THE PROMISE OF GENERATIVE ARTIFICIAL INTELLIGENCE. PSYCHOLOGICAL IMPLICATIONS IN EDUCATIONAL CONTEXTS

LA PROMESSA DELL'INTELLIGENZA ARTIFICIALE GENERATIVA. IMPLICANZE PSICOLOGICHE NEI CONTESTI EDUCATIVI

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ABSTRACT

The integration of Conversational Generative Artificial Intelligence into educational settings has generated both excitement and caution due to their potential to revolutionize learning experiences. This paper explores the dual nature of AI advancements, highlighting both their promises and challenges. It examines the role of AI-powered chatbots, exemplified by ChatGPT, in enhancing critical thinking, problem-solving, and decision-making skills among students. The paper examines the implications of equipping AI chatbots with Theory of Mind capabilities to enhance their credibility as interlocutors, emphasizing the potential for personalized learning and cognitive scaffolding. While advocating for strategies to

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integrate AI technologies into schools, such as new school subjects and "incorporating" ChatGPT into robots, the paper underscores the need for further research. In conclusion, it is recommended that educators, teachers, and parents be trained in the effective utilization of AI technologies in the classroom. This will empower students to flourish in an increasingly digitalized world.

KEYWORDS

ChatGPT, Theory of Mind (ToM), Critical Thinking, Problem-solving, Educational strategies.

RIASSUNTO

L'integrazione dell'Intelligenza Artificiale Generativa Conversazionale nei contesti educativi ha generato sia entusiasmo che cautela per il suo potenziale di rivoluzionare le esperienze di apprendimento. Questo articolo esplora la duplice natura dei progressi dell'IA, evidenziandone sia le promesse che le sfide. Esamina il ruolo delle chatbot alimentate dall'IA, esemplificate da ChatGPT, nel sostenere lo sviluppo del pensiero critico, delle capacità di problem-solving e dei processi decisionali degli studenti. L'articolo esamina le implicazioni di dotare le chatbot AI con capacità di Teoria della Mente con il fine di migliorare la loro credibilità come interlocutori, sottolineando il potenziale di apprendimento personalizzato e di scaffolding cognitivo. Pur sostenendo le strategie per integrare le tecnologie IA nelle scuole attraverso nuove materie scolastiche e l'"incorporazione" di ChatGPT nei robot, l'articolo sottolinea la necessità di ulteriori ricerche. In conclusione, si raccomanda che educatori, insegnanti e genitori siano formati all'utilizzo efficace delle tecnologie di IA in classe. Questo permetterà agli studenti di crescere in un mondo sempre più digitalizzato.

PAROLE CHIAVE

ChatGPT, Teoria della mente (ToM), pensiero critico, problem-solving, strategie educative.

RESUMEN

La integración de la Inteligencia Artificial Generativa Conversacional en los contextos educativos ha generado tanto entusiasmo como cautela por su potencial de revolucionar las experiencias de aprendizaje. Este

artículo explora la doble naturaleza de los progresos de la IA, poniendo en evidencia ya sean las promesas, ya sean los desafíos. Examina el papel de las chatbot alimentadas por IA, en el sostenimiento del pensamiento crítico, de las capacidades de resolución de problemas y de los procesos de toma de decisiones de los estudiantes.

El artículo examina las implicaciones de la dotación del chatbot IA con la capacidad de Teoría de la Mente con el fin de mejorar su credibilidad como interlocutores, sosteniendo el potencial de aprendizaje personalizado y de andamiaje cognitivo. Aun sosteniendo las estrategias para integrar las tecnologías de IA en las escuelas a través de nuevas materias escolares y de la "incorporación" de ChatGPT en los robots, el artículo subraya la necesidad de investigaciones ulteriores. En conclusión, se aconseja que los educadores, los docentes y los padres se formen en el uso eficaz de las tecnologías de IA en clase. Esto permitirá a los alumnos crecer en un mundo cada vez más dominado por la digitalización.

PALABRAS CLAVE

ChatGPT, Teoría de la mente (ToM), pensamiento crítico, resolución de problemas (problem-solving), estrategias educativas.

1. Introduction

We live in a world where machines are capable of producing content that mimics human intelligence, thus making Alan Turing's prediction of the *Imitation Game* a reality. This realization of Turing's vision represents an era of both promise and peril[2] as the advent of artificial intelligence (AI) brings both boundless potential and profound challenges for society. The revolutionary advances in AI technologies promise, on the one hand, unparalleled enhancements in efficiency, cost reduction, and accelerated research and development; on the other hand, they also cast a shadow of apprehension over issues of privacy violation, surveillance, and the perpetuation of bias and discrimination. Thus, the topic of AI elicits both optimistic and cautious perspectives, due to the double-edged sword it presents. The optimism and concerns that these advances bring are reflected in literature, which describes AI technologies now enthusiastically as an intellectual revolution,[3] now critically as a false promise.[4] Undoubtedly, the birth of OpenAI's ChatGPT and other so-

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[2] Cf Schwab Klaus, *The Fourth Industrial Revolution*, Crown 2017.

[3] Cf Kissinger Henry A. - Schmidt Eric - Huttenlocher Daniel, *ChatGPT Heralds an Intellectual Revolution*, in *The Wall Street Journal* (February 24, 2023), in https://www.henryakissinger.com/articles/chatgpt-heralds-an-intellectual-revolution/.

[4] Cf Chomsky Noam, *The False Promise of ChatGPT,* in *The New York Times* (March 8, 2023),

called Conversational Generative AI (GenAI) represents one of the most significant developments in the field of artificial intelligence over the last few years.[5] However, GenAIs have come a long way since the ELIZA computer programs of the 1960s.[6] Advancements in artificial intelligence have resulted in the development of highly advanced automated chatbots that can analyze and comprehend text and audio data. These chatbots can interact with and respond to virtual conversations with human users more quickly and accurately than their predecessors.[7] This is achieved through the integration of deep learning and language models using the Generative Pre-training Transformer (GPT) architecture,[8] as demonstrated by ChatGPT, a conversational AI model launched by OpenAI in 2022. ChatGPT is a well-known chatbot that has become a topic of conversation among insiders and laymen. ChatGPT processes text inputs and produces responses that resemble human-like conversations with the aim of emulating human dialogue and comprehension. ChatGPT and other GenAI technologies have a significant impact on our daily lives, including education.[9] The recent literature on GenAIs reiterates the metaphor of the double-edged sword once more, emphasizing the dual nature of these advances as a mixture of excitement and caution.[10] This ambivalence arises from the impressive capacity of these technologies to produce text (such as ChatGPT and Gemini) and images (such as DALL-E and Midjourney) that akin abilities similar to those of humans. On one hand, AIs have the potential to significantly impact various aspects of human life by enhancing efficiency, accelerating innovation, and assisting in

in https://www.nytimes.com/2023/03/08/opinion/noam-chomsky-chatgpt-ai.html.

