity of the mathematical proposition that the student is entering, both in its form and its relevance to solving the problem in question. This means that the software must know, in advance, the entire set of proofs that a student might provide. Finally, the software can determine the proof the student is working on in real-time. This requires the creation of various structures to store and manipulate the student's progression on their personal proof (Lagrange et al, 2024, p. 14).

In this research, we deliberately used the term "errare" (in Italian it's a synonym of "to make a mistake") in its Latin etymology, meaning to wander without a precise goal. Wandering is a creative process: it allows for the discovery of things that would not be noticed by following the main path; with this attitude, with a group of twenty-five specialized teachers for inclusion, we explored some GenAI platforms asking them to find errors in the resolution of problems taken from high school textbooks. We chose problems (and thus: errors) of different types, precisely to evaluate the type of responses: an algebraic error, a triangle that cannot be a triangle, a Euclidean geometry construction that requires choices to be resolved. Below is the method used to proceed.

2 METHODOLOGY

This experiment was conducted during the training course for teachers specialized in inclusion in high schools, at the Department of Human Sciences of Verona University, from February to May 2024. The training course for inclusive teachers is aimed at teachers already specialized in teaching their subject, for training teachers who accompany disabled students in their school journey. The experimental team consists of twenty-five teachers with different degrees and different teaching qualifications; there are three engineers (teaching mathematics and physics), six architects (teaching technical and architectural drawing), six with degrees in foreign language and literature (teaching foreign language and literature), four with degrees in law and economics (teaching law and economics), two musicians (teaching music), two graduates in physical education (teaching physical education), two in history and philosophy (teaching history and philosophy). The author of this article teaches "codes of logical and mathematical language" and "special didactics and pedagogy for visual impairments": the aim of the course is to make mathematics accessible to students with visual impairments, building an inclusive approach to the traditionally proposed teaching in high schools.

During the course to become inclusive teachers, the approach to mathematics education is: a) critical: despite the various guidelines provided by the World Wide Web Consortium (W3C) and the Web Content Accessibility Guidelines (WCAG), mathematics texts are often “digital” but not equally accessible, often containing errors and distortions; b) inclusive: new solutions and strategies designed for specific categories of students with disabilities translate into inclusive teaching practices suitable for the entire class, generating innovation.

In this experiment, mathematics was approached as a language; blind students cannot understand its logic solely through alternative text: these are generated to explain a certain mathematical structure set up with visual logic and lead to risky approximations, as highlighted in the study by Adnin and Das (2024). For a blind student, a mathematical statement is analyzed by decoding the sequence of antecedents and consequents that compose it: if the structure is linear and coherent, it acquires a descriptive and operational meaning. The main difficulties are a) internal coherence not always present in the statements analyzed; b) the length of the sequences: as demonstrated by Dehaene (1998), the human brain is not structured to handle long sequences of actions, quickly fatiguing working memory; excessive length is one of the main sources of procedural errors.

The three questions presented here were taken from textbooks:

| Text A: what’s wrong? | Text B: Camilla’s problem | Text C: at least find a solution |
|---|--|---|
| $a=b$ $a^2=ab$ $a^2-b^2=ab-b^2$ $(a+b)(a-b)=b(a-b)$ $a+b=b$ | Draw a triangle ABC with a base AB of 8 cm, a height CH of 5 cm, and an angle at C measuring 60°. Draw the three altitudes of the triangle and indicate the orthocenter O. Under the drawing, indicate the measure of all three angles using a protractor. | Given two Cartesian axes, draw a quarter circle and inscribe a quadrilateral whose vertex touches the arc and whose base is $\frac{1}{2}$ of the radius of the circle; calculate the length of the diagonal that starts from the y-axis and reaches the x-axis. |

Figure 1. The Three questions

Text A is the solution to an equation containing a semantic error (between the fourth and fifth lines, a division by zero is performed, creating a paradox); Text B indicates a triangle that cannot exist with the provided data, which are approximate; Text C contains both semantic inaccuracies (the concept of an “inscribed quadrilateral” belongs to a complete circle, not a portion) and implies choices to be resolved. We chose to start from the analysis of the semantic structure of the statement to evaluate if it was coherent, complete, and error-free. In the first phase, the questions were manually solved by the teaching team; in the second phase, the same statements were posed to some of the most commonly available and mainstream GenAI platforms. Below we present a comparison between the different solutions found by the mainstream GenAI and the critical comments of the teachers.

