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AI-enhanced Maths: active metacognition and transformative assessment

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AI-enhanced Maths: active metacognition and transformative assessment

Lina Hoyos, Colombia

AI-enhanced Maths: active metacognition and transformative assessment

School context

Saint George's School, located in Bogota, Colombia, is a private co-educational, bilingual institution with British origins. With an average of 1300 students, the school is divided into three sections: preschool, primary and high school. Its vision is to shape society through a liberal, dynamic, innovative, and high-quality education that upholds a tradition of excellence.

About the author

Lina Hoyos is a biologist with a Master's degree in education. With over 18 years of experience in education, she holds the position of biology teacher at Saint George's School in Bogota, Colombia. In addition, she is actively involved in the school's Innovation Centre and serves as a member of the research office.



Key learnings

This research investigated active learning methodologies and AI tools to enhance the Maths performance of 10th grade students.

- Incorporating an AI platform (Educo) significantly enhanced students' understanding and performance in Maths, both in content learning and critical thinking skills.
- After implementing Educo, 29% of students reported increased confidence in solving Maths problems; 56% claimed to think more critically; 61% said it helped them identify errors; and 87% found the step-by-step guidance for problem-solving highly useful.
- The research offered the Maths department tools for interactive, student-centred teaching to improve learning and reduce anxiety. It led to significant changes in teaching methodology, shifting towards a more direct approach to knowledge where students play an active role in their learning.
- AI technologies should also be implemented in other areas of the curriculum; they underscore the importance of ongoing teacher training and the development of pedagogical strategies to maximise learning and teaching.

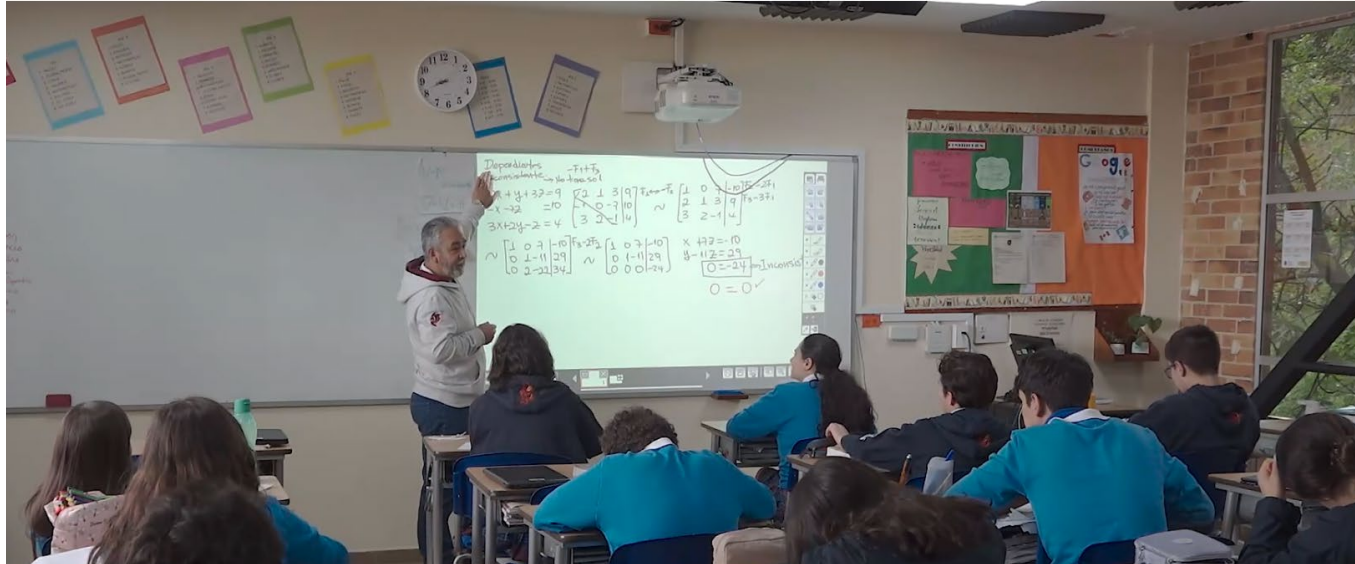


Figure 1: A class in action. The goal is to enhance student performance in Maths and create a more inclusive, equitable learning environment by integrating AI tools with effective teaching practices.

Action research rationale

Over the years, Lina has observed that students face challenges in subjects like Mathematics. Contributing factors include insufficient foundational knowledge, pandemic-related learning gaps, difficulties with abstract thinking and problem-solving, and ineffective teaching methodologies. She proposes an action-research approach to identify reasons for poor performance and to develop interventions using active learning methodologies and AI tools like simulations and formative assessments. This aims to provide a more engaging, personalised learning experience while emphasising ethical AI implementation.

By integrating virtual environments with effective teaching practices, the goal is to enhance 10th grade students' performance in Maths and create a more inclusive, equitable learning environment. This research acknowledges the importance of integrating technology, such as Artificial Intelligence (AI), to assist students in obtaining more personalised feedback processes. By doing so, it aids learners in identifying their mistakes and strengths, ultimately enhancing their metacognitive processes.

Exploratory research questions

1. How do students in the 11th grade feel about the teaching and learning methods in Maths?
2. According to students and teachers, what is the most appropriate artificial intelligence platform to assist students in enhancing the teaching and learning processes in 10th grade mathematics?
3. What are the beliefs and expectations regarding the utilisation of artificial intelligence in the classroom by the mathematics teacher?

Data collection procedures

Firstly, a survey was conducted with 65 students from 11th grade to gain insights into their perceptions and identify areas for improvement. In addition, focused group discussions with nine students (three from high, three from average, and three from low-performance categories in Maths classes) provided a deeper understanding of their experiences. The Maths teacher's perspective was gathered in an interview.

A comparative analysis of the last six years' maths outcomes for 10th grade identified trends and highlighted areas in need of improvement. Further, 153 students (10th and 11th-grade) were surveyed to understand the integration of AI platforms in their learning process.

To analyse the use of technology and AI in teaching, student engagement and classroom dynamics, three classroom observations were recorded prior to the adoption of new teaching strategies.

Lastly, an 88-participant survey assessed metacognitive awareness, using the Metacognitive Awareness Inventory (MAI) developed by Schraw & Dennison in 1994.

Before initiating the research, we obtained consent from all participants, ensuring they fully understood the study's objectives and their rights. For student participants, we secured mandatory consent from parents or guardians, supplying them with detailed information documents and consent forms. Alongside written consent, we verbally verified students' understanding of the research and their voluntary participation. We provided all participants with thorough explanations regarding the use, storage, and protection of their data. It is noteworthy that we kept all collected data confidential, anonymising any personally identifiable information to safeguard participant privacy.

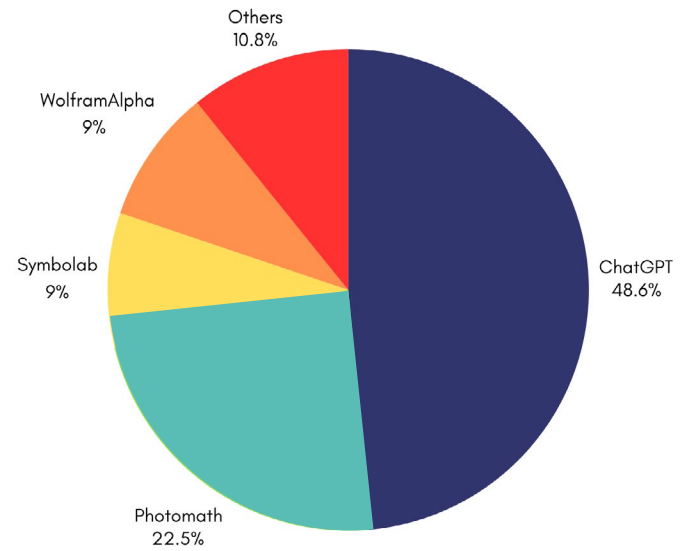
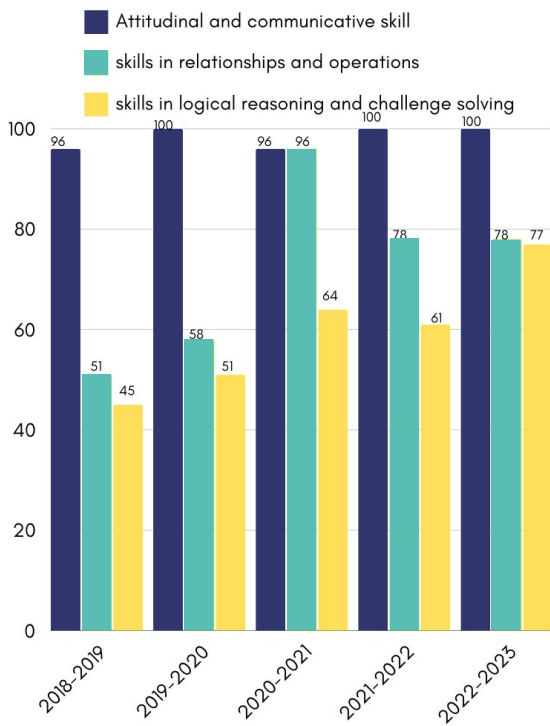


Figure 2 (left): Percentage of approval per skill results for 10th grade in Maths subject in the five past years

Figure 3 (above): Use of artificial intelligence platforms for the study of Maths in 10th and 11th graders

Key findings from exploration

Students have highlighted feedback as an essential component of their learning, greatly valuing this aspect. However, they express a desire for more personalised feedback that makes it easier to understand the processes of solving mathematical problems and helps them identify their mistakes. Similarly, they show a preference for more interactive lessons with greater integration of technology

In the school's mathematics area, three competencies are assessed: attitudinal and communicative; skills in relationships and operations; and skills in logical reasoning and solving mathematical challenges. The analysis of the last five years indicates that the most challenging competency for students is related to logical reasoning and solving mathematical challenges, as shown by the lowest averages and approval percentages (see Figure 2).

Regarding the implementation of AI technologies, 67% of both 10th and 11th grade students have used such platforms to understand and solve mathematical problems. The most used platforms include ChatGPT, Photomath, WolframAlpha, and Symbolab (see Figure 3). Considering these results, it was determined that the selected platform should be engaging, adaptable, user-friendly, and encourage independent work by students.

The analysis of the results from the Metacognitive Awareness Inventory (MAI) revealed that participants achieved an average score of 13.08 out of a possible total of 17 in the 'Knowledge About Cognition'

category, suggesting a moderate level of awareness of their own cognitive processes and understanding. In the 'Regulation of Cognition' category, the average score was higher, reaching 24.52, indicating that participants generally have greater skills in monitoring and regulating their learning strategies and processes. The difference between the two scores highlights an opportunity for potential development in improving students' understanding of their own cognition.

Action plan

- Teacher professional development: training the Maths teacher in using and implementing an AI platform for more active lessons with technology use.
- Developing metacognitive skills in 10th grade students through the use of an AI platform in Maths class.

Action plan implementation

The implementation of the action plan was divided into two main sections: one directed at the teacher and the other at students.

For the teacher, training focused on reviewing objectives, success criteria, and their alignment with planning. Regarding metacognition, training was provided on the use of tools for the development of metacognitive skills, such as feedforward. Additionally, training was offered in the use of AI platforms like Educo and ChatGPT.

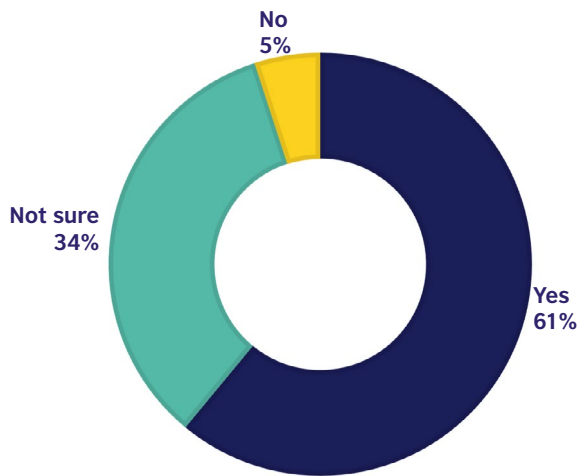


Figure 4 (left): Effectiveness of Educo in error identification and understanding in Maths problem solving



Figure 5 (above): Percentage of change in some skills for Regulation of Cognition

As for the students, two main tools were implemented: Educo (<https://www.educo.co/>) and feedforward. Educo, an artificial intelligence platform, allows students to explore the step-by-step process for solving mathematical problems. Unlike other platforms, Educo does not immediately show the answer or the problem's development; instead, it guides the student through questions, offering theoretical explanations when it detects conceptual difficulties. The platform allows for interaction via questions, which is very useful for teachers as they can include exercises, class workshops and exams.

The other tool used, especially during the correction of exams, was feedforward. This technique not only helps students to identify errors but also plan future actions to improve their performance.

Data collection procedure

Structured dialogues involving the teacher, head of department, educational coach and research office members were held to review objectives, success criteria, and their alignment with planning, alongside discussions on AI platform implementation. Topics included expectations, creating prompts, challenges, and benefits in developing students' problem-solving skills, with a focus on assessing professional development needs for effective platform use.

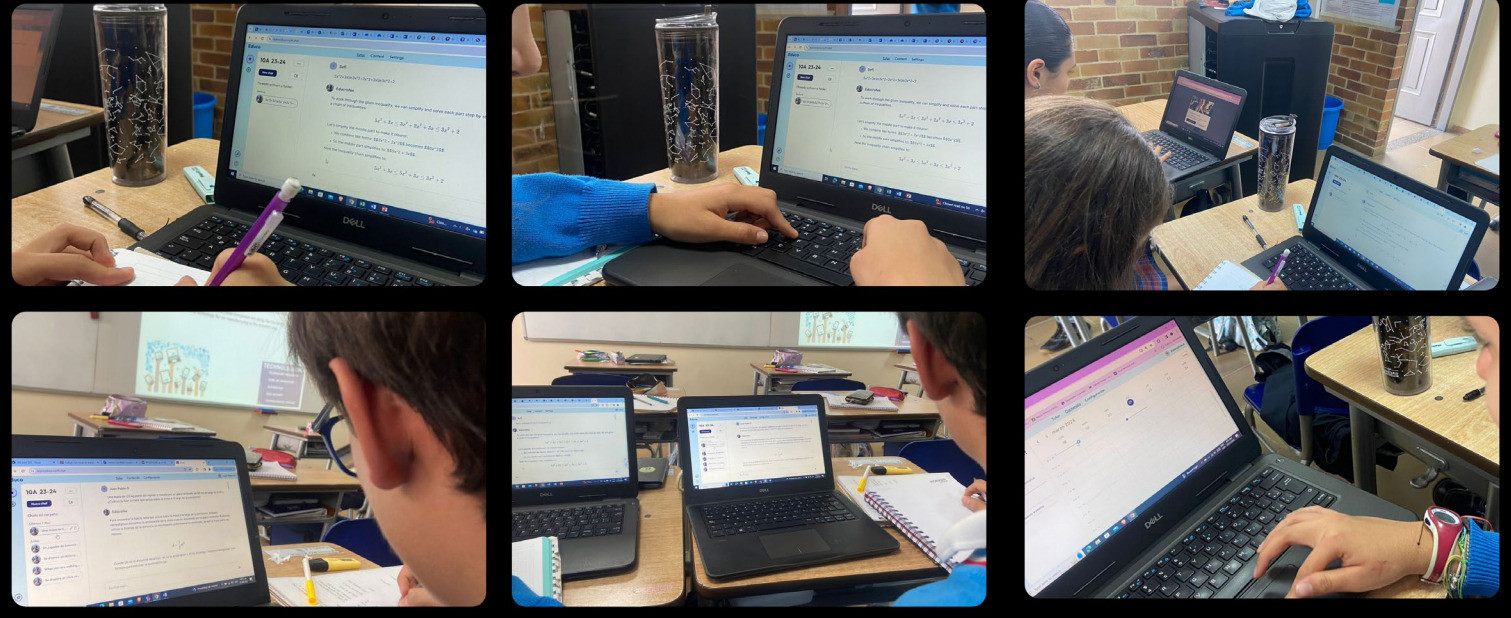
The teacher underwent a survey and interview to evaluate expectations and perspectives on the AI platform. Additionally, a survey was conducted among 88 students in 10th grade to understand their expectations and perceptions of platform usage, followed by a focus group for deeper understanding.

Academic outcomes, including logical reasoning, mathematical problem-solving skills, and exam results, were compared between terms and with the past five years among 10th grade students.

Metacognitive awareness levels were re-evaluated using the MAI to detect changes in students. Finally, school leaders were interviewed to explore their future expectations regarding the implementation.

Key findings

- After the implementation of the Educo platform, 29% of the students reported increased confidence in solving mathematical problems.
- 56% claimed to think more critically when seeking solutions to mathematical problems.
- 61% of the students stated that the platform helped them identify their errors in solving mathematical problems (see Figure 4).
- 87% found the platform's step-by-step guidance for problem-solving highly useful.
- Although *t*-tests did not reveal statistically significant changes, an observable change of 11% in the average final results between the first and second term was noted, with a 22% improvement in the percentage of approval for the subject.
- Results from the Metacognitive Awareness Inventory (MAI) also did not show statistically significant changes after conducting a *t*-test. However, there was a noticeable improvement in cognitive regulation skills.
- Detailed analysis of the scores from each test revealed a 50% improvement in planning, 58% in monitoring comprehension, and 56% in evaluation skills (Figure 5).
- The teacher enhanced his professional growth, through an in-depth exploration of AI, highlighting the importance of staying current with technology. It also led to significant changes in teaching methodology, shifting towards a more direct approach to knowledge where students play an active role in their learning.
- The research offered the Maths department tools for interactive, student-centred teaching to improve learning and reduce anxiety.



Conclusions

It's crucial to stay aware of the social changes and the evolving needs of contemporary students, who are calling for more interactive, personalised classes with deeper technological integration. This study reveals how incorporating artificial intelligence (AI) platforms, like Educo, can significantly enhance students' understanding and performance in mathematics. Tangible improvements were observed in final results and exam percentages of approval.

In addition to aiding specific content learning, AI-assisted education can enhance critical thinking skills, vital for long-term learning and application across various contexts. While progress in students' metacognition did not meet expectations, notable enhancements were seen in specific cognitive regulation skills.

For future research, it is recommended to explore additional tools, like feedforward, to further boost the development of these skills, crucial for effective and autonomous learning.

It is also recommended to advocate for the expanded implementation of AI technologies in other areas of the school curriculum. They underscore the importance of ongoing teacher training and the development of pedagogical strategies that effectively integrate these technologies to maximise their impact on learning and teaching.

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Additionally, I would like to note that I used ChatGPT in refining style, grammar and summarising texts.

'The project significantly boosted my professional development, especially through exploring artificial intelligence, underscoring the need to stay abreast of technology for our students' futures.'

Maths teacher