Tipo de documento: Documento de Políticas Públicas N° 35

Escuela de Gobierno.Centro para la Evaluación de Políticas basadas en Evidencia (CEPE)

Generative AI in Education: A Framework for Leveraging Digital Tools in Latin American Classrooms

Autoría ditelliana: Levy Yeyati, Eduardo (*Universidad Torcuato Di Tella. Escuela de Gobierno. Centro para la Evaluación de Políticas basadas en Evidencia (CEPE)*)
Otras autorías: Robano, Virginia; Pereiro, Emiliano; Porto, Camila; Koleszar, Victor (*Centro Ceibal*)
Fecha de publicación: 03/2025

Generative AI in Education: A Framework for Leveraging Digital Tools in Latin American Classrooms [1]

Eduardo Levy Yeyati*, Virginia Robano**, Emiliano Pereiro**, Camila Porto**, Víctor Koleszar**[2]

March 2025

Abstract

Generative Artificial Intelligence (AI) has the potential to help educators tackle persistent challenges—such as complex problem-solving and personalized mentoring—while preserving the essential human elements of judgment and empathy. Focusing on Latin American classrooms, this study explores how AI-powered chatbots can complement teachers in elementary and secondary education. Drawing on quantitative and qualitative evidence, we identify strategies to minimize gender gaps, strengthen teacher preparedness, and maximize student engagement. The study proposes actionable policies, including targeted teacher training, gender-inclusive AI adoption strategies, and scalable hybrid teaching models, as well as a blueprint for testing chatbot effectiveness. By incorporating a gender lens and a phased AI adoption strategy, our study not only outlines best practices for AI deployment but also offers empirical insights into how chatbots impact learning engagement, teacher preparedness, and student equity. Our framework serves as a guide for policymakers aiming to integrate AI tools in a way that supports—not replaces—educators while addressing disparities in access and usage.

JEL: C9, I21, J24, O33

Keywords: artificial intelligence, education, ChatGPT, complementarity, LLM, automated tutor, chatbot, classroom, teaching

---

[1] We are grateful to the Inter-American Development Bank (IDB) for its financial support. The opinions expressed in this document are solely those of the authors and do not necessarily reflect the views of the IDB. Errors are our responsibility.

[2] *The Brookings Institution and Universidad Torcuato Di Tella, ely@utdt.edu , ** Centro Ceibal, virobano@ceibal.edu.uy , epereiro@ceibal.edu.uy, cporto@ceibal.edu.uy, vkoleszar@ceibal.edu.uy

1. Introduction

As generative AI rapidly transforms industries worldwide, its potential to revolutionize education—particularly in underserved regions like Latin America—has become both promising and contentious. Unlike earlier waves of educational technology—such as learning management systems, static content platforms, or intelligent tutoring systems—generative AI introduces dynamic, dialogic tools that can create, adapt, and respond to learners in real time. These tools hold particular promise in environments where teacher shortages, content gaps, and resource constraints hinder effective instruction.

This study examines whether and how AI can complement teachers, address systemic challenges, and promote equitable learning outcomes in Latin American classrooms. Our core premise is that AI's capabilities—specifically natural language processing and content generation—enable a different class of interventions than those offered by prior technologies. Where past edtech offered scale, automation, or access, generative AI adds interaction, customization, and reasoning—features that are especially relevant in low-capacity systems where teachers are overburdened and pedagogical support is limited.

Yet the promise of AI must be assessed alongside its risks. Generative AI, and chatbots in particular, are often deployed rapidly, with limited oversight or evidence on their pedagogical effectiveness. In education systems already strained by inequality, the indiscriminate adoption of these tools may exacerbate existing gaps. For example, there is emerging concern that chatbots—though capable of providing instant feedback and scaffolding—may also deliver inaccurate content, entrench stereotypes, or divert attention from meaningful human interaction if not properly integrated. To guide this exploration, the paper addresses three core questions:

- **Which AI applications most effectively enhance educational progress in under-resourced settings?**
- **What factors drive disparities in AI adoption, and how can these gaps be addressed?**
- **What risks and unintended consequences emerge from rapid AI adoption in Latin American classrooms, and how can they be mitigated?**

To address these questions, we narrow our focus to generative tools aimed at supporting teaching and learning—rather than administrative automation or parent communication—and examine how their use varies across schools and teachers. Among these, chatbots are particularly relevant due to their capacity to deliver instant feedback, provide context-specific explanations, and simulate dialogic learning. When well-designed and appropriately integrated, they can support content mastery, stimulate student curiosity, and reduce teacher workload by handling routine instructional tasks.

However, these benefits come with significant challenges. Chatbot-generated content varies in quality and accuracy, posing risks of misinformation and pedagogical inconsistencies. In under-resourced settings, where both teachers and students may have limited access to high-quality educational materials, over-reliance on AI-generated content could deepen—not bridge—learning gaps. This underscores the need for structured AI integration frameworks that prioritize teacher oversight and content verification. In this context, the pedagogical value of chatbots may lie not only in the information they provide, but also in how they encourage a "fact-checking" mindset and critical engagement with sources. This reinforces the need for a phased, supervised adoption model in which teachers first use AI tools to strengthen their own mastery and instructional planning before introducing them to students (Appendix I presents a glossary table comparing different types of AI tools).

Empirical evidence on these dynamics remains limited. While AI adoption is expanding across Latin America, especially through national edtech platforms, structured evaluations of its educational impact—particularly for vulnerable populations—are still rare. This study seeks to fill that gap by analyzing existing quantitative and qualitative data, with a focus on Ceibal's Computational Thinking Program and Gender Dashboard. We document current patterns of AI tool usage and investigate adoption barriers, particularly among female teachers and students, drawing on observed disparities in access to programming tools, participation in robotics competitions, and engagement with AI-based learning platforms.

Building on this analysis, we propose a research design that tests a staged integration model—beginning with teacher-facing uses of AI for professional development and pedagogical support, and then gradually incorporating student-facing applications. This sequencing reflects the view that AI's educational effectiveness depends not only on its technical capabilities but also on the institutional conditions that enable its meaningful and equitable use.

Our analysis finds that AI tools, particularly chatbots, can enhance personalized learning, reduce teacher workload, and promote engagement. However, their integration requires careful attention to gender disparities, pedagogical oversight, and ethical considerations. Using data from Ceibal's Computational Thinking Program, we propose a hybrid AI adoption framework emphasizing teacher training and student empowerment while mitigating potential risks associated with over-reliance on AI.

Gender and socioeconomic disparities in AI adoption

Our review indicates that generative AI tools, such as text-based models deployed as chatbots, hold significant potential to improve educational outcomes. However, their impact depends on the quality of the underlying model, as well as the modality of use (e.g., content generation, personalized feedback, or scaffolding), the interface (text, voice, or multimodal), and the degree of teacher mediation in their integration. While gender differences in AI adoption exist, they do not always imply inequity. In some cases, lower adoption rates may reflect a strategic avoidance of potential risks, such as AI overuse and its effects on mental health—concerns that parallel findings on adolescent girls' engagement with social media.

For instance, data from Ceibal's Computational Thinking Program and Gender Dashboard show that, while overall adoption rates are promising, boys disproportionately access programming resources like micro:bit boards, and male students dominate participation in Robotics Olympiads.[3] Additionally, female teachers -the majority of the global teaching workforce- show lower rates of AI tool usage, often linked to cultural and self-perception barriers. Structural factors such as limited access to training or infrastructure, as well as a deliberate wait-and-see approach in the face of fast-moving technologies, may also be contributing. Despite these gaps, targeted interventions, such as women-only training programs, have demonstrated

[3] Evidence from the U.S. suggests that while girls in middle and high school often outperform boys academically, they also face greater mental health risks associated with excessive use of digital platforms. If generative AI follows a similar pattern—where certain applications disproportionately affect specific groups—the focus should be on identifying *which AI applications benefit students* and which introduce risks, rather than simply increasing usage across the board.

positive outcomes in improving skills and confidence among female participants. These insights underscore the need for carefully designed policies to ensure equitable access and inclusive adoption of AI technologies.

The paper is structured as follows: Section 2 reviews the literature on AI's role in complementing human labor in education and other sectors. Section 3 describes the data sources, including Ceibal's computational thinking program and gender dashboard. Section 4 presents the proposed methodological framework and outlines the experimental design. Sections 5 and 6 discuss the policy implications and conclude the paper.

2. Literature review

The integration of AI in education has emerged as a significant area of academic inquiry due to its potential to enhance learning outcomes and reshape traditional teaching practices (Varsik and Vosberg, 2024). AI integration -understood here as the purposeful use of generative tools, such as chatbots or adaptive tutors, within teaching and learning practices- also holds significant promise for fostering equitable learning opportunities, as these tools can reduce educational disparities by expanding access to high-quality learning resources and enhancing instruction for disadvantaged students (INTEF, 2022). Such advancements illustrate the potential of technology to act as a leveling force in education, particularly in regions like Latin America, where systemic inequities persist.

Many international studies have explored the potential of AI tools in education, demonstrating innovative approaches and highlighting both opportunities and challenges at all school levels, building a preliminary but growing body of evidence that points in the same direction: AI-based models offer substantial benefits in enhancing learning outcomes, particularly in resource-constrained environments (UNESCO, 2021; Thomas et al., 2023), and address students with diverse needs (Hollingsworth, 2024; Tiernan, 2025), particularly as a complement to human teachers (Wang et al., 2025). However, concerns related to data privacy, accessibility gaps, and the reinforcement of existing inequities require proactive policy interventions to ensure inclusive adoption.