3 RESULTS

3.1 What did we find?

For each of the three texts, the results of the analysis are presented, as emerged from the synthesis of the research group.

3.1.1 Text A: what’s wrong with?

This exercise, seemingly simple, was not understood by the majority of neurotypical students who, reading (visually) the text, do not grasp the contradiction; better results are found with blind students who, listening to the statement of the different steps and analyzing the meaning step by step, perceive the contradiction between the initial condition ($a=b$) and the impossibility of dividing by their difference ($a-b=0$) at the fourth line. They verbally express, “if a and b are equal, dividing by their difference means dividing by zero, and in mathematics, this is not possible”. The lexical solution captures the paradox that arises between the fourth and fifth lines; the visual interpretation focuses on the error at the fifth line but often without being able to explain why. We were surprised to find that GenAI platforms fall into the

same bias: those that accept visual prompts (jpg image of the question) tend to make mistakes more frequently than those that require textual prompts or are written directly in source code (Python or others). Among the GenAI platforms consulted: Gemini does not resolve the contradiction if the prompt is an image, for which it reports “the equation is incorrect: it is necessary to check the original equation and identify the error”. However, Gemini correctly resolves it if the prompt is textual. Photomath app reports “Oops! We can't solve this problem yet, but we will soon”. The same dichotomy is observed for other GenAI platforms, less known but reviewed as widespread (Smodin Omni, Socratic, Wolfram Alpha, Pop AI): if the input is graphical, the solutions are ambiguous; if it is textual, the results are correct.

3.1.2 Text B: “Camilla’s problem”

Camilla is a teenage student, daughter of a teacher specialized in inclusion. She receives the problem illustrated in the box from her math teacher: in the class, few manage to solve it, and no one is certain of the solution. The problem is structural: the text contains errors such that the internal question of the problem cannot be satisfied. The research group makes a first attempt with Gemini, which responds that it has found an error and is unable to produce a drawing; therefore, it advises trying to solve the problem with Geogebra. The following figure presents the comparison between Gemini and Geogebra.

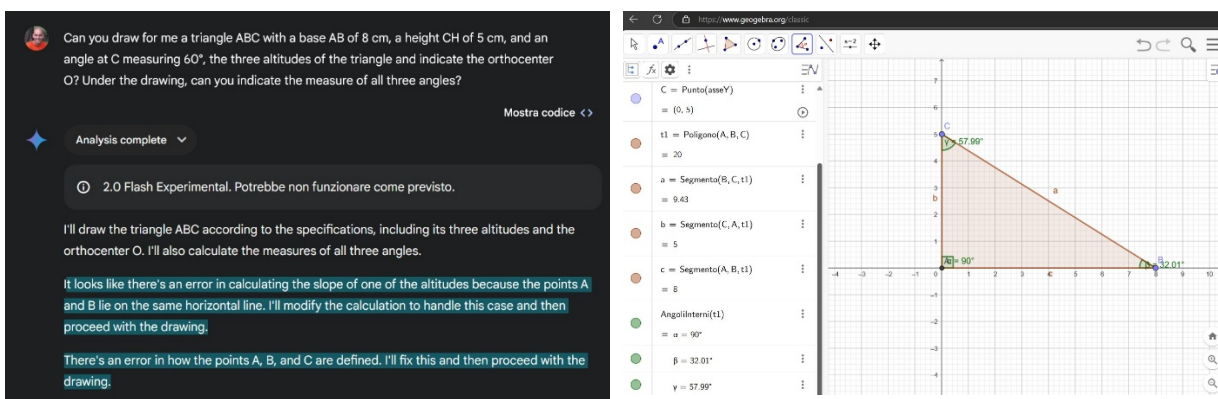


Figure 2: Gemini vs. Geogebra

The text is then submitted to Copilot and Photomath app: Copilot also detects the presence of an error, writing: “it seems there was a glitch, and I can't generate an image for you right now. However, I can guide you through the steps to draw it yourself: 1) Draw the base AB: Draw a line segment AB that is 8 cm long. 2) Draw the height CH: From point A, draw a perpendicular line segment CH that is 5 cm long. 3) Draw the angle at C: From point H, draw a line segment HC such that the angle at C is 60°. 4) Complete the triangle: Connect points B and C to complete the triangle ABC”. It is noted that, in point 2), there is a semantic contradiction: it is not possible to start from point A and draw a segment named CH, as point A would end up coinciding with B or H. Therefore, Copilot’s response is syntactically incorrect. Photomath app simply responds, “we couldn't recognize your problem”, without providing further indications. ChatGPT also provides the same response, without further specifications. In the end, Copilot and Gemini attempt to draw the figure, stating that they have corrected the errors: Gemini also provides the Python codes, while Copilot limits itself to the drawing. In the following image, the comparison between ChatGPT, the two drawings by Gemini and Copilot, which are graphically incorrect because the corrections made are semantically incorrect. Only the solution with Geogebra clearly demonstrates the flaw in the text: having to manually write the coordinates of the triangle vertices, the software determines the lengths of the segments and the angles, whose results collide with the original text.