[5] Cf QADIR Junaid, *Engineering Education in the Era of ChatGPT: Promise and Pitfalls of Generative AI for Education*, in *TechRxiv* (2022) December, 30, in https://doi.org/10.36227/techrxiv.21789434.

[6] Cf WEIZENBAUM Joseph, *ELIZA-a computer program for the study of natural language communication between man and machine*, in *Communications of the ACM*, 9(1966)1, 36-45, in https://doi.org/10.1145/365153.365168.

[7] Cf BRACHTEN Florian - KISSMER Tobias - STIEGLITZ Stefan, *The acceptance of chatbots in an enterprise context - A survey study*, in *International Journal of Information Management*, 60(2021) October, 102375, in https://doi.org/10.1016/j.ijinfomgt.2021.102375.

[8] Cf RADFORD Alec - NARASIMHAN Karthik - SALIMANS Tim - SUTSKEVER Ilya, *Improving Language Understanding by Generative Pre-Training* (June 11, 2018), in https://cdn.openai.com/research-covers/language-unsupervised/language_understanding_paper.pdf.

[9] Cf GILLATH Omri - AI Ting - BRANICKY Michael S. - KESHMIRI Shawn - DAVISON Robert B. - SPAULDING Ryan, *Attachment and trust in artificial intelligence*, in *Computers in Human Behavior* 115(2021) February, 106607, in https://doi.org/10.1016/j.chb.2020.106607.

[10] Cf LABADZE Lasha - GRIGOLIA Maya - MACHAIDZE Lela, *Role of AI chatbots in education: Systematic literature review*, in *International Journal of Educational Technology in Higher Education* 20(2023)1, 56, in https://doi.org/10.1186/s41239-023-00426-1; LIM Weng Mar - GUNASEKARA Asanka - PALLANT Jessica Leigh - PALLANT Jason Ian - PECHENKINA Ekaterina, *Generative AI and the future of education: Ragnarök or reformation? A paradoxical perspective from management educators*, in *The International Journal of Management Education*, 21(2023)2, 100790, in https://doi.org/10.1016/j.ijme.2023.100790.

solving complex problems in fields such as healthcare, climate modeling, and scientific research. On the other hand, several concerns have been raised regarding the potential for artificial intelligence to replace humans, as well as ethical and moral issues surrounding the excessive granting of autonomy and decision-making power to AI systems.

With respect to education settings, AI advancements have contributed to improvements in teaching and learning processes and fostering 21st-century competencies.[11] AI-powered chatbots, such as ChatGPT, offer personalized guidance and feedback to students, catering to their individual needs.[12] For instance, ChatGPT serves as a supportive study companion, delivering explanations and clarifications across various subjects.[13] One effective strategy involves providing step-by-step solutions and guiding students through complex problems.[14] Additionally, AI-powered chatbots provide significant advantages for educators by simplifying administrative tasks such as scheduling, grading, and information dissemination.[15] Furthermore, AI chatbots can improve pedagogy by tailoring content to meet students' diverse needs and preferences, thus improving the overall learning experience. Nevertheless, the indiscriminate use of AI-powered chatbots raises significant concerns in education systems, particularly

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[11] Cf TRILLING Bernie - FADEL Charles, *21st Century Skills: Learning for Life in Our Times,* John Wiley & Sons 2012.

[12] Cf FARIANI Rida Indah - JUNUS Kasiyah - SANTOSO Harry Budi, *A Systematic Literature Review on Personalised Learning in the Higher Education Context*, in *Technology, Knowledge and Learning*, *28*(2022)November, 449-476, in https://doi.org/10.1007/s10758-022-09628-4; KIKALISHVILI Shalva, *Unlocking the potential of GPT-3 in education: Opportunities, limitations, and recommendations for effective integration*, in *Interactive Learning Environments* (2023)1-13, in https://doi.org/10.1080/10494820.2023.2220401; SCHIFF Daniel, *Out of the laboratory and into the classroom: The future of artificial intelligence in education*, in *AI & Society*, 36(2021)1, 331-348, in https://doi.org/10.1007/s00146-020-01033-8.

[13] Cf LABADZE et al., *Role of AI chatbots in education: Systematic literature review.*

[14] Cf CRAWFORD Joseph - COWLING Michael - ALLEN Kelly-Ann, *Leadership is needed for ethical ChatGPT: Character, assessment, and learning using artificial intelligence (AI)*, in *Journal of University Teaching & Learning Practice*, 20(2023)3, in https://doi.org/10.53761/1.20.3.02; FAUZI Fauzi - TUHUTERU Laros - SAMPE Ferdinandus - AUSAT Abu Muna Almaududi - HATTA Heliza Rahmania, *Analysing the Role of ChatGPT in Improving Student Productivity in Higher Education*, in *Journal on Education* 5(2023)4, Article 4, in https://doi.org/10.31004/joe.v5i4.2563; LO Chung Kwan, *What Is the Impact of ChatGPT on Education? A Rapid Review of the Literature*, in *Education Sciences*, 13(2023)4, 410, in https://doi.org/10.3390/educsci13040410; MHLANGA David, *Open AI in Education, the Responsible and Ethical Use of ChatGPT Towards Lifelong Learning.* (February 11, 2023). Avalaible in SSRN: https://doi.org/10.2139/ssrn.4354422; QADIR, *Engineering Education in the Era of ChatGPT: Promise and Pitfalls of Generative AI for Education*; SHIDIQ Muhammad, *The use of Artificial Intelligence-based Chat-GPT and its challenges for the world of education; from the viewpoint of the development of creative writing skills*, in *Proceeding of International Conference on Education, Society and Humanity* 1(2023)1, in https://ejournal.unuja.ac.id/index.php/icesh/issue/view/239.