The distinction between AI as an educational enhancer versus AI as a cognitive crutch is crucial. AI tutors that provide interactive and adaptive feedback can reinforce comprehension, improve engagement, and support student learning. However, when students use AI passively—such as copying AI-generated responses without critical engagement—it can diminish cognitive effort, weaken problem-solving skills, and encourage superficial learning. This dichotomy emphasizes the need for AI literacy training to help students distinguish productive vs. unproductive AI interactions (Mollick & Mollick, 2023; Darvishi et al., 2024; Bastani et al., 2025). Additionally, AI's impact extends beyond individual learning to classroom dynamics. Does AI increase student motivation, does it disengage them from teacher-led discussions, or both? Are students using AI tools to explore new ideas? Are they becoming overly reliant on automation? These distinctions are crucial for understanding AI's role in education.

AI in early childhood education

Evidence from OECD countries highlights the dual-edged nature of technology integration in early childhood education. While digital tools and unplugged activities like coding puzzles can enrich learning, risks such as prolonged screen time, reduced interpersonal interactions, and privacy breaches must be carefully managed. Programs like Estonia's ProgeTiger demonstrate how a balanced approach, combining technology with physical play and face-to-face activities, can support holistic development (OECD, 2023).[4]

While the use of AI in early childhood education remains controversial—and in many contexts legally constrained—the Estonian case of ProgeTiger offers an example of how age-appropriate digital and computational thinking tools are being introduced in preschool settings. Although these programs do not involve direct use of generative AI by children, they reflect broader efforts to build foundational digital literacy from an early age. The inclusion of such examples raises important questions about readiness, ethical guardrails, and the evolving boundaries of AI use in early education.

[4] Also, in the context of early childhood education, Su and Yang (2023) propose a framework (IDEE) for integrating ChatGPT and other generative AI tools, tackling challenges related to ethics, practicality, and effectiveness.

AI in K-12 education

While traditional Intelligent Tutoring Systems (ITS) have often relied on rule-based "if-then" logic and predictive algorithms, the introduction of GenAI technologies into educational tools has recently enabled more dynamic and personalized learning experiences, representing a significant shift towards more personalized and transformative educational experiences (Abbes et al., 2024).

In the context of K-12 education, Sahito et al. (2024) highlight the positive impact of personalized AI-based learning tools in Pakistan, showing improvements in academic performance and student engagement. These tools, which tailor content based on individual performance, help keep students engaged and provide timely feedback. However, the authors also identified challenges, including concerns about data privacy, unequal access to technology and the need for teacher training. Specifically for primary and secondary school students in South Korea, Son (2024), in a scholarly review of the integration of Intelligent Tutoring Systems (ITS) for mathematics teaching, also finds positive impacts but reveals a predominance of approaches in which technology enhances traditional practices without completely transforming them. Furthermore, the review also finds that, although ITS were initially designed to minimize teacher involvement through predictive AI and rule-based systems, emphasize greater teacher support to enhance adaptability, provide deeper personalization, and foster exploratory learning environments (Zhai, 2024; Frosig, 2024).

AI in higher education

In higher educational settings, AI-based simulation tools like game-based learning, chatbots, virtual reality (VR), and augmented reality (AR) enhance the understanding of complex topics, overcoming geographical and budgetary constraints. These technologies provide immersive and interactive experiences, making learning more relevant and accessible, especially when adapted to cultural contexts (Varsik & Vosberg, 2024). Chatbots also offer benefits for sensitive subjects like sex education by providing anonymity, reducing discomfort, and fostering an open learning environment (Park et al., 2024). Additionally, they are expanding into mental health support (Lakho et al. 2024; Lopes et al., 2024; Olawade et al. 2024), using data analytics to detect distress and improve student well-being, demonstrating AI's potential to diversify educational experiences.

For instance, Bodonhelyi et al. (2024) investigate the use of an AI-driven educational chatbot to transform passive video watching into an interactive learning experience. By allowing higher education students to ask questions and receive immediate, tailored responses during lectures, this tool significantly enhanced knowledge retention and user satisfaction, showcasing the potential of AI to foster engagement and support personalized education.

Regarding student motivation and effort, there are positive but nuanced findings. Pappagallo (2024) argues that the use of chatbots can increase student motivation by providing immediate feedback and fostering a more interactive learning environment.[5] Analogously, Lee and Kwon (2024) find significant improvements in engagement and in anxiety reduction of girls and non-binary students. The health industry provides valuable insights into optimizing bot engagement. Adam Rodman and Goh et al. (2024) highlights the importance of interactive, empathetic, and user-centered design in fostering trust and sustained engagement. Features like personalized responses and contextual adaptation enhance user satisfaction and effectiveness. Similar strategies can be applied in classrooms, where empathetic chatbots can encourage active participation, reduce student anxiety, and create a supportive learning environment.

However, Zhai, Wibowo and Li (2024) indicate that over-reliance on AI technologies can lead individuals to favor efficient cognitive shortcuts or heuristics over more effortful, deliberate reasoning. Such tendencies pose the risk of undermining deeper cognitive engagement, which is essential for learning. Similarly, Acemoglu (2021) highlights the broader risks of automation displacing human judgment and effort, underscoring the importance of using AI as a complementary tool rather than a replacement for human interaction in educational settings. And Lee & Kwon (2024) find that students who regularly consulted chatbots for answers, without verifying sources, exhibited lower retention rates than those who actively engaged with AI-generated content. To counteract these effects, AI literacy curricula must emphasize verification skills and source triangulation."

Together, these insights suggest that while AI technologies have the potential to enhance motivation and engagement, their implementation must be carefully designed to avoid

[5] Pappagallo (2024) extends the discussion to address ethical considerations, particularly those involving sentiment analysis and student privacy concerns.

diminishing student effort. That said, a note of caution is in order: if these tools are so fast and produce outputs that may be significantly better than what students and teachers might produce without them, the hardwired human behavior of taking shortcuts and the path of least resistance may inhibit the use of complementarities and choose AI-based apps simply as a replacement, despite our best efforts. The experience with chatbots certainly underlines this suboptimal outcome.

AI and teachers

The complementarity between AI and human teachers, especially when addressing an heterogeneous class with diverse needs, manifests in a number of ways: AI can provide adaptive responses to individual learning needs, helping teachers to deliver personalized instruction while in the classroom; AI can also provide real-time feedback and support as students solve complex problems, allowing teachers to focus on higher-order tutoring and guidance; AI can also help address issues of low self-confidence among some students by providing a judgment-free environment, enabling them to pose questions or engage in tasks they might hesitate to undertake in the presence of a teacher (Brynjolfsson, Li and Raymond, 2024). This complementary approach is in line with economic studies showing that technological tools are more productive when they support high-skill activities than when they replace basic tasks (Ayres and Miller, 1983). However, here it is important to distinguish performance from actual learning: AI tools can improve the former with minimal effects on the latter (Lehman, 2025)

Brynjolfsson, Li, and Raymond (2024) suggest that AI technologies serve as a significant equalizer, elevating the performance of less experienced or average workers while having little impact on those already excelling. Applied to education, this insight highlights AI's potential to empower teachers in the classroom by enhancing their ability to transfer knowledge and support diverse learning needs. For teachers with limited knowledge or confidence in specific subject areas, AI can serve as a valuable tool to deliver personalized instruction, provide real-time explanations, and address gaps in student understanding –although an insufficient knowledge may reduce the teacher’s capacity to monitor AI’s actions. Highly skilled teachers, while less directly impacted, can use AI to diversify and amplify their instructional reach, focusing on fostering higher-order thinking and deeper engagement among their students.[6] As a result, AI offers a door to mitigate a generalized –and growing– problem in education quality: the declining number of trained teachers.

However, significant challenges hinder the integration of AI in education. One prominent issue is, precisely, associated with training; specifically, the lack of AI preparedness, which also includes, most notably, connectivity infrastructure and broad digital access. While factual knowledge is now widely accessible online, the role of educators in helping students organize and synthesize this information into meaningful mental frameworks (on which to build further knowledge) remains indispensable. Without this guidance, students risk relying on fragmented information rather than developing the deeper understanding necessary for learning. In many Latin American countries, however, systemic shortcomings in teacher education and professional development mean that many educators are insufficiently equipped to perform this complementary role effectively.

Another critical challenge in AI integration is the risk of overreliance, where both teachers and students may depend excessively on AI tools, potentially undermining critical thinking, and effort (Zhai et al. 2024). Evidence from educational contexts indicates that AI tools can inadvertently promote shortcuts, such as relying on AI-generated answers instead of engaging in problem-solving. Strategies to mitigate overreliance include i) encouraging balanced use by framing AI as a supplement rather than a substitute for human judgment; ii) incorporating reflective practices, such as requiring students to explain or critique AI-generated outputs; and iii) training teachers to blend AI tools with traditional pedagogical approaches that prioritize deep learning.

More generally, AI strategies that emulate human interactions, such as those used in Replika or Character.AI, offer both opportunities and challenges (Zhang et al., 2025; van der Rijt et al., 2025). While bots that simulate human-like conversations can foster connections, improve user engagement, and create a sense of psychological safety, encouraging students to explore

[6] Although AI primarily supports teachers in classroom activities, its effectiveness ultimately shapes student outcomes. By leveraging AI tools, teachers can create more inclusive and equitable learning environments, particularly for students who may otherwise struggle to engage. However, the success of these efforts depends on thoughtful implementation, ensuring AI complements teaching practices rather than substituting critical elements of human interaction and mentorship.

and ask questions, excessive human-like emulation may blur boundaries between AI and human relationships, leading to ethical concerns, dependency, or reduced critical thinking. For educational use, AI should prioritize transparency and emphasize its role as a tool, ensuring students and teachers remain aware of its limitations and biases.