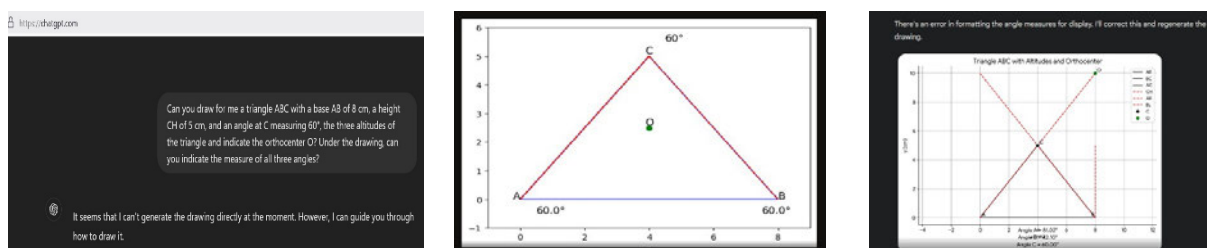


Figure 3: ChatGPT, Copilot, Gemini

3.1.3 Text C: a tough choice

This text presents numerous ambiguities: firstly, the concept of an inscribed polygon should refer to an entire circumference and not to a portion of it; secondly, in the construction of the quadrilateral, students often resolve it by choosing a rectangle, but this is an interpretative bias of the text that leads to a perceptual bias. Let's see why. Starting from the base (half of the radius), they proceed vertically until they touch the quarter circle (consistent with the text: it asks that a vertex touches the arc); having previously proceeded horizontally (base) and vertically (height), students tend to close the quadrilateral with the upper side parallel to the base and orthogonal to the height; therefore, the final result is a rectangle. In this way, the solution is simple, as shown by GeoGebra.

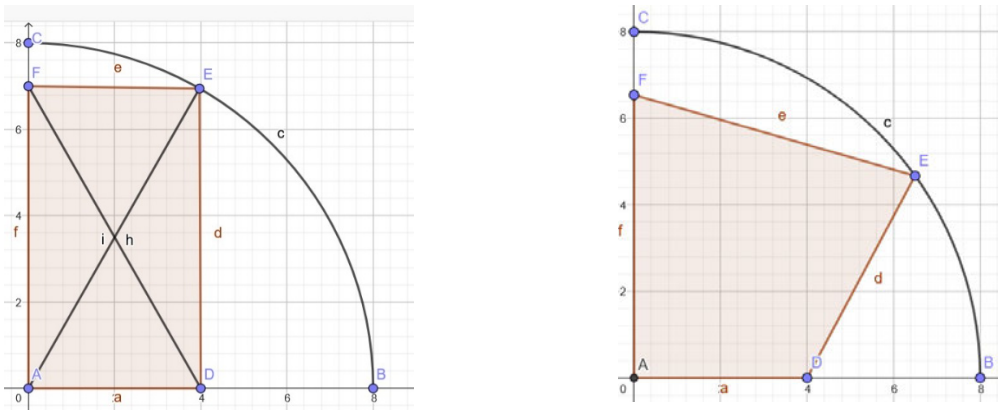


Figure 4: Geogebra sol. A (left), Geogebra sol. B (right)

Since the diagonals of a rectangle are equal, the answer to the question is found by matching the length of the diagonal with the radius (figure 4, solution A). However, one could proceed differently: the text does not prescribe touching the arc of the circumference by proceeding parallel to the y-axis; similarly, the upper side of the quadrilateral might not be parallel to the x-axis, thus touching the y-axis at any point. In this way, an irregular quadrilateral would result, for which we cannot determine anything more with the available data (figure 4, solution B). We have no better luck with Copilot or Gemini, even translating the text into source code before requesting the image. In fact, the problem does not lie in translating the problem text into an accessible code by GenAI, but in the interpretative choices that human intelligence can make beforehand. The following figure shows the graphical output of Copilot with the source code, resulting from precise choices made by the teachers.