[15] Cf LABADZE et al., *Role of AI chatbots in education: Systematic literature review.*

concerning the data used to train these AI models.[16] Biases in training data can lead to the reproduction of distorted perspectives, stereotypes, discriminatory language, or biased recommendations.[17] For instance, image-generating AIs may produce biased representations due to poorly represented minority datasets. For example, requests for images of professionals like engineers on Midjourney may result in predominantly Caucasian male images, which may reinforce societal stereotypes. In an attempt to avoid bias and promote inclusivity, Google AI's Gemini is struggling with the opposite problem. To be more inclusive, it went so far as to distort historical accuracy by depicting British sovereigns as African Americans, American presidents as Chinese, and ancient Greek philosophers as Native Americans. The reliability and accuracy of information provided by chatbots are critical considerations[18] and the issue of biases in training data is especially problematic in educational contexts, where the overreliance on AI-generated information may negatively impact the information students receive and their critical thinking skills.[19] This may result in a failure to verify the information provided, the perpetuation of biases, or even the generation and propagation of false information.[20] Nevertheless, schools and education systems must provide the necessary skills for a world that is increasingly digitalized and has a complex and ever-changing career landscape, despite valid concerns. Today's students and future workers must be prepared to use emerging technologies effectively while avoiding the risks of dysfunctional use,[21] which can hinder human development and cause problems in various aspects of life. In order to succeed in our digitized society, students must develop competencies in critical and computational thinking, problem-solving, decision-making,

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[16] Cf KUHAIL Mohammad Amin - ALTURKI Nazik - ALRAMLAWI Salwa - ALHEJORI Kholood, *Interacting with educational chatbots: A systematic review*, in *Education and Information Technologies*, 28(2023)1, 973-1018, in https://doi.org/10.1007/s10639-022-11177-3.

[17] Cf *ivi*.

[18] Cf KHAN Rehan Ahmed - JAWAID Masood - KHAN Aymen Rehan - SAJJAD Madiha, *ChatGPT - Reshaping medical education and clinical management*, in *Pakistan Journal of Medical Sciences* 39(2023)2, 605-607, in https://doi.org/10.12669/pjms.39.2.7653.

[19] Cf KASNECI Enkelejda - SESSLER Kathrin - KÜCHEMANN Stefan - BANNERT Maria - DEMENTIEVA Daryna - FISCHER Frank - GASSER Urs - GROH Georg - GÜNNEMANN Stephan - HÜLLERMEIER Eyke - KRUSCHE Stephan - KUTYNIOK Gitta - MICHAELI Tilman - NERDEL Claudia - PFEFFER Jürgen - POQUET Oleksandra - SAILER Michael - SCHMIDT Albrecht - SEIDEL Tina - STADLER Matthias - KASNECI Gjergji, *ChatGPT for good? On opportunities and challenges of large language models for education*, in *Learning and Individual Differences* 103(2023), 102274, in https://doi.org/10.1016/j.lindif.2023.102274.

[20] Cf MHLANGA, *Open AI in Education, the Responsible and Ethical Use of ChatGPT Towards Lifelong Learning*.

[21] Cf BENVENUTI Martina - CANGELOSI Angelo - WEINBERGER Armin - MAZZONI Elvis - BENASSI Mariagrazia - BARBARESI Mattia - ORSONI Matteo, *Artificial intelligence and human behavioral development: A perspective on new skills and competences acquisition for the educational context*, in *Computers in Human Behavior* 148(2023), 107903, in https://doi.org/10.1016/j.chb.2023.107903.

creativity, and teamwork.[22] Interestingly, the same skills demanded by our digitalized world can be cultivated through the use of AI technologies themselves.[23] As will be further clarified in the following paragraphs, the typical interaction modes of ChatGPT, such as providing step-by-step solutions, guiding students through complex problems, and providing personalized feedback, appear to be an approach that enables students to enhance and reinforce their critical thinking and problem-solving abilities.[24] Furthermore, it enables students to engage in group discussions and debates, thereby training their abilities to communicate, collaborate, consider each other's points of view, and defend their positions through persuasive argumentation.[25] These critical thinking skills, problem-solving strategies, communication skills, and teamwork are essential for functioning as citizens and workers in a world permeated by digital and technology. Developing these essential skills required for success in the digital age seems to be the promise of GenAI technologies, but this demands an inevitable paradigm shift in the educational landscape and curricula, in line with the recommendation of the European Commission's Digital Education Action Plan (2021-2027).

The following sections will build on this foundation to examine a novel approach to GenAIs in educational settings. Firstly, the focus will be on exploring the aforementioned 21st-century skills and considering how they can be trained. Although these transversal skills are to some extent

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[22] Cf Alam Ashraf, Employing Adaptive Learning and Intelligent Tutoring Robots for Virtual Classrooms and Smart Campuses: Reforming Education in the Age of Artificial Intelligence, in Shaw Rabindra Nath - Das Sanjoy Das - Piuri Vincenzo - Bianchini Monica (Eds.), Advanced Computing and Intelligent Technologies, Springer Nature 2022, 395-406, in https://doi.org/10.1007/978-981-19-2980-9_32; Benvenuti et al., Artificial intelligence and human behavioral development: A perspective on new skills and competences acquisition for the educational context; Chassignol Maud - Khoroshavin Aleksandr - Klimova Alexandra - Bilyatdinova Anna, Artificial Intelligence trends in education: A narrative overview, in Procedia Computer Science, 136(2018), 16-24, in https://doi.org/10.1016/j.procs.2018.08.233; Ruthotto Isabel - Kreth Quintin - Stevens Jillian - Trively Clare - Melkers Julia, Lurking and participation in the virtual classroom: The effects of gender, race, and age among graduate students in computer science, in Computers & Education 151(2020), 103854, in https://doi.org/10.1016/j.compedu.2020.103854; Van Laar Ester - Van Deursen Alexander J.A.M. - Van Dijk Jan A.G.M. - De Haan Jos, Determinants of 21st-Century Skills and 21st-Century Digital Skills for Workers: A Systematic Literature Review, in SAGE Open 10(2020) January, 215824401990017, in https://doi.org/10.1177/2158244019900176; Wang Qiaosi - Jing Shan - Camacho Ida - Joyner David - Goel Ashok, Jill Watson SA: Design and Evaluation of a Virtual Agent to Build Communities Among Online Learners, in Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems (2020)1-8, in https://doi.org/10.1145/3334480.3382878.