Despite AI's potential to alleviate teacher workload and personalize instruction, there is a risk that over-reliance on chatbots may inadvertently deskill educators, particularly those in training or early-career stages. If teachers defer increasingly to AI-generated content, their role may shift from knowledge facilitators to AI supervisors, reducing opportunities for professional growth. Policymakers must ensure that AI tools are integrated in ways that reinforce teacher expertise rather than substituting pedagogical judgment.

AI integration in low-resource settings

The research detailed above highlights the focus on improving the quality of education in Latin America and the Caribbean (LAC). While LAC face significant obstacles in integrating AI into classrooms, including technical, socio-economic, and cultural barriers, While AI technologies are not a solution to the structural inequities that shape educational quality in Latin America, they may help address specific instructional challenges—such as limited individualized feedback, content gaps, or teacher workload—that constrain learning within classrooms. Their potential lies in complementing human-led pedagogy, not in replacing the systemic investments needed to ensure equity and quality at scale. In addition, they may also contribute on another critical front, improving attendance and completion rates, thereby addressing another aspect deeply linked to education quantity.

That said, for AI to fulfill this potential, there are critical prerequisites, other than teacher training and adoption that must be met, such as ensuring access to affordable connectivity and digital devices (Saavedra et al., 2024). Internet connectivity plays a pivotal role in the effective use of AI-based educational tools, yet significant disparities persist, particularly in schools serving socio-economically disadvantaged communities (Varsik and Vosber, 2024; Saavedra et al., 2024). These inequalities contribute to widening digital divides (Sulkunen, 2013; Carvajal, Franco, and Isaksson, 2024) and exacerbate low attendance, high dropout rates, low completion rates, and poor learning outcomes. These issues disproportionately affect low-income students, rural populations, and racial and ethnic minorities (Arias Ortiz et al., 2024). Carvajal, Franco, and Isaksson (2024) warn that disparities in AI adoption and usage risk exacerbating existing inequities, including gender gaps, due to biases in design, implementation, and access. Their findings underscore the socio-economic implications of unequal AI integration and highlight the need for intentional efforts, such as tailored training and infrastructure investment, to prevent the reinforcement of systemic inequities.

Relatedly, gender gaps in learning outcomes present another dimension of inequity in the region. Evidence from Uruguay highlights that gender disparities in STEM-related learning outcomes emerge as early as first grade, with female students showing lower performance in areas such as mathematical reasoning and computational thinking (San Román, 2023; INEEd, 2025). While international patterns vary—some countries report boys lagging in literacy or girls closing gaps in STEM—Uruguayan data consistently reveal early and persistent disadvantages for girls in these domains. These findings underscore the importance of country-specific analysis when designing equitable AI-supported interventions in education.[7] This gap persists and widens across educational levels, as confirmed by PISA and Aristas studies (Robano, 2023; Robano, Galland, and González, 2025).

The observed gender disparities in AI adoption may stem from two primary factors: (1) structural barriers, such as unequal access to training opportunities and technology, and (2) socio-cultural influences, including self-perception biases in STEM-related tasks. The Ceibal data suggests that even when access is equalized, female students and teachers remain less likely to engage with AI tools, indicating a potential preference for human-centered learning interactions. Understanding whether this preference reflects a strategic decision (avoiding over-reliance) or a constraint (lack of confidence) is crucial for designing effective interventions.

These findings point to the need for gender-sensitive interventions in educational policies and AI implementation. But, while gender gaps in participation exist, it is important to consider that lower engagement with AI tools does not necessarily equate to a disadvantage. In some cases, lower usage rates may reflect not a deficit, but a protective stance—reducing exposure to risks such as overreliance on AI, diminished critical thinking, or adverse effects on mental health.

[7] STEM is an acronym for Science, Technology, Engineering and Mathematics

This cautious approach may be particularly rational in contexts where the educational value of AI tools remains uncertain, and where adoption is often driven more by technological availability or market pressures than by clearly defined pedagogical needs.

Moreover, rather than evaluating AI's impact solely through adoption rates, we must assess whether students are using it in ways that enhance learning. Some applications, such as AI tutors providing real-time feedback, may yield positive effects, whereas overreliance on AI-generated answers without critical engagement could be detrimental. Understanding *who is using AI effectively and who is not* is key to designing policies that maximize its benefits.

Our note introduces new strategies to address the integration of AI in the classroom, as well as understanding gender disparities in AI adoption (both in teachers and students). While current studies acknowledge gender gaps in technology use, few provide concrete policy recommendations tailored to AI in education. This study bridges that gap by using one of Ceibal's Computational Thinking Program (CTP) and tools (the gender dashboard, which tracks participation and performance gaps), to propose actionable measures towards a more equitable AI usage among both male and female teachers and students. By doing so, the research provides a clearer understanding of how the adoption of artificial intelligence in education can be structured to enhance learning outcomes for all students, acting as an effective complement to support both teachers and students, while promoting gender equity in the access and use of these technologies, especially in the Latin American context.

Other studies have explored innovative applications of generative AI in education, offering insights into their impact and challenges:

- **ChatGPT in Nigeria (2024):** Teachers have successfully used ChatGPT to create lesson plans and personalized instructional materials, overcoming resource constraints. The AI tool has been particularly effective in supporting non-specialist teachers, enhancing their ability to address diverse student needs.[8]
- **Generative AI for Coding Education (2024):** AI tools have been utilized to introduce coding skills in secondary education. Evidence shows improvements in logical reasoning

[8] https://blogs.worldbank.org/en/education/From-chalkboards-to-chatbots-Transforming-learning-in-Nigeria and https://blogs.worldbank.org/en/education/From-chalkboards-to-chatbots-in-Nigeria and personal communications with the World Bank team in charge of implementation.

and debugging skills among students, with AI offering dynamic, contextual feedback (Lehman et al., 2025).

- **WhatsApp in Ghana (2024):** In low-connectivity settings, WhatsApp groups supported by AI-based chat assistants have facilitated collaborative learning and communication between teachers and students, demonstrating the feasibility of low-tech solutions (Henkel et al., 2024).
- **ChatGPT in Turkey (2024):** Bastani et al. (2024) examined the impact of GPT-4–based tutors on student learning in high school mathematics. The study revealed that while access to generative AI significantly boosted short-term performance—by 48% with a standard GPT interface and 127% with a pedagogy-informed version called GPT Tutor—students who lost access later performed worse than those who never used the tool, suggesting a "crutch effect" from overreliance. These negative outcomes were mitigated when safeguards were embedded into the AI system, reinforcing the importance of thoughtful integration. The Turkish case highlights not only the potential of generative AI to improve instruction, but also the risks of its premature or unstructured adoption—particularly relevant for systems seeking scalable yet equitable AI strategies.

Generative AI pilots in developing countries have demonstrated the importance of tailoring implementations to local constraints. Low-connectivity environments benefit from tools that can operate offline or with minimal bandwidth, such as pre-trained AI models integrated into locally hosted platforms. Initiatives like WhatsApp-based learning in Ghana illustrate how ubiquitous, low-tech platforms can effectively deliver AI-enhanced educational interventions. These pilots highlight the importance of simplicity, accessibility, and scalability in designing AI solutions for resource-constrained settings.

3. Evidence and data sources

Understanding the challenges and opportunities of integrating AI into education in LAC requires a comprehensive examination of both regional and country-specific evidence. Low attendance rates, teacher turnover, and socio-economic disparities significantly hinder educational outcomes across the region. This section highlights key data and insights, focusing on attendance, student performance, and gender inequalities, while positioning Ceibal as a case study for addressing these challenges and fostering equitable educational opportunities.

Our findings from Ceibal's CTP indicate that while female students demonstrate equal aptitude in AI-based tasks, their engagement levels are lower due to a combination of structural barriers (e.g., limited access to AI-focused training) and cultural factors (e.g., self-perception biases in STEM fields). Addressing these disparities requires targeted interventions, including gender-responsive AI training programs and improved teacher awareness of unconscious biases.

Despite the expansion of educational coverage at all levels in the LAC, low student attendance persists as one of the most pressing challenges, albeit heterogeneous across countries and with a lack of comparative data (ECLAC, 2024). For instance, in Uruguay, the average school attendance rate fell to 86.6 percent in 2022, with 54.5 percent of students chronically absent, defined as missing 10 percent or more of school days. In 2023, attendance declined further to 86.1 percent, and chronic absenteeism increased to 59.3 percent (INEEd, 2024). This widespread absenteeism directly hampers academic progress, as pupils who are absent from school find it difficult to catch up with their peers. In addition, teachers often must spend extra time catching up with absent students, which disrupts the flow of instruction for the whole class. Compounding this issue, high teacher turnover destabilizes learning environments and limits the consistent implementation of innovative teaching practices (Castro et al., 2024). Drawing on Brynjolfsson, Li, and Raymond's (2023) findings that AI tends to complement—rather than replace—human labor in cognitively demanding tasks, we hypothesize that AI integration in classrooms could improve workplace conditions for educators. By automating routine instructional tasks and supporting content generation, these tools may allow teachers to focus on higher-value pedagogical activities, potentially alleviating some of the pressures that contribute to job dissatisfaction and turnover. LAC also face significant challenges in student performance. According to PISA assessments, 55% of students in the region perform poorly in reading (compared to 26% in OECD countries), while 75% and 57% struggle in mathematics and science, respectively (Arias Ortiz et al., 2024). Uruguay mirrors these trends, with 41% of students below the minimum reading proficiency level and 57% struggling in mathematics (ANEP, 2022).

Socio-economic disparities heavily influence these outcomes. In Uruguay, 18% of differences in mathematics scores are attributed to socio-economic inequalities, compared to less than 5% in the most equitable OECD countries (ANEP, 2022).