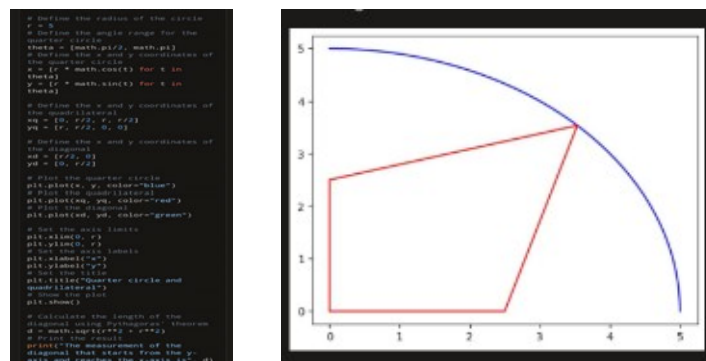


Figure 5: python code on left, graphic solution on right

4 CONCLUSIONS

This research on the trouble liaison between blind students and the study of mathematics through GenAI does not start from the specific characteristics of blind students, but from the inclusive professionalism of the teachers: the students appear only 'by reflection'; secondly, it does not move from clear mathematical structures (which usually must be adapted for neuro-atypical students), but from errors. Why? The method used to proceed is the result of a precise methodological choice.

Errors in mathematics involve cognitive aspects of absolute interest: every student, when engaged in solving a mathematical task, commits their whole self; over two decades of working with neuro-atypical students have shown that no student makes mistakes with the deliberate aim of failing. The error is truly to be understood in the Latin etymology of the word “errare”, meaning “to wander in search of the goal”: very often these errors serve to decode the cognitive structure of the students, other times they show entirely new heuristic solutions, even if sometimes unsuccessful or lengthy in practice. The role of error in mathematics must be absolutely reconsidered: it is not a judgment on the person who did not understand, as if it were the “bill that the last customer has to pay when everyone has left the restaurant”. Errors in mathematics are precious pearls because they help to understand a lot about the people who make them and, above all, not only students make mistakes: textbooks are riddled with errors, GenAI platforms are subject to numerous biases.

The three exercises analyzed in this article are cases taken from textbooks or situations that arose during math classes, which the teachers chose not to dismiss as “mistakes”, but to analyze the deep structure of the text and the procedure. In the first case, the method of proceeding is correct from an algebraic point of view, but there is a lack of awareness of the meaning of the symbols being used; in the second case, Camilla seeks an algebraic solution to a problem designed graphically: the content of the problem is approximate; therefore, it reveals itself to be inconsistent between its graphical structure and its semantic structure. The third problem contains ambiguities (the concept of a quadrilateral inscribed in a portion of a circumference is a geometrically questionable statement) and leads to infinite solutions, provided they are well-argued: the diagonal constructed from the y-axis and ending on the x-axis is determinable only if precise choices are made; in other cases, it is not possible. If the teacher abandons the judgmental attitude, the student is willing to seek the reasons for their “wandering without a goal” and to question it: just as they put maximum effort into finding a solution, they are equally willing to abandon a dysfunctional procedure and embrace doubt as a moment of personal growth. Defined the value of error and the teacher’s attitude, the hunt for error through GenAI becomes an enlightening experience: students realize that the type of response they can obtain strictly depends on the type of prompt they provide to GenAI platforms. The same question presented in graphic-visual form (jpg or other), expressed in natural language, expressed in source code provides different outputs. They understand that the language used is of fundamental importance, and that it is not merely a technological aspect determined by the type of GenAI platform: it becomes a matter of the anthropology of mathematics.

Referring to K. Devlin's definition (1998), mathematics is considered a way to “make the invisible visible”, much of the approach to mathematics in recent decades has been based on this visual-centric assumption. But is it correct? Why has mathematics education in high schools been designed to make visible what is not? Blind students, and not only them, have paid a high price for this approach: having to understand through lexical adaptations what was understandable to everyone else using the sense of sight. With evident distortions: the research by Adnin and Das (2024) reports all the aberrations derived from this approach by blind students. The layout of these platforms is designed for the sighted: often a blind person is unable to find the tools where they would expect; secondly, the descriptions (alternative text) are often written by sighted people who do not know how to describe things to the blind, having no idea of what the blind can or cannot see, what they need or do not need to know. Finally, these platforms often have evident biases towards the blind, considered with pity or excessive ableism. Blind students themselves come to a very practical conclusion: the type of responses they can obtain strictly depends on how they pose the questions. Ultimately, obtaining incorrect solutions stems from poorly framing the initial question. Is this trivial? No: if it leads to thinking that mathematics is not “what makes the invisible visible” (visual approach), but what makes “the incomprehensible understandable” (semantic approach). Considering mathematics as a language, a foreign language of which to learn symbolism, grammar, syntax, and semantics would make it more inclusive, a true narrative in which everyone can find their translation. Conversely, trying to create inclusive mathematics from its visual declinations would be like reading a text already translated many times: distortions increase.