[23] Cf BENVENUTI et al., Artificial intelligence and human behavioral development: A perspective on new skills and competences acquisition for the educational context;

[24] Cf ivi.

[25] Cf RUTHOTTO et al., Lurking and participation in the virtual classroom: The effects of gender, race, and age among graduate students in computer science; WANG et al., Jill Watson SA: Design and Evaluation of a Virtual Agent to Build Communities Among Online Learners.

determined by personal and psychological factors, it is crucial to identify effective strategies that can enhance their acquisition and application in digital contexts. And one potential way to do so is through generative AI. Furthermore, the objective is to examine how to enhance the credibility of AI-powered chatbots as interlocutors. The proposed approach involves equipping AI chatbots with Theory of Mind capabilities, thereby underlining the potential for personalized learning and cognitive scaffolding. Moreover, it will examine practical strategies for the integration of AI, focusing on the introduction of novel school subjects, the integration of ChatGPT into robotic platforms, and the necessity of equipping educators and parents with the requisite skills for effectively leveraging AI technologies within educational settings.

2. Can AI-powered chatbots foster critical thinking, problem-solving, and decision-making?

The main concerns about the integration of AI technologies into educational contexts are related to the reliability and accuracy of information provided by AI chatbots and the potential for students to become overly reliant on AI responses.[26] For instance, if students consistently receive pre-made solutions from AI systems, they may be unable to engage deeply with the subject matter, potentially reducing their critical thinking and creativity. Thus, the prevailing perspective often advanced is that critical thinking and problem-solving skills are essential prerequisites for engaging with AI technology effectively. Individuals equipped with these skills possess the ability to discern the reliability and accuracy of information provided by AI chatbots. They can scrutinize responses, fact-check assertions, and identify potential biases or inaccuracies regarding AI-generated content.[27] In summary, several papers have emphasized the importance of integrating diverse in-class activities and assignments to cultivate critical thinking and problem-solving skills for the effective and safe use of AI-powered chatbots.[28]

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[26] Cf KASNECI et al., *ChatGPT for good? On opportunities and challenges of large language models for education*.

[27] Cf *ivi*; SEDAGHAT Sam, *Success Through Simplicity: What Other Artificial Intelligence Applications in Medicine Should Learn from History and ChatGPT*, in *Annals of Biomedical Engineering* 51(2023)12, 2657-2658, in https://doi.org/10.1007/s10439-023-03287-x; SEVGI Umut Tan - EROL Gökberk - DOĞRUEL Yücel - SÖNMEZ Osman Fikret - TUBBS Richard Shane - GÜNGOR Abuzer, *The role of an open artificial intelligence platform in modern neurosurgical education: A preliminary study*, in *Neurosurgical Review* 46(2023)1, 86, in https://doi.org/10.1007/s10143-023-01998-2.

[28] Cf ALAFNAN Mohammad Awad - DISHARI Samira - JOVIC Marina - LOMIDZE Koba, *ChatGPT as an Educational Tool: Opportunities, Challenges, and Recommendations for Communication, Business Writing, and Composition Courses*, in *Journal of Artificial Intelligence and Technology* 3(2023)2, Article 2, in https://doi.org/10.37965/jait.2023.0184; KUNG Tiffany H.

In contrast, a recent review of the existing literature from 2018 to 2023 by Benvenuti et al.[29] proposes a diverse approach: AI-powered chatbots can promote the development and refinement of critical thinking, problem-solving skills, and decision-making. Going into these concepts, critical thinking is the ability to systematically and logically analyze, evaluate, and synthesize information. It involves rational and reflective thinking to assess the validity, relevance, and credibility of ideas while recognizing biases.[30] This cognitive skill enables individuals to make informed decisions, solve problems effectively, and navigate complex issues with clarity and precision. It is quite clear that critical thinking can be seen as a prerequisite for problem-solving, as the person facing a problem critically analyzes the information they have, extrapolates it, evaluates the possibility, and tries to find a solution .[31] Moreover, critical thinking and problem-solving are key elements in the decision-making process and all these three elements are interconnected to achieve the best solution.[32] Thus, an improvement in one of these elements is an improvement in the other two.

From a Piagetian perspective, the process of understanding the world emerges from the dynamic interplay between an individual's cognitive processes and the objects of their own experience. According to this and in light of the digitalization of society, technological tools can be effective means of knowledge construction.[33] Therefore, technological

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- CHEATHAM Morgan - MEDENILLA Arielle - SILLOS Czarina - DE LEON Lorie - ELEPAÑO Camille - MADRIAGA Maria - AGGABAO Rimel - DIAZ-CANDIDO Giezel - MANINGO James - TSENG Victor, *Performance of ChatGPT on USMLE: Potential for AI-assisted medical education using large language models*, in *PLOS Digital Health 2*(2023)2, e0000198, in https://doi.org/10.1371/journal.pdig.0000198; LI Lingyao - MA Zihui - FAN Lizhou - LEE Sanggyu - YU Huizi - HEMPHILL Libby, *ChatGPT in education: A discourse analysis of worries and concerns on social media* (2023), in https://doi.org/10.48550/ARXIV.2305.02201; TAHIRU Fati, *AI in Education: A Systematic Literature Review*, in *Journal of Cases on Information Technology* 23(2021)1, 1-20, in https://doi.org/10.4018/JCIT.2021010101; WOLLNY Sebastian - SCHNEIDER Jan - DI MITRI Daniele - WEIDLICH Joshua - RITTBERGER Marc - DRACHSLER Hendrik, *Are We There Yet? A Systematic Literature Review on Chatbots in Education,* in *Frontiers in Artificial Intelligence* (2021)4, in https://doi.org/10.3389/frai.2021.654924.