Uruguay's Ceibal initiative demonstrates how targeted policies and investments can address systemic challenges and reduce educational inequalities. Ceibal serves as a pivotal bridge between advanced economies—such as Finland, the United States, Estonia, Sweden, and the United Kingdom—and LAC in the integration of educational technology. Drawing lessons from global leaders in AI and educational innovation, Ceibal demonstrates how a well-implemented, contextually relevant policy framework can adapt these advanced practices to the realities of an emerging economy. Its success highlights the potential of targeted policy intent to overcome socio-economic barriers, address digital divides, and promote equity in access to and use of technology. By incorporating cutting-edge tools like AI into public education and aligning them with broader social inclusion goals.

Gender inequalities persist in STEM education, reflected in disparities in PISA results and program participation. In Uruguay, girls outperform boys in reading comprehension but lag in mathematics and science (Arias Ortiz et al., 2024). Ceibal actively addresses these gaps through initiatives like the Gender Dashboard, designed by Robano (2023), which tracks gender disparities in access, performance, and leadership roles. While most indicators show no significant gender gaps, disparities emerge in areas like the distribution of micro:bit boards and participation in programming competitions, where boys dominate. Such inequalities highlight cultural and self-perceived barriers that influence girls' engagement in STEM fields.

The Robotics and Programming Olympiads (ORP) and Jóvenes a Programar (JaP) initiatives further underscore gender gaps in participation. For example, a women-only edition of JaP demonstrated that, in the absence of men, women improved their performance in areas like mathematics and logical reasoning (Gómez-Ruiz et al., 2024). Despite these targeted efforts, biases persist, as teachers often perceive boys as more skilled in programming, while attributing organizational and teamwork strengths to girls (Porto et al., 2024). Addressing these biases requires sustained strategies to challenge stereotypes and foster equitable participation in STEM education.

Case Study: The CTP Program of Ceibal

Ceibal was created in 2007 in Uruguay with the mission of promoting innovative and inclusive education, aligned with emerging technological opportunities, and ensuring access to digital devices for all children in public education. Since its beginning, Ceibal has delivered 2.9 million laptops and tablets, ensuring coverage for all primary and secondary school students and teachers. Additionally, the program has equipped 100% of the country's educational centers with Wi-Fi and broadband internet access for over 778,000 users, contributing to a significant reduction in the digital divide. In collaboration with the National Administration of Public Education (ANEP), Ceibal has integrated technology into education through a variety of resources and programs.

Since 2017, Ceibal has been implementing the CTP, which began as a pilot in 30 urban public schools and, by 2024, had expanded to 5457 groups, 90313 students, and 3981 teachers in approximately 83% of the country's urban public schools. This program aims to develop key skills associated with problem-solving using concepts from computer science, such as abstraction, decomposition, and generalization. Computational thinking is a cognitive process that allows the learner to approach complex problems in a systematic and logical manner. It involves breaking down a problem into smaller, more manageable parts, identifying patterns and relationships, and developing algorithms to find solutions.

CTP classes combine the work of classroom teachers with the involvement of remote teachers specializing in computer science. Each week, for 45 minutes, students participate in virtual sessions where they work on projects that integrate computational thinking concepts with content from other areas of knowledge. The program not only promotes early digital literacy but also lays the foundation for the integration of AI into Uruguay's public education system. The inclusion of AI-related content, such as machine learning, data processing, and ethical considerations, has enriched the curriculum, preparing students to understand and engage with emerging technologies critically. Educational activities such as "The Cow is a Good Apartment Pet" and "BiblioData" allow students to explore AI concepts and data science through hands-on, interactive projects (Curi et al., 2020).

Access to the CTP program is through voluntary teacher enrollment, ensuring equitable participation for all students. Ceibal actively incorporates a gender perspective to challenge stereotypes and create an inclusive learning environment, particularly for girls in STEM disciplines (Curi et al., 2020).

As noted by INTEF (2022), disparities in access to devices and connectivity among students from low-income backgrounds can exacerbate existing inequalities. Moreover, technologies that operate uniformly across diverse learning contexts may inadvertently favor students with stronger prior knowledge, allowing them to progress more rapidly while leaving others behind. These challenges highlight the importance of ensuring equitable access to technology and tailoring its implementation to diverse educational needs. Ceibal offers a compelling case study of how these risks can be mitigated. By providing universal access to digital devices and connectivity across Uruguay's public education system, Ceibal has significantly reduced the digital divide. This foundational equity in access creates an enabling environment for the integration of more advanced technologies, such as chatbots, into classrooms.

In a context where the digital divide is exacerbated by socioeconomic factors, the integration of technologies like artificial intelligence into public education is essential to closing these gaps. Ceibal stands as a successful model of how public policies can foster equal opportunities, preparing new generations for a digital and globalized future (Curi et al., 2020).

The Gender Dashboard of Ceibal

The Gender Dashboard of Ceibal, designed by Robano (2023), systematically tracks differences in AI adoption and usage patterns, allowing for a nuanced assessment of how various groups engage with AI tools. While gender disparities exist in STEM participation, their implications must be assessed beyond simple gaps, recognizing that different usage patterns may reflect both opportunities and adaptive responses to emerging technology risks.

The analysis reveals that, out of more than 100 evaluated indicators, most do not show significant gender gaps, and when gaps do exist, they often favor women. However, disparities are evident in contexts where resources are not universally distributed. For example, micro:bit boards, programmable devices designed to introduce students and teachers to programming, show a gender gap in distribution that favors boys. Since 2018, over 90,000 micro:bit units have been delivered to students from 5th grade primary to 3rd grade middle school and their teachers, but the data indicate that boys disproportionately request and receive these resources. These findings highlight both logistical challenges and cultural and self-perception barriers, where girls and female teachers may feel less confident or entitled to request resources.

Consistent with these patterns, gender gaps are observed in participation in the Robotics and Programming Olympiads (ORP), where male students dominate, and in the Jóvenes a Programar (JaP) program. JaP, which trains young people aged 18 to 30 in programming, testing, English, and socio-emotional skills to facilitate entry into the ICT sector, implemented a women-only edition in 2019. According to Gómez-Ruiz et al. (2024), this intervention revealed that in the absence of male participants, women demonstrated improved performance, particularly in areas traditionally dominated by men, such as mathematics and logical reasoning. These results underscore the importance of targeted strategies to reduce barriers and promote equity in STEM programs.

Despite ongoing efforts to foster gender equity in Ceibal's CTP, biases persist among teachers. Active strategies to engage girls, such as including female role models in pedagogical guides and fostering participation through classroom interaction (Curi et al., 2020), have not fully mitigated these biases. Although girls and boys perform similarly in assessments, teachers frequently perceive boys as more skilled in programming and problem-solving, while attributing stronger organizational and teamwork skills to girls (Porto et al., 2024). Such biases influence girls' participation in computational thinking activities, underscoring the need for continued teacher training and systemic efforts to challenge stereotypes. While addressing these systemic issues is essential for improving educational outcomes, this study specifically focuses on the integration of AI as a tool to enhance classroom teaching and learning processes.

The data from Ceibal's Computational Thinking Program and Gender Dashboard provide critical insights into the challenges and opportunities of AI integration in Latin American classrooms. These findings underscore the need for targeted interventions to address gender disparities, improve teacher preparedness, and ensure equitable access to AI tools

4. Proposed methodological framework

Despite advancements in educational access and technology integration across Latin America, significant gaps persist in learning outcomes, attendance, and gender equity, as highlighted by the evidence. Challenges such as low student engagement, disparities in access to resources, and biases in participation continue to hinder progress. For example, data from Ceibal reveal that while gender gaps are minimal in some areas, they remain prevalent in contexts where resources are not universally distributed or where cultural and self-perception barriers affect participation. These systemic issues underscore the need for innovative, scalable interventions that can complement traditional teaching methods while addressing these disparities.

This study proposes a methodological framework to evaluate the integration of generative AI tools, specifically chatbots, in classrooms. Rather than focusing on the automation of routine tasks, the research explores how chatbots can complement human teachers. The framework aims to foster personalized learning, provide real-time feedback, and enhance engagement, addressing gaps in access, participation, and pedagogical support.

This research aims to advance the understanding of AI's role in education by shifting the focus from the automation of teaching tasks to AI's complementarity with human teachers, particularly in areas that require empathy, judgment, and experiential knowledge. While much of the existing research on AI in education highlights its potential to automate routine tasks such as grading or answering factual questions, this study shifts the focus to how AI can complement human interaction in the classroom. This study goes beyond viewing AI as a tool for efficiency, exploring its potential to foster personalized learning, provide real-time feedback, and assist with problem-solving in ways that enhance both student engagement and teacher effectiveness.

For instance, research highlights that chatbots can increase interactivity, providing personalized support and reducing anxiety by dynamically adapting to student needs (Pappagallo, 2024). These tools have been shown to improve engagement, particularly in large classes, and even contribute to the development of higher-order cognitive skills like meta-cognition (Fodouop and Muchowe, 2024). By proposing a hybrid teaching model, where AI tools are integrated into classroom practices, the research discusses how teachers can focus on higher-order tasks that are less amenable to automation. Additionally, it addresses an often-overlooked challenge: the tendency of students to exert less effort when they know their work is graded as a robot instead of a person. By investigating strategies to counteract this issue, we provide actionable insights for the effective integration of AI in education.

As a complement to human instruction, chatbots can help bridge gaps in content delivery, offering structured explanations and interactive exercises. However, their effectiveness hinges on teachers' ability to integrate them meaningfully into pedagogy rather than as a substitute for direct instruction. For instance, chatbots can provide students with clear explanations of factual content, engage them in problem-solving exercises, or offer alternative perspectives on complex topics, effectively supplementing the instruction of teachers with limited expertise. This potential highlights the value of AI in leveling the playing field, particularly in resource-constrained environments. This strategy aligns with the broader goal of ensuring AI technologies complement human labor, as automation alone can exacerbate inequalities and reduce labor demand (Acemoglu and Restrepo, 2021).

That said, effective use of chatbots in education depends on comprehensive professional development programs focused on teaching educators how to incorporate AI into their teaching practices (teaching *about* Chatbots). These programs shall address the technical aspects of AI usage and the strategies for using tools like Chatbots to enhance classroom engagement and improve learning outcomes (teaching *with* Chatbots). By doing so, teachers can be empowered to harness AI's potential as a supportive tool rather than a replacement for human expertise.

Over and above these essential technological resources, are the teachers. Teachers are at the heart of learning, and their ability to use AI meaningfully will determine its impact on students. Therefore, equipping teachers with the skills and confidence to effectively integrate AI tools into their practices is critical for the success of AI in education (Saavedra et al. 2024; Robano, 2024). Training programs should go beyond technical know-how, addressing pedagogical strategies for blending AI with traditional methods and fostering a deep understanding of AI's capabilities and limitations. Regular professional development opportunities, paired with peer support networks and practical resources, can help teachers adapt to rapid technological advancements. Ultimately, empowering teachers ensures that AI tools enhance their roles rather than diminish their importance (Saavedra et al., 2024).

Framework for Chatbot Integration in Classrooms

Chatbots in education can be implemented through three primary approaches: purely human interactions, hybrid models, and autonomous bot operations. Each approach has distinct advantages and challenges, as summarized below.

1. Purely human interactions

Human-led instruction remains unmatched in fostering deep social and emotional learning, as teachers bring empathy, intuition, and adaptability to classroom interactions.

On the upside, it cultivates relationships and trust, essential for addressing emotional and behavioral challenges, and encourages collaborative and experiential learning that builds social skills.

On the downside, they are resource-intensive and lacks scalability, and they exhibit inconsistent quality across teachers and classrooms, depending on expertise and training. Also, teachers take full responsibility for instruction, interaction, and feedback, which limits scalability but enhances personalization through human judgment.

2. Autonomous bot operations

In this approach, advanced chatbots operate independently, delivering tailored educational experiences without direct human intervention. They have the advantage of potentially larger scalability to large student populations with minimal human oversight, and the ability to provide instant, individualized responses based on real-time data. On the other hand, they risk over-reliance on AI, potentially diminishing critical thinking and human connection, and they are faced with ethical concerns, including data privacy and the quality of AI-generated content.

Here, the division of labor is slightly different: chatbots take on an autonomous instructional role, handling learning modules, quizzes, and adaptive exercises, while teachers primarily act as monitors and troubleshooters. Luckin et al. (2016) highlights how autonomous bots in intelligent tutoring systems can be highly effective in supplementing instruction in resource-constrained environments.

At any rate, understanding the trade-offs between these three approaches is crucial for effective integration of chatbots in classrooms. Hybrid models are often the most feasible and beneficial, balancing scalability with human judgment. Policymakers and educators should align chatbot usage with educational objectives, emphasizing the complementarity between AI and teachers rather than replacement. Training programs must prepare teachers to harness chatbot capabilities while maintaining the human elements essential to holistic education.

3. Hybrid Models

Hybrid approaches combine the efficiency of automation with the nuanced understanding of human teachers, leveraging the strengths of both. Again, they have pros and cons.

Among the former, chatbots handle repetitive tasks such as grading, providing instant feedback, or facilitating routine problem-solving, freeing teachers to focus on higher-order tasks like fostering critical thinking. They also promote inclusivity by enabling students to ask questions they might hesitate to ask in front of peers.

However, they require teachers to be trained in blending AI tools into pedagogical practices effectively and present challenges in determining the appropriate balance between AI and human roles.

A salient characteristic of hybrid models is their efficient division of Labor, whereby teachers focus on mentoring, contextualizing information, and addressing complex queries while chatbots support personalized learning, routine tasks, and real-time feedback.

Among real-life examples, Holmes et al. (2019) demonstrate how hybrid models enhance learning outcomes in STEM education by allowing teachers to focus on conceptual clarity while AI systems handle routine skill drills.

Advantages	Challenges
Efficiency: Frees teachers for higher-order tasks	Teacher Training: Requires resource-intensive professional development
Personalization: Tailored feedback for students	Balancing Roles: Complex division of labor between AI and teachers

Inclusivity: Encourages participation from hesitant students	Over-Reliance: Risk of undermining critical thinking
Scalability: Effective for larger class sizes	Technical Limitations: Struggles with nuanced queries
Enhanced Engagement: Gamified learning increases motivation	Equity Concerns: Unequal access to technology

Evaluating chatbot impact in Ceibal's CTP

A natural follow-up of the previous discussion is a randomized controlled trial (RCT) to evaluate the impact of chatbot interaction on learning outcomes within Ceibal's CTP. The 10-week intervention will involve approximately 2000 6th-grade students from 40 public schools, who will be randomly assigned to either a control group or an experimental group. Participation in Ceibal's CTP is voluntary, with school teachers enrolling based on their interest.

To ensure robust analysis, we will employ a difference-in-differences approach, comparing pre- and post-intervention scores across control and treatment groups. In addition to final evaluations, engagement metrics (e.g., chatbot interaction frequency, time spent per session) will be logged and analyzed using hierarchical linear modeling to account for classroom-level variations. Gender-stratified analyses will be conducted to assess differential effects, ensuring that AI adoption benefits all student groups equitably.

Before randomization, students will first be asked about their preference for a human or an AI tutor. This step allows us to capture expectations and potential resistance, particularly if students strongly prefer one option and are then assigned to the other. After collecting these preferences, randomization will take place, ensuring balanced demographic, socioeconomic, and academic characteristics between the groups. Additionally, previous exposure to AI tools in the classroom will be examined as a potential moderator, and self-reported tutor preference will be considered as a control variable.

The control group will follow the existing model of weekly 45-minute virtual classes led by the school teacher and a remote instructor specializing in computer science. In contrast, the experimental group will enhance these sessions by engaging with either ChatGPT or a chatbot on the CREA (Schoology) platform, designed to facilitate learning, address inquiries, and provide real-time feedback.[9]

The primary outcome of the RCT will be student performance, assessed through final evaluations that align with the pedagogical objectives of Ceibal's CTP. As the study progresses, we will further define the specific assessment instrument, ensuring it accurately reflects the intended learning outcomes—whether through a dedicated final evaluation of the program or another validated measure. Secondary outcomes will include completion rates, which serve as indicators of program engagement, and improvements in school attendance as a proxy for addressing the quantity of education. Additionally, we will incorporate control variables such as prior academic performance, baseline attendance rates, and socioeconomic background to account for external factors that could influence these outcomes. Additionally, engagement levels will be tracked through platform usage data, including metrics such as interaction frequency, time spent, and the types of interactions students have with the chatbot. To ensure a fair assessment, we will establish minimum usage conditions and guarantee that all participants have adequate access and opportunities to engage with the platform under similar conditions. The Gender Dashboard will track gender-specific differences in these outcomes. To complement these quantitative measures, classroom observations and teacher interviews will provide qualitative insights into the fidelity of implementation, exploring how both students and teachers interact with the chatbot and identifying potential barriers to its adoption. Barriers to adoption, particularly cultural or self-perception challenges, will also be explored to inform future scalability. More specifically, in the experimental group, chatbots may serve three primary functions:

1. **Instructional support:** Chatbots will provide immediate answers to student questions, explanations of computational thinking concepts, and step-by-step guides for solving problems. To ensure effectiveness, we will plan for dedicated training and calibration periods to refine chatbot responses, improve alignment with learning objectives, and address potential gaps in explanations or guidance.

[9] Conditional on the implementation of such chatbot being available in 2025.

2. **Practice and feedback:** Students will engage with chatbots to complete exercises, receive personalized feedback, and explore alternative solutions to computational tasks.
3. **Engagement enhancement:** Chatbots will encourage exploration by posing challenges, suggesting additional resources, and gamifying problem-solving tasks to maintain student interest.

Teachers will be trained to use chatbots as a supplementary tool during lessons, focusing on integrating chatbot interactions into classroom activities. Teachers will also monitor chatbot interactions to identify common misconceptions and tailor instruction accordingly. In turn, students will access chatbots during and after lessons, engaging in activities such as debugging code, practicing algorithms, and exploring new computational concepts. Interaction logs will track the frequency, duration, and nature of student-chatbot exchanges to analyze engagement patterns.

To measure student performance in Computational Thinking (CT), we could use a validated pre-and post-assessment designed to evaluate computational thinking skills, including problem-solving, abstraction, and algorithmic reasoning. Tasks will include debugging, designing algorithms, and applying logical reasoning to novel problems. Performance will be scored using standardized criteria to ensure reliability and comparability.

To assess student learning, we will use a combination of tasks designed to evaluate their ability to apply key concepts in different contexts. The assessment will include a variety of problem-solving activities, ensuring a comprehensive measure of student understanding. Performance will be scored using standardized criteria to ensure reliability and comparability.

To measure student effort and engagement with AI-generated content, we will combine multiple data sources. While chatbot interaction data—such as time spent on tasks, number of attempts, and completion rates—provides a surface-level indicator of engagement, it does not fully capture cognitive effort or deep learning strategies. To address this, we will integrate a multi-dimensional approach, including:

- **AI verification tasks**, where students must cross-check AI-generated responses for accuracy, fostering analytical thinking.

- **Problem-solving reflection logs**, requiring students to articulate their reasoning process, strengthening metacognitive skills.
- **Teacher assessments**, evaluating whether AI-using students demonstrate stronger conceptual understanding compared to peers using traditional methods.
- **Self-reported effort surveys**, assessing perceived challenge, persistence, and time investment in learning activities.

To ensure that AI contributes to deep learning rather than mere task completion, we adopt a rigorous evaluation framework. By triangulating behavioral data, self-reported insights, and teacher evaluations, we aim to distinguish between AI as a cognitive enhancer versus AI as a task accelerator. Additionally, we will refine the data collection process to ensure feasibility, accuracy, and consistency in measuring student effort across different learning contexts. Specifically, we draw on Bloom's Taxonomy and metacognitive learning models to differentiate between lower-order and higher-order AI engagement. AI-generated responses will be assessed for their depth of reasoning, originality, and integration of multiple sources, rather than just factual correctness. This approach ensures that students are engaging in knowledge construction rather than passive retrieval.

Finally, student engagement can be quantified via the interaction frequency with chatbots, time spent using AI tools, and completion rates of optional challenges. Qualitatively, we would use classroom observations and student focus groups to assess engagement levels, interest in computational thinking activities, and overall enthusiasm for learning.

The detailed analysis of chatbot usage, teacher adoption, and student interaction should contribute to understanding how AI complements human instruction in computational thinking. This data will test hypotheses regarding:

- The effectiveness of chatbots in improving computational thinking outcomes.
- The relationship between chatbot interaction and indicators like effort, engagement, and performance.
- Potential differential impacts by gender, socioeconomic status, or prior knowledge levels.

Before full implementation, we suggest conducting a pilot study in 4-5 schools (approximately 500 students) to refine the prompts, ensure we are measuring the intended outcomes, and identify potential challenges. A plausible timeline for this implementation could be: Phase 1 (3 months): Pilot study execution, sample selection, group randomization, and baseline data collection to validate the study design and ensure robust initial conditions; Phase 2 (3 months): Full-scale implementation of the intervention, allowing sufficient time for program delivery and participant engagement; Phase 3 (2 months): Post-intervention evaluation, including data collection and analysis to assess outcomes, followed by the preparation of the Final Report and Analysis to synthesize findings and provide actionable insights.

While the randomized controlled trial aims to rigorously assess chatbot integration in classrooms, several implementation challenges must be addressed. Teacher buy-in remains a critical factor, as educators may perceive AI tools as replacements rather than supplements to their roles. Additionally, student resistance—particularly among those unfamiliar with AI interactions—could affect engagement levels. To mitigate these risks, we propose preliminary teacher workshops and a phased introduction of AI tools, ensuring alignment with pedagogical objectives before full deployment.

5. Policy implications: A roadmap for action

To maximize the benefits of AI in education while mitigating potential risks, policymakers should focus on the following key areas. These recommendations are designed to ensure equitable access, effective implementation, and sustainable integration of AI tools in Latin American classrooms.

1. **Train teachers to maximize the benefits of AI tools like chatbots.**

These programs should focus on teaching educators how to effectively integrate AI into classroom practices to enhance learning (teaching *with* AI). By empowering teachers to use AI as a supportive tool, these policies can help reduce resistance to AI adoption among female educators, who are currently less likely to use these technologies. Moreover, the awareness and promotion of equitable use among educators serves as a pathway to leverage AI's potential and enhance student learning outcomes.

2. **Conduct cost-benefit analyses to ensure sustainable AI integration in resource-constrained settings.**

AI integration into education offers potential cost advantages by automating certain teaching tasks, thereby allowing human educators to focus on higher-order activities. However, it is essential to weigh the upfront costs of infrastructure, training, and AI tools against their long-term benefits. Evidence from Uruguay's Ceibal initiative indicates that investments in foundational digital resources, such as devices and connectivity, provide substantial returns by reducing digital divides and improving educational outcomes. A comprehensive cost-benefit analysis should consider not only monetary savings but also the qualitative improvements in teaching and learning, particularly in underserved regions.

3. **Promote inclusive adoption strategies to address disparities in STEM education.**

Female students and teachers often face cultural and self-perception barriers in adopting AI tools. Targeted interventions, such as women-only training programs and mentorship initiatives, can help close gender gaps in AI usage and STEM participation.

4. **Promote AI literacy (teaching *about* AI).**

AI literacy is essential for preparing students for a world shaped by intelligent technologies. AI literacy includes teaching students how to critically evaluate their outputs, recognize biases, and understand ethical implications.

AI literacy should not be confined to STEM subjects but integrated across disciplines, ensuring that students recognize its applications in social sciences, creative fields, and ethical decision-making. In humanities courses, AI can be used for source analysis and bias detection; in business and law, it can facilitate case studies and predictive analytics. AI literacy should be treated as a core 21st-century competency, equally relevant across STEM and non-STEM disciplines. Beyond technical skills, AI literacy must emphasize critical evaluation, bias detection, and responsible AI engagement, ensuring students become active participants rather than passive consumers of AI-generated content.

Findings from Ceibal's Computational Thinking Program underscore the importance of AI literacy in ensuring equitable adoption. Many teachers and students lack foundational AI knowledge, limiting their ability to critically engage with chatbot-generated content. Incorporating AI literacy modules into teacher training programs can enhance educators' confidence and equip students with essential digital skills. This approach aligns with global best practices, such as Estonia’s ProgeTiger initiative, which integrates early AI education into national curricula.

5. **Develop phased implementation plans to address infrastructure and training gaps.**

Scaling AI in education requires more than just access—it demands robust infrastructure, teacher readiness, and equitable digital literacy. Key barriers include gaps in educator training, disparities in internet connectivity, and resource constraints in rural areas.

AI adoption in low-connectivity environments requires multi-layered solutions, including offline AI models, SMS-based educational interventions, and hybrid digital-analog learning frameworks. Ceibal’s model offers a case study in leveraging existing infrastructure to ensure that AI integration remains equitable and inclusive. Successful examples, such as Ceibal’s nationwide rollout of computational thinking programs, demonstrate that targeted strategies—such as phased implementation and localized training—can overcome scalability hurdles. Furthermore, public-private partnerships can play a crucial role in addressing resource limitations, particularly for low-income schools.

6. **Establish ethical guidelines focusing on data privacy, algorithmic bias, and transparency.**

AI tools must be designed and implemented in ways that protect student data, minimize biases, and foster accountability. Educators and students should be aware of AI's limitations and potential risks.

Ethical AI integration in education extends beyond bias mitigation to encompass transparency in AI decision-making and data privacy protections. Chatbot interactions generate valuable student data, raising concerns about consent and algorithmic profiling. Policymakers must establish clear guidelines on AI data storage, usage, and deletion, ensuring compliance with regional privacy regulations. Additionally, AI models should be continuously audited for bias, particularly in generating feedback that may unconsciously reinforce gender or socioeconomic stereotypes.

7. **Ensure AI is used selectively rather than indiscriminately.**

Policymakers should ensure AI is used selectively, focusing on applications that enhance learning progress. A dual approach is needed: evaluating AI's impact on classroom dynamics (e.g., student engagement and teacher-student interactions) and assessing whether it fosters critical thinking or encourages cognitive shortcuts. This will help avoid unintended consequences, such as reduced student effort or exacerbated inequalities in access to quality learning.

8. **Pilot, experiment, and test AI tools in diverse educational contexts before scaling.**

Structured experimentation, not only in the form of randomized controlled trials (RCTs) but also –and perhaps more effectively– with lighter impact and process evaluation methodologies can provide evidence-based insights into the effectiveness of AI tools and help refine implementation strategies with the needed attention to practical implementation obstacles and idiosyncratic, to avoid inadequate generalizations and external validity concerns. Generative AI tools such as ChatGPT has functioned as a global social experiment—an unprecedented, rapid introduction of transformative technology without structured evaluation mechanisms. Most countries, including those in Latin America, currently lack systematic data on AI's impact on learning. Given the potential risks and benefits, policymakers should promote sandboxes and experimental studies that analyze AI's effects across different student populations.

Indeed, Latin America offers a unique testing ground for AI's impact in education, given its diverse socio-economic landscapes, digital divides, and varying levels of AI adoption. By systematically evaluating AI's role in different educational contexts, LAC could provide globally relevant insights into best practices and risks. To move beyond anecdotal evidence, systematic monitoring and experimentation should focus on:

- Identifying the causal impact of AI tools on learning outcomes.
- Differentiating between individual-level benefits and classroom-wide externalities.
- Assessing whether AI integration affects student effort, engagement, and critical thinking.
- Investigating whether overreliance on AI might reduce deeper cognitive learning.
- Evaluating AI's potential for either mitigating or reinforcing existing inequalities.

9. **Involve teachers, parents, and students in the design and implementation of AI tools.**

Building trust and addressing concerns about AI replacing human roles in education is critical for successful adoption. Stakeholder input can help ensure that AI tools are culturally relevant and aligned with local needs. Adoption of AI in classrooms necessitates a coordinated approach involving policymakers, educational institutions, and technology providers. Strategies should include:

- Developing a clear policy framework that outlines AI use cases and ethical guidelines.
- Providing continuous professional development for teachers to foster confidence and expertise in AI integration.
- Establishing pilot programs to evaluate AI's effectiveness in diverse educational contexts before scaling.
- Engaging stakeholders—teachers, parents, and students—to build trust and address concerns about AI replacing human roles in education.

The Ceibal initiative's success demonstrates the value of strong institutional support and alignment with national educational goals. Lessons from this program suggest the importance of sustained funding, regular evaluations, and an adaptive approach to policy implementation.

LAC challenges

The integration of chatbots in education offers transformative potential globally but requires careful adaptation to address the unique challenges in LAC. Here, we examine general benefits alongside specific solutions tailored to common issues in LAC, such as low-quality teaching, limited device access, and low investment in training.

Teachers in need of improvement

Chatbots enhance learning by providing consistent, scalable, and high-quality instructional support across diverse contexts. They offer personalized feedback and access to a wide range of curated content, ensuring that students receive accurate and tailored instruction. In contexts with insufficient teacher quality or expertise, autonomous bots loaded with content can compensate by delivering guided instruction and addressing gaps in subject mastery. Hybrid models can also help underprepared teachers by acting as co-instructors, where chatbots handle foundational content while teachers focus on classroom management and fostering critical thinking. In this light, for regions like LAC, where teacher shortages and variability in quality are prevalent, chatbots can act as equalizers, ensuring access to reliable and standardized educational content.

Limited access to devices and connectivity

Chatbots offer flexible, adaptive tools that enhance student engagement and learning outcomes, even in resource-rich settings. In low-connectivity environments, solutions such as shared devices and locally hosted chatbot models (offline-capable AI systems) can minimize dependency on high-speed internet. Initiatives leveraging widely available platforms like WhatsApp or SMS-based interactions demonstrate the feasibility of using existing infrastructure for AI-based interventions. In Ghana, for example, AI-enabled WhatsApp groups successfully facilitated collaborative learning in schools with minimal internet access, a model that could be replicated in LAC.

Low incentives to invest in training

Generative AI tools like chatbots are designed with user-friendly interfaces, minimizing the need for extensive technical training. Teachers can quickly adopt and integrate these tools into their practices, lowering adoption barriers. For regions where financial or institutional incentives for professional development are limited, low-cost, intuitive AI tools can encourage adoption. Professional development programs focusing on practical, easy-to-implement AI solutions can demonstrate immediate benefits to teachers, fostering buy-in and reducing resistance. In Uruguay’s Ceibal initiative, for instance, AI tools were incorporated into teacher practices through straightforward training modules, emphasizing usability and immediate application.

Final remarks

While this study highlights the transformative potential of AI in education, several limitations remain. The long-term impact of AI tools on learning retention, student autonomy, and teacher agency requires further research. Additionally, the scalability of AI interventions in low-connectivity environments must be rigorously tested.

AI adoption in low-connectivity environments requires multi-layered solutions, including offline AI models, SMS-based educational interventions, and hybrid digital-analog learning frameworks. Ceibal's model offers a case study in leveraging existing infrastructure to ensure that AI integration remains equitable and inclusive

Future studies should not only track AI's effects on critical thinking and creativity but also evaluate its impact on educational equity, workforce preparedness, and long-term student outcomes. As AI in education evolves rapidly, policies must remain adaptable, incorporating continuous impact assessments and iterative policy adjustments.

To ensure sustainable AI integration, governments should establish longitudinal monitoring systems that track AI's effects across multiple academic cycles, providing evidence-based refinements to national AI education strategies. Above all, policymakers must ensure that AI adoption enhances—not replaces—the human elements of teaching and learning.

By providing personalized support and fostering engagement, chatbots can enhance learning outcomes, particularly in under-resourced classrooms. However, for this potential to be fully realized, foundational issues such as equitable access to connectivity, devices, and teacher training must be addressed. Ceibal's experience highlights how targeted policies and investments can bridge the digital divide, providing a replicable model for other LAC. It demonstrates that equitable integration of AI tools requires not only resources but also strategies that actively challenge socio-economic and gender disparities.

While chatbots offer promising solutions, their integration in LAC must account for systemic inequalities, including resource gaps, capacity building, and context-specific design. Future research should focus on the long-term effects of AI on learning quality, student motivation, and equity.

Beyond immediate learning outcomes, future research should examine AI's long-term effects on student self-efficacy, intrinsic motivation, and cognitive resilience. A key question remains: does AI-assisted learning produce durable knowledge gains, or does it create dependency on external intelligence? Longitudinal studies tracking student performance over multiple academic years will be essential in answering this question. Additionally, cross-country comparisons between AI-integrated and traditional classrooms could provide insights into the optimal balance between automation and human-led instruction.

The success of AI in education hinges on thoughtful, evidence-based implementation that prioritizes teacher empowerment, student engagement, and long-term learning equity. As AI capabilities evolve, so too must our strategies for leveraging them. The future of AI in education hinges on adaptive, evidence-based policymaking that prioritizes teacher empowerment, student engagement, and long-term learning equity—ensuring that AI remains a tool for enhancement, not replacement.

References

Abbes, Abbes, F., Bennani, S. & Maalel, A. (2024). "Generative AI and Gamification for Personalized Learning: Literature Review and Future Challenges". *SN COMPUT. SCI*. vol 5 (1154). https://doi.org/10.1007/s42979-024-03491-z

Acemoglu, Daron.2021. "Harms of AI." National Bureau of Economic Research Working Paper 29247.

Acemoglu, Daron, and Pascual Restrepo. 2021. "Tasks, Automation, and the Rise in US Wage Inequality." National Bureau of Economic Research Working Paper 28920.

Administración Nacional de Educación Pública [ANEP]. (2023). Uruguay en PISA 2022: Volumen 2. Calidad, equidad y metas educativas. Consejo Directivo Central, Dirección Sectorial de Planificación Educativa. ISBN: 978-9974-887-64-0. https://pisa.anep.edu.uy/sites/default/files/Recursos/Publicaciones/Informes/2022/Uruguay%20en%20PISA%202022_Volumen%202_Calidad,%20equidad%20y%20metas%20educativas.pdf

Arias Ortiz, E., Giambruno, C., Morduchowicz, A., & Pineda, B. (2024). El estado de la educación en América Latina y el Caribe 2023. https://doi.org/10.18235/0005515

Ayres, R.U., and S.M. Miller.1983.Robotics, Applications and Social Implications. Ballinger Publishing Company

Bastani, Hamsa and Bastani, Osbert and Sungu, Alp and Ge, Haosen and Kabakcı, Özge and Mariman, Rei, Generative AI Can Harm Learning (July 15, 2024). The Wharton School Research Paper, Available at SSRN: https://ssrn.com/abstract=4895486 or http://dx.doi.org/10.2139/ssrn.4895486

Bodonhelyi, Anna, Enkeleda Thaqi, Suleyman Ozdel, Efe Bozkir, and Enkelejda Kasneci.2024. "From Passive Watching to Active Learning: Empowering Proactive Participation in Digital Classrooms with AI Video Assistant. https://arxiv.org/html/2409.15843v1

Brynjolfsson, E., Li, D., & Raymond, L. (2023). "Generative AI at Work". https://doi.org/10.48550/arXiv.2304.11771

Carvajal, Daniel, Catalina Franco, and Siri Isaksson.2024. "Will Artificial Intelligence Get in the Way of Achieving Gender Equality?" NHH Dept. of Economics 03. Revised in the Paper Series.

Castro, Juan F., Paul Glewwe, Alexandra Heredia-Mayo, Stephanie Majerowicz, Ricardo Montero (2024) Can Teaching Be Taught? Improving Teachers' Pedagogical Skills at Scale in Rural Peru1

Curi, M. E., Koleszar, V., Capdehourat, G., Pereiro, E., Lorenzo, B., & Folgar, L. (2020). Construyendo inteligencia artificial para la educación. Cristóbal Cobo (Prólogo). ISBN 978-9915-9660-0-7.

Darvishi, A., Khosravi, H., Sadiq, S., Gašević, D., & Siemens, G. (2024). "Impact of AI assistance on student agency". Computers & Education, vol 210. https://doi.org/10.1016/j.compedu.2023.104967

ECLAC. (2024). Prevención y reducción del abandono escolar en América Latina y el Caribe. CEPAL. https://repositorio.cepal.org/server/api/core/bitstreams/b80b4d28-e4df-4c5c-9659-dd78d4d1b527/content

Education Estonia. (2021). "ProgeTiger – Estonian way to create interest in technology". https://www.educationestonia.org/progetiger/

Fodouop Kouam, Arthur William & Muchowe, Regis. (2024). Exploring graduate students' perception and adoption of AI chatbots in Zimbabwe: Balancing pedagogical innovation and development of higher-order cognitive skills. Journal of Applied Learning & Teaching. 7. 1-11. 10.37074/jalt.2024.7.1.12.

Frosig, T. B., & Romero, M. (2024). "Teacher agency in the age of generative AI: towards a framework of hybrid intelligence for learning design". Université Côte d'Azur, France. https://doi.org/10.48550/arXiv.2407.06655

Goh E, Gallo R, Hom J, et al. Large Language Model Influence on Diagnostic Reasoning: A Randomized Clinical Trial. JAMA Netw Open. 2024;7(10):e2440969. doi:10.1001/jamanetworkopen.2024.40969

Gomez-Ruiz, Marcela and Cervini-Plá, María and Ramos, Xavier, Do Women Fare Worse When Men are Around? Quasi-Experimental Evidence. IZA Discussion Paper No. 16782, Available at SSRN: https://ssrn.com/abstract=4717695 or http://dx.doi.org/10.2139/ssrn.4717695

Henkel, O., Horne-Robinson, H., Kozhakhmetova, N., Lee, A. (2024). Effective and Scalable Math Support: Experimental Evidence on the Impact of an AI-Math Tutor in Ghana. In: Olney, A.M., Chounta, IA., Liu, Z., Santos, O.C., Bittencourt, I.I. (eds) Artificial Intelligence in Education. Posters and Late Breaking Results, Workshops and Tutorials, Industry and Innovation Tracks, Practitioners, Doctoral Consortium and Blue Sky. AIED 2024. Communications in Computer and Information Science, vol 2150. Springer, Cham. https://doi.org/10.1007/978-3-031-64315-6_34

Hollingsworth, H. (2024). "AI is a game changer for students with disabilities. Schools are still learning to harness it". Associated Press News. https://apnews.com/article/artificial-intelligence-students-disabilities-ff1f51379b3861978efb0c1334a2a953

Holmes, W., Bialik, M., & Fadel, C. (2019). "Artificial Intelligence in Education. Promise and Implications for Teaching and Learning." *Center for Curriculum Redesign*. ISBN: 978-1794293700.

INEEd (2024). Reporte del Mirador Educativo 10. Ausentismo crónico en educación primaria pública: caracterización del período 2019-2023. Recuperado de https://www.ineed.edu.uy/images/Mirador/Reportes/Ausentismo-cronico-en-educacion-primaria-publica-2019-2023.pdf

INEEd (2025). Aristas 2023. Informe de resultados de tercero y sexto de educación primaria. Resumen ejecutivo. Recuperado de: https://www.ineed.edu.uy/images/Aristas/Publicaciones/Aristas2023/Aristas-Primaria-2023-Resumen-ejecutivo.pdf

INTEF (2022). Pushing the frontiers of education with intelligent technologies. Available at: https://intef.es/wp-content/uploads/2022/10/2022_01_Pushing-the-frontiers_INTEF.pdf.

Lakho, S., Farooqi, S. A., Zafar, F., & Siraj, S. (2024). "Developing AI-Powered Chatbots for Mental Health Support". *Spectrum of Engineering Sciences*, 2(3), 179–199. Retrieved from: https://www.sesjournal.com/index.php/1/article/view/38

Lee, S. J., & Kwon, K. (2024). "A systematic review of AI education in K-12 classrooms from 2018 to 2023: Topics, strategies, and learning outcomes". *Computers and Education: Artificial Intelligence*, vol. 6 (100211). https://doi.org/10.1016/j.caeai.2024.100211

Lopes, R. M., Silva, A. F., Rodrigues, A. C. A., & Melo, V. (2024). "Chatbots for Well-Being: Exploring the Impact of Artificial Intelligence on Mood Enhancement and Mental Health". European Psychiatry, 67(S1):S550-S551. https://doi.org/10.1192/j.eurpsy.2024.1143

Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). "Intelligence Unleashed: An Argument for AI in Education.". London, Pearson. ISBN: 9780992424886.

Lehmann, Matthias and Cornelius, Philipp B. and Sting, Fabian J., AI Meets the Classroom: When Do Large Language Models Harm Learning? (March 07, 2025). Available at SSRN: https://ssrn.com/abstract=4941259 or http://dx.doi.org/10.2139/ssrn.4941259

Mollick, E. (2023). "Assigning AI: Seven Ways of Using AI in Class". One Useful Thing. Substack. Available at: https://www.oneusefulthing.org/p/assigning-ai-seven-ways-of-using

OECD (2023), Empowering Young Children in the Digital Age, Starting Strong, OECD Publishing, Paris, https://doi.org/10.1787/50967622-en .

OECD. (2024). Equity in education and on the labour market: Main findings from Education at a Glance 2024 (OECD Education Policy Perspectives No. 107). OECD Publishing. https://doi.org/10.1787/b502b9a6-en

Olawade, D. B., Wada, O. Z., Odetayo, A. David-Olawade, A. C., Asalou, F., & Eberhardt, J. (2024). "Enhancing mental health with Artificial Intelligence: Current trends and future prospects". *Journal of Medicine, Surgery, and Public Health*, vol. 3 (100099). https://doi.org/10.1016/j.glmedi.2024.100099

Pappagallo, S. (2024), Chatbots in Education: A Dual Perspective on Innovation and Ethics – Journal of Digital Pedagogy

Park, J. K., Singh, V., & Wisniewski, P. (2024). "Current Trends and Future Directions for Sexual Health Conversational Agents (CAs) for Youth: A Scoping Review". Elsevier B.V. https://doi.org/10.48550/arXiv.2409.14226

Porto, C., Pereiro, E., Curi, M. E., Koleszar, V., & Urruticoechea, A. (2024). Gender perspective in the computational thinking program of Uruguay: teachers' perceptions and results of the Bebras tasks. Journal of Research on Technology in Education, 1-15.

Robano, V., O. Galland and I. González (forthcoming, 2025) "De la teoría a la práctica: construyendo equidad de género en el ecosistema STEM de Ceibal"

Robano, V. (2024) Tecnologías Digitales para la Educación, https://ceibal-fichas-edtech.netlify.app/

Robano, V. (2023) Equidad de género en el ecosistema STEM de Ceibal ISBN: 978-9915-9470-5-1 Equidad de género en el ecosistema STEM de Ceibal

Saavedra, Jaime, Cristóbal Cobo, Emanuela Di Gropello, Ezequiel Molina, Helena Rovnerr, Alex Twinomugisha, (2024), Educating for the (present and) future: using Artificial Intelligence (AI) to address the learning crisis

Sahito, Z. H., Sahito, F. Z., & Imran, M. (2024). The role of artificial intelligence (AI) in personalized learning: A case study in K-12 education. *Global Educational Studies Research Journal*, 9(3), 15. http://dx.doi.org/10.31703/gesr.2024(IX-III).15

San Román Inzaurralde, N. Matemática temprana y género: un análisis de resultados en escuelas uruguayas [en línea] Trabajo final de grado. Montevideo: Udelar.FP, 2023.https://hdl.handle.net/20.500.12008/37071

Son, T. (2024). Intelligent Tutoring Systems in Mathematics Education: A Systematic Literature Review Using the Substitution, Augmentation, Modification, Redefinition Model. Computers, 13(10), 270.

Su, Jiahong, and Weipeng Yang.2023. "Unlocking the Power of ChatGPT: A Framework for Applying Generative AI in Education." ECNU Review of Education, 6(3): 355–366.

Sulkunen, S. (2013). Adolescent Literacy in Europe—An Urgent Call for Action. European Journal of Education, 48(4), 528-542.

Thomas, D., Lin, J., Gatz, E., Gurung, A., Gupta, S., Norberg, K., Fancsali, S. E., Aleven, V. Branstetter, L., Brunskill, E., & Koedinger, K. R. (2023). "Improving Student Learning with Hybrid Human-AI Tutoring: A Three-Study Quasi-Experimental Investigation". In The 14th Learning Analytics and Knowledge Conference (LAK '24), March 18–22, 2024, Kyoto, Japan. ACM, New York, NY, USA, 17 pages. https://doi.org/10.1145/3636555.3636896

Tiernan, C. (2025). "Applications for AI in education." MIT Jameel World Education Lab. Available at: https://openlearning.mit.edu/news/applications-ai-education

UNESCO. (2021). "AI and education: guidance for policy-makers". Paris, https://doi.org/10.54675/PCSP7350 van der Rijt, J., Mollo, D. C., & Vaassen, B. (2025). "AI Mimicry and Human Dignity: Chatbot Use as a Violation of Self-Respect". Umeå University. https://doi.org/10.48550/arXiv.2503.05723

Varsik, S., and L. Vosberg. 2024. "The Potential Impact of Artificial Intelligence on Equity and Inclusion in Education." OECD Artificial Intelligence Papers, (23).

Wang, R. E., Ribeiro, A. T., Robinson, C. D., Loeb, S., & Demszky, D. (2025). "Tutor CoPilot: A Human-AI Approach for Scaling Real-Time Expertise". https://doi.org/10.48550/arXiv.2410.03017

Zhai, C., Wibowo, S. & Li, L.D. The effects of over-reliance on AI dialogue systems on students' cognitive abilities: a systematic review. Smart Learn. Environ. 11, 28 (2024). https://doi.org/10.1186/s40561-024-00316-7

Zhai, X. (2024). "Transforming Teachers' Roles and Agencies in the Era of Generative AI: Perceptions, Acceptance, Knowledge, and Practices". University of Georgia. https://doi.org/10.48550/arXiv.2410.03018

Zhang, R., Li, H., Meng, H., Zhan, J., Gan, H., & Lee, Y. (2025). "The Dark Side of AI Companionship: A Taxonomy of Harmful Algorithmic Behaviors in Human-AI Relationships". Manuscript Conditionally Accepted by the *CHI Conference on Human Factors in Computing Systems* (CHI '25). https://doi.org/10.48550/arXiv.2410.20130

Appendix I. Glossary

Term	Definition
AI-tutor	An AI-powered tool designed to provide tailored educational assistance to students
Chatbot	A computer program designed to simulate conversation with a human user, often used to provide information or assistance. Powered by generative AI, chatbots like ChatGPT offer dynamic, natural conversations.
ChatGPT	A specific implementation of a generative AI chatbot, developed by OpenAI, based on a GPT (Generative Pre-trained Transformer) model. It excels in generating human-like, contextually relevant text. ChatGPT combines the general capabilities of generative AI and the conversational focus of chatbots.
CREA (Schoology)	A digital learning platform used in Uruguay's public education system
CTP	Computational Thinking Program
Generative AI	A type of artificial intelligence that creates new content, such as text, images, audio, or video, based on input data or prompts. An umbrella term encompassing various models and tools, including LLMs, chatbots, and ChatGPT, that generate outputs rather than just analyzing or categorizing data.
LLM	A computer program that uses very large collections of language data in order to understand and produce text in a way that is similar to the way humans do large language model noun - Definition, pictures, pronunciation and usage notes | Oxford Advanced Learner's Dictionary at OxfordLearnersDictionarie A subset of generative AI. LLMs are the foundation for building tools like Chatbots and ChatGPT, enabling them to understand context and generate text-based outputs.
STEM	STEM is an acronym for Science, Technology, Engineering and Mathematics