From the reports collected by the team of inclusive teachers involved in this research, promising results emerge for future research: studying mathematics with GenAI leads students to invest more cognitive resources in the meaning of the structures they are studying, knowing that AI is a useful support for the more laborious part (calculations and demonstrations), despite the awareness of its limitations. Moreover, some platforms that use data-based modeling can be useful for various reasons in teaching mathematics. Firstly, deep learning allows the construction of models that are used to obtain information on specific aspects of the learning process of individual students. For example, Smith et al. (2015) studied the drawings produced by primary school students in science learning activities, assuming that the evolution of these drawings is predictive of conceptual progress (Lagrange et al., 2023); so far, there

is a lack of similar evidence on the study of lexical structures in general, which we have instead from blind students (Adnin & Das, 2024). Secondly, the research and analysis of errors through AI involves students in a stimulating metacognitive process completely free of the judgment they would feel from the teacher. All this is possible by shifting the focus of mathematics from imaginative understanding to semantic understanding: in this sense, the accessibility of mathematics to students with blindness or other neuro-atypicality is almost naturally achieved as it is based on language. Rethinking the teaching of mathematics is an operation that inclusive education specialists already must do to make mathematics accessible to neuro-atypical individuals. There is still a long way to go: in Italian high schools, mathematics is often still taught in its dichotomous division between algebra and geometry, with separate textbooks and dedicated lesson hours, as if they were two complementary but distinct subjects. GenAI is proving promising, as it allows teachers to radically change the way they conceive teaching, provided they can overcome some resistance and biases around the use of artificial intelligence, an evolution like that experienced a few decades ago with the introduction of computer science and scientific calculators. At a time when it was still important to be able to do calculations without making mistakes, computer science and automatic calculation were often seen with the distrust of those who were replacing human skills. Now the context is similar: GenAI tools are often accused of being high-tech plagiarism due to the difficulty of understanding what depends on the skills of the student and what on the skills of the technology. But: just as the first technological revolution due to computers allowed the teaching of mathematics to shift from calculations to structures, now GenAI can allow the shift from structures to the languages in which they are described, in a way accessible to everyone. Blind students are already doing this because for them it is the only possible alternative.

Concluding with a contribution from Lim and collaborators (2023), which is fully shared: “Generative artificial intelligence tools like Bard, ChatGPT, and DALL-E are opening new frontiers that will influence the way we learn, interact, and work with each other, thus forcing us to reinvent existing practices to be prepared and remain relevant in the future. Our experience working with generative artificial intelligence tools suggests that it is important for users to be (i) complete and specific in their prompts, which may involve (ii) scaling (e.g., clarifying with examples, structured questions) and (iii) keeping in mind the limitations of the technology to set expectations and ensure the best outcomes (lessons) [...]. Educational entities and institutions must embrace a cultural shift when it comes to generative artificial intelligence and similar 'disruptive' technologies. As history has shown, bans may not be as effective as expected; therefore: strategic governance and regulation are key to seamless integration. However, it may also be necessary to rethink how educational entities and institutions conceptualize academic misconduct, which is a much larger and more challenging task than writing the use and abuse of AI into policies. Finally, the current narrative on academic misconduct places the burden entirely on students not to engage in unethical and dishonest practices and behaviors. The bottom line is that students are expected to cheat and therefore cannot be trusted: the policy language is clear on this. Students are warned of severe punishments if discovered, from suspension to expulsion. We argue that it is time to change this narrative in favor of one that highlights distributed responsibility when it comes to academic misconduct, i.e., leaders, administrators, educators, and students must share the responsibility. Educational entities and institutions should therefore allocate adequate resources to support staff and students in effectively addressing the challenges related to generative AI and optimizing the opportunities offered by its tools (Lim et al., 2023).”

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