[29] Cf BENVENUTI et al., *Artificial intelligence and human behavioral development: A perspective on new skills and competences acquisition for the educational context.*

[30] Cf FAGIN Barry - HARPER Jim - BAIRD Leemon - HADFIELD Steve - SWARD Ricky, *Critical thinking and computer science: implicit and explicit connections*, in *Journal of Computing Sciences in Colleges* 21(2006)4, 171-177, in https://www.researchgate.net/publication/234808860_Critical_thinking_and_computer_science_implicit_and_explicit_connections.

[31] Cf VOSKOGLOU Michael Gr. - BUCKLEY Sheryl, *Problem Solving and Computational Thinking in a Learning Environment*, in *Arxiv* (2012), in https://doi.org/10.48550/arXiv.1212.0750.

[32] Cf ÖZGENEL Mustafa, *Modeling the relationships between school administrators' creative and critical thinking dispositions with decision making styles and problem solving skills*, in *Educational Sciences: Theory & Practice* 18(2018)3, in https://doi.org/10.12738/estp.2018.3.0068.

[33] Cf FERRARI Anusca - PUNIE Yves - REDECKER Christine, *Understanding Digital Competence in the 21st Century: An Analysis of Current Frameworks*, in RAVENSCROFT Andrew - LINDSTAEDT Stefanie - KLOOS Carlos Delgado - HERNÁNDEZ-LEO Davinia (Eds.), *21st Century Learning*

innovation should aim to expand students' learning opportunities and explore new teaching and learning. In this context, the use of AI-powered chatbots offers a promising avenue for fostering critical thinking, problem-solving, and decision-making skills in students, serving as valuable tools in fostering so-called 21st-century skills. AI-powered chatbots provide step-by-step solutions, targeted guidance, and personalized feedback,[34] which can encourage students to think critically and apply problem-solving strategies.[35] In this perspective, the assistance provided by AI chatbots extends beyond the goal of enhancing educational efficiency, such as automating repetitive tasks or saving time.[36] It primarily enhances a student's abilities,[37] enabling students to progress beyond operational and technical skills, fostering creativity and problem-solving capabilities,[38] rather than treating students as passive recipients of technology. Engaging in dialogue with chatbots encourages students to inquire, explore, and critically evaluate information, stimulating curiosity and critical thinking. These chatbots offer personalized assistance and guidance, helping students navigate through intricate concepts and tasks while promoting the development of problem-solving and decision-making abilities. Integrating AI-powered chatbots into educational settings can empower students to become more analytical, problem-solvers, and critical thinkers. To achieve this, it is essential to create awareness among students about digital inequality, the reliability and accuracy of AI chatbots, and associated ethical considerations. This will prompt students to accurately verify the information provided and, consequently, improve their critical thinking skills.

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for 21st Century Skills, Springer Nature 2012, 79-92, in https://doi.org/10.1007/978-3-642-33263-0_7; TRILLING - FADEL, *21st Century Skills: Learning for Life in Our Times.*

[34] CRAWFORD et al., *Leadership is needed for ethical ChatGPT: Character, assessment, and learning using artificial intelligence (AI)*; FAUZI et al., *Analysing the Role of ChatGPT in Improving Student Productivity in Higher Education;* LO Chung Kwan, *What Is the Impact of ChatGPT on Education? A Rapid Review of the Literature*, in *Education Sciences*, 13(2023)4, 410, in https://doi.org/10.3390/educsci13040410; QADIR, *Engineering Education in the Era of ChatGPT: Promise and Pitfalls of Generative AI for Education*; SHIDIQ, *The use of Artificial Intelligence-based Chat-GPT and its challengese for the world of education; from the viewpoint of the development of creative writing skills.*

[35] Cf BENVENUTI et al., *Artificial intelligence and human behavioral development: A perspective on new skills and competences acquisition for the educational context.*

[36] Cf COOPER Grant, *Examining Science Education in ChatGPT: An Exploratory Study of Generative Artificial Intelligence*, in *Journal of Science Education and Technology* 32(2023)3, 444-452, in https://doi.org/10.1007/s10956-023-10039-y; LABADZE et al., *Role of AI chatbots in education: Systematic literature review* 56.

[37] Cf OKONKWO Chinedu Wilfred - ADE-IBIJOLA Abejide, *Chatbots applications in education: A systematic review*, in *Computers and Education: Artificial Intelligence 2*(2021), 100033, in https://doi.org/10.1016/j.caeai.2021.100033; WOLLNY et al., *Are We There Yet? A Systematic Literature Review on Chatbots in Education.*

[38] Cf BENVENUTI et al., *Artificial intelligence and human behavioral development: A perspective on new skills and competences acquisition for the educational context.*

Nevertheless, this interesting perspective - that AI chatbots can be effectively used as tools to improve and expand several soft and transversal skills in students - needs further investigation in light of some studies that claim the contrary. Deng & Yu's meta-analysis review[39] found that the implementation of chatbots did not have a statistically significant effect on the critical thinking abilities, learning engagement levels, or motivational factors of the participants. The data indicates that the presence of chatbots did not result in significant improvements in the key outcome variables. This finding may prompt further investigation into the mechanisms by which chatbots interact with students and the contextual factors that may influence their effectiveness. Moreover, Kasneci et al.[40] also found that an excessive reliance on AI-generated responses may have a negative impact on students' critical thinking and problem-solving skills. In sum, further research is needed to investigate potential mediators or variables of the interaction between chatbot usage and student outcomes. The next paragraph will analyze a possible variable, i.e., the simulation of Theory of Mind in the AI chatbots' responses and the usage of mentalistic language. This is a key element in interactions between humans and may play a central role in interactions with AI chatbots.

3. Personalized learning and cognitive scaffolding: Implications of mentalistic language and AI mentalization capabilities for educational practice

The advancement of AI technologies has also led to the development of applications and platforms that serve as tutors for users who become learners. Importantly, the Vygotskian concept of potential human development through interaction with more experienced partners or peers appears to be applicable even in the field of generative conversational AIs. AIs operate within each learner's zone of proximal development, providing personalized support and adaptive scaffolding to gradually increase task complexity while offering personalized feedback, timely guidance, and support to learners.[41] One of the most notable examples is the use of

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[39] Cf Deng Xinjie - Yu Zhonggen, *A Meta-Analysis and Systematic Review of the Effect of Chatbot Technology Use in Sustainable Education*, in *Sustainability* 15(2023)4, Article 4, in https://doi.org/10.3390/su15042940.

[40] Cf Kasneci et. al., *ChatGPT for good? On opportunities and challenges of large language models for education.*

[41] Cf Crompton Helen - Burke Diane, *Artificial intelligence in higher education: The state of the field*, in *International Journal of Educational Technology in Higher Education* 20(2023)1, 22, in https://doi.org/10.1186/s41239-023-00392-8; Liu Chen-Chung - Liao Mo-Gang - Chang Chia-Hui - Lin Hung-Ming, *An analysis of children' interaction with an AI chatbot and its impact on their interest in reading*, in *Computers & Education* 189(2022), 104576, in https://doi.org/10.1016/j.compedu.2022.104576; Neo Mai - Mahendru Nazi, *Scaffolding learning with Merlin: malaysian students' perceptions of an AI chatbot*, in *EduLearn21 Proceedings*

artificial intelligence by individuals, including those who have completed their scholastic path, to facilitate the acquisition or maintenance of a foreign language. In this regard, a literature review by Rusmiyanto and colleagues[42] examined the effectiveness of AI-based virtual tutors in enhancing learners' communication skills. The study found that learners demonstrated significant improvements in both speaking fluency and accuracy.[43] AI tutors analyze students' language usage, comprehension levels, and learning progress to provide targeted feedback and exercises that reinforce key language skills. From vocabulary acquisition to grammar comprehension and conversational fluency, AI tutors create an immersive learning environment through interactive dialogues and engaging activities, fostering active participation and skill refinement among learners. Furthermore, learners who utilized AI tutors demonstrated improved speaking abilities and increased confidence in real-life communication scenarios.[44] Another example of an AI tutor is reported in the study by Callaway and colleagues.[45] They aimed to develop an intelligent cognitive tutor that provides metacognitive feedback to guide the decision-making process rather than the content of the decisions made. Based on the theory of metacognitive reinforcement learning, the authors developed a system that can identify the most effective cognitive strategies and accelerate metacognitive learning by providing optimal feedback signals.[46] The effectiveness of this approach was confirmed through six experiments. The results showed that individuals who interacted with the AI tutor equipped with metacognitive feedback achieved significantly better performance than those in other groups, including those who received feedback related to action and those who received no feedback. Additionally, the study revealed that the benefits of utilizing this method extended beyond immediate performance enhancement, encompassing proficiency in new scenarios and the retention of acquired skills over time.[47]

(2021)4260-4265, in https://doi.org/10.21125/edulearn.2021.0902.

[42] Cf Rusmiyanto Rusmiyanto - Huriati Nining - Fitriani Nining - Tyas Novita Kusumaning - Rofi'i Agus - Sari Mike Nurmalia, *The Role of Artificial Intelligence (AI) In Developing English Language Learner's Communication Skills*, in *Journal on Education* 6(2023) 1, 750-757, in https://doi.org/10.31004/joe.v6i1.2990.

[43] Cf *ivi*.

[44] Cf Son Jeong-Bae - Ružić Natasha Kathleen - Philpott Andrew, *Artificial intelligence technologies and applications for language learning and teaching*, in *Journal of China Computer-Assisted Language Learning* (2023) September, in https://doi.org/10.1515/jccall-2023-0015.

[45] Cf Callaway Frederick - Jain Yash Raj - Van Opheusden Bas - Das Priyam - Iwama Gabriela - Gul Sayan - Krueger Paul M. - Becker Frederic - Griffiths Thomas L. - Lieder Falk, *Leveraging artificial intelligence to improve people's planning strategies*, in *Proceedings of the National Academy of Sciences* 119(2022)12, e2117432119, in https://doi.org/10.1073/pnas.2117432119.

[46] Cf *ivi*.

[47] Cf *ivi*.

A pertinent question arises: how can students be encouraged to become active users of new AI technologies, rather than merely passive beneficiaries? One potential solution is to ensure that interactions between users and AI-powered chatbots are perceived as credible. This requires the chatbots to possess, or simulate possessing, a serious set of skills that govern human-human interactions. Specifically, the success of human interactions relies on the cognitive ability to recognize that others may have beliefs, desires, intentions, and emotions that differ from one's own.[48] This cognitive ability, known as Theory of Mind (ToM), is the capacity to comprehend one's and others' mental states (intentions, emotions, desires, beliefs) and to anticipate and comprehend behaviors based on this meta-representation.[49] This enables individuals to predict and interpret the behavior of others, anticipate their reactions, and adjust their own actions accordingly.[50] ToM develops from early childhood, starting with precursors such as joint attention, and gradually matures through even more complex social situations involving multiple perspectives, conflicting desires, and hidden intentions. By understanding others' mental states, individuals can empathize with their feelings, communicate effectively, and establish relationships. For instance, being able to recognize when someone is upset or happy allows individuals to respond appropriately, offering support or sharing in their joy. Thus, ToM holds profound importance in shaping social dynamics and facilitating effective communication among individuals. The advent of conversational generative AI has led many to question whether these conversational technologies are capable of exhibiting ToM capabilities. ChatGPT, for instance, was trained to simulate aspects of Theory of Mind by understanding human mental states. As noted by Marchetti et al.,[51] ChatGPT effectively completed the first and second-

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[48] Cf Premack David - Woodruff Guy, *Does the chimpanzee have a theory of mind?*, in *Behavioral and Brain Sciences* 1(1978)4, 515-526, in https://doi.org/10.1017/S0140525X00076512; Wellman Henry M. - Cross David - Watson Julanne, *Meta-Analysis of Theory-of-Mind Development: The Truth about False Belief*, in *Child Development* 72(2001)3, 655-684, in https://doi.org/10.1111/1467-8624.00304.

[49] Cf Perner Josef - Wimmer Heinz, *"John thinks that Mary thinks that…" attribution of second-order beliefs by 5- to 10-year-old children*, in *Journal of Experimental Child Psychology* 39(1985)3, 437-471, in https://doi.org/10.1016/0022-0965(85)90051-7; Premack - Woodruff, *Does the chimpanzee have a theory of mind?*; Wimmer Heinz, *Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception*, in *Cognition* 13(1983)1, 103-128, in https://doi.org/10.1016/0010-0277(83)90004-5.

[50] Cf Premack - Woodruff, *Does the chimpanzee have a theory of mind?*

[51] Cf Marchetti Antonella - Di Dio Cinzia - Cangelosi Angelo - Manzi Federico - Massaro Davide, *Developing ChatGPT's Theory of Mind*, in *Frontiers in Robotics and AI* 10(2023), 1189525, in https://doi.org/10.3389/frobt.2023.1189525.

order false-belief tasks[52] as well as advanced ToM tasks[53] that involve ambiguity in everyday situations. Although ChatGPT may hypermentalize and occasionally make mistakes[54] its sophisticated algorithms and natural language processing techniques enable it to discern nuances in human speech and respond accordingly, thereby enhancing the quality of interpersonal exchanges. However, the use of mentalistic language and AI mentalization capabilities not only enhances conversational experiences but also has significant implications for educational practices. As a matter of fact, cognitive development and learning occur primarily at the social level through interaction dynamics, sharing of points of view, socio-cognitive conflict dynamics, and negotiation, and are then internalized by individuals. As a consequence, AI-powered chatbots with a simulated ToM can be valuable tools in fostering lifelong skills in schools and educational contexts. This convergence can customize educational content and strategies based on individual cognitive profiles, thus enhancing learning outcomes and accommodating diverse learning styles.

4. ChatGPT in Schools: Strategies for effective use

Although opinions about the integration of Artificial Intelligence in schools vary, as discussed in the preceding paragraphs, it is undeniable that these agents have become firmly embedded in the learning experiences of many students. As their presence becomes more pervasive, there is a growing need to explore and understand how these agents can be used effectively in educational settings. In this regard, the integration of Theory of Mind (ToM) capabilities offers significant potential for enhancing educational practices and fostering lifelong skills by making these agents more credible interlocutors for tasks in medium- to long-term interactions. ChatGPT, for example, showcases remarkable abilities to understand and respond to nuances in human speech. Moreover, the recently released version of ChatGPT (GPT-4), which enables the customization of AI chatbots, opens up new possibilities for personalized learning and cognitive scaffolding. Studies have shown that AI tutors equipped with metacognitive feedback can significantly enhance learners' performance

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[52] Cf PERNER - WIMMER, *"John thinks that Mary thinks that…" attribution of second-order beliefs by 5- to 10-year-old children*; WIMMER, *Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception.*
[53] Cf GREGORY Carol - LOUGH Sinclair - STONE Valerie - ERZINCLIOGLU Sharon - MARTIN Louise - BARON-COHEN Simon - HODGES John R., *Theory of mind in patients with frontal variant frontotemporal dementia and Alzheimer's disease: Theoretical and practical implications*, in *Brain* 125(2002)4, 752-764, in https://doi.org/10.1093/brain/awf079; VALLE Annalisa - MASSARO Davide - CASTELLI Ilaria - MARCHETTI Antonella, *Theory of Mind Development in Adolescence and Early Adulthood: The Growing Complexity of Recursive Thinking Ability*, in *Europe's Journal of Psychology* 11(2015)1, 112-124, in https://doi.org/10.5964/ejop.v11i1.829.
[54] Cf MARCHETTI et al., *Developing ChatGPT's Theory of Mind.*

and skill retention over time.[55] Furthermore, they have been shown to facilitate students' communication skills through targeted feedback and interactive activities.[56] This is in addition to the actual and ongoing digital transformation that necessitates future professionals to be equipped with transversal skills and key competencies, including critical thinking, problem-solving, decision-making strategies, creativity, and working in teams.[57] Whichever direction allows these skills to be developed - whether through the use of new AIs or, conversely, the refinement of existing skills to accommodate these technologies -, it is imperative to determine the most effective means of integrating AI into the schools' curricula. In recent times, Computational Thinking (CT), defined as a cognitive process that employs analytical and algorithmic techniques to formulate, analyze, and resolve problems,[58] has attracted growing interest from researchers in the field of education. From the earliest stages of education, programming activities such as coding and educational robotics can facilitate the acquisition of CT skills in children.[59] Coding is increasingly regarded as a new literacy for the twenty-first century, enabling novel modes of thought, communication, and idea expression, as well as fostering novel avenues for civic participation.[60] For instance, tangible interfaces, such as floor robots (e.g., Cubetto, Bee, and Blue-Bot), are frequently utilized in kindergartens: children are requested to program the correct sequence of actions to achieve a specific goal, e.g., defining Cubetto's orientation and the direction needed to reach a specific target throughout subsequent path episodes. Coding education has been demonstrated to promote

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[55] Cf CALLAWAY et al., *Leveraging artificial intelligence to improve people's planning strategies*.

[56] Cf CELIK Ismail - DINDAR Muhterem - MUUKKONEN Hanni - JÄRVELÄ Sanna, *The Promises and Challenges of Artificial Intelligence for Teachers: A Systematic Review of Research*, in *TechTrends* 66(2022)4, 616-630, in https://doi.org/10.1007/s11528-022-00715-y; FARIANI et al., *A Systematic Literature Review on Personalised Learning in the Higher Education Context*; SCHIFF, *Out of the laboratory and into the classroom: The future of artificial intelligence in education*; WOLLNY et al., *Are We There Yet? A Systematic Literature Review on Chatbots in Education*.

[57] Cf MANGIDUYOS Gladys P. - SUBIA Gener S., *Twenty-First (21st) Century Skills of College of Education Alumni*, in *Open Journal of Social Sciences* 09(2021)09, 330-337, in https://doi.org/10.4236/jss.2021.99023; TRILLING - FADEL, *21st Century Skills: Learning for Life in Our Times*; VAN LAAR et al., *Determinants of 21st-Century Skills and 21st-Century Digital Skills for Workers: A Systematic Literature Review*.

[58] Cf WING Jannette M., *Computational thinking*, in *Communications of the ACM*, 49(2006)3, 33-35. https://doi.org/10.1145/1118178.1118215.

[59] Cf ROMÁN-GONZÁLEZ Marcos - PÉREZ-GONZÁLEZ Juan-Carlos - JIMÉNEZ-FERNÁNDEZ Carmen, *Which cognitive abilities underlie computational thinking? Criterion validity of the Computational Thinking Test*, in *Computers in Human Behavior* 72(2017), 678-691, in https://doi.org/10.1016/j.chb.2016.08.047.

[60] PAPADAKIS Stamatios - KALOGIANNAKIS Michail, *Evaluating the effectiveness of a game-based learning approach in modifying students' behavioural outcomes and competence, in an introductory programming course. A case study in Greece*, in *International Journal of Teaching and Case Studies* 10(2019)3, 235-250, in DOI:10.1504/IJTCS.2019.10024369.

and enhance cognitive abilities, including problem-solving, spatial skills, reasoning skills, and short-term memory.[61] Peretti et al.[62] examined the impact of a coding intervention using the Cubetto robot on cognitive skills in 4-year-old children. The results demonstrated a significant improvement in sequential programming abilities in the experimental group compared to the control group post-intervention. Another study found that coding activities facilitate the development of motor, logical, visual, and problem-solving skills in four-year-olds, with the mediation of physical and digital interfaces.[63] For these reasons, coding and educational robotics activities are encouraged as early as kindergarten. In recent years, the integration of computational thinking and programming/coding into the curriculum of compulsory education has become a reality in northern EU and Extra-EU countries.[64] In 2013, the United Kingdom introduced Computer Science into its school curriculum at an early age. Furthermore, in Finland, Sweden, Denmark, and Norway, computational thinking and programming are

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[61] Cf Bers Marina U., *The TangibleK Robotics Program: Applied Computational Thinking for Young Children*, in *Early Childhood Research & Practice* 12(2010)2, in https://eric.ed.gov/?id=EJ910910; Bers Marina U., *Coding and Computational Thinking in Early Childhood: The Impact of ScratchJr in Europe*, in *European Journal of STEM Education* 3(2018)3, in https://doi.org/10.20897/ejsteme/3868; Bers Marina Umaschi - Flannery Louise - Kazakoff Elizabeth R. - Sullivan Amanda, *Computational thinking and tinkering: Exploration of an early childhood robotics curriculum*, in *Computers & Education* 72(2014), 145-157, in https://doi.org/10.1016/j.compedu.2013.10.020; Bers Marina U. - González-González Carina - Armas-Torres M. Belén, *Coding as a playground: Promoting positive learning experiences in childhood classrooms*, in *Computers & Education* 138(2019), 130-145, in https://doi.org/10.1016/j.compedu.2019.04.013; Nulli Giovanni - Di Stasio Margherita, *Coding alla scuola dell'Infanzia con docente esperto della scuola primaria,* in *Italian Journal of Educational Technology* 25(2017)2, 59-65, in https://doi.org/10.17471/2499-4324/902; Sung Woonhee - Ahn Junghyun - Black John B., *Introducing Computational Thinking to Young Learners: Practicing Computational Perspectives Through Embodiment in Mathematics Education*, in *Technology, Knowledge and Learning* 22(2017)3, 443-463, in https://doi.org/10.1007/s10758-017-9328-x.

[62] Cf Peretti Giulia - Villani Daniela - Marangi Michele - Pelizzari Federica - Di Bruno Sara - Guida Igor - Marchetti Antonella - Riva Giuseppe - Rivoltella Pier Cesare - Massaro Davide, *Coding with me: Exploring the effect of coding intervention on preschoolers' cognitive skills*, in *Annual Review of Cybertherapy and Telemedicine* 18(2020) Summer, 153-156; Cf Peretti Giulia - Villani Daniela - Marangi Michele - Pelizzari Federica - Di Bruno Sara - Guida Igor - Marchetti Antonella - Riva Giuseppe - Rivoltella Pier Cesare - Massaro Davide, *Il viaggio di Cubetto*, in *Pedagogika* 25(2021)4, 57-62, in http://hdl.handle.net/10807/200879.

[63] Cf Pelizzari Federica - Marangi Michele - Rivoltella Pier Cesare - Peretti Giulia - Massaro Davide - Villani Daniela, *Coding and childhood between play and learning: Research on the impact of coding in the learning of 4-year-olds*, in *Research on Education and Media*, 15(2023)1, 9-19, in https://doi.org/10.2478/rem-2023-0003.

[64] Cf Bocconi Stefania - Chioccariello Augusto - Dettori Giuliana - Ferrari Anusca - Engelhardt Katja - Kampylis Panagiotis - Punie Yves, *Developing Computational Thinking in Compulsory Education. Implications for policy and practice*, in *EUR - Scientific and Technical Research Reports* (2016), in https://doi.org/10.2791/792158; Bocconi Stefania - Chioccariello Augusto - Earp Jeffrey, *The nordic approach to introducing computational thinking and programming in compulsory education.* Report prepared for the Nordic@BETT2018 Steering Group, CNR Edizioni 2018, in https://doi.org/10.17471/54007.

already included in the primary and secondary school curricula. This occurs either as a transversal competency integrated into existing subject matter (e.g., in Finland and Sweden) or as a new elective subject (e.g., in Denmark and Norway).[65] The implementation or integration of programming as a subject in the compulsory education curriculum in these countries has been demonstrated to be of significant value in fostering critical thinking and creativity, fundamental transferable and soft skills.[66]

A further potential avenue for integrating generative AI into educational systems could be to equip them with a tangible interface that allows for much more fluid and autonomous interactions with students and teachers. Thanks to the physical-social environment with which to interact, it would be possible to hypothesize that these AI entities could not only assist in classroom activities but also foster a more dynamic and personalized learning experience. A case in point is the first integration in Italy of ChatGPT with a social robot, namely the NAO robot. Previously, the humanoid and social robot NAO required pre-programming for even basic tasks and exhibited limited conversational abilities. However, the incorporation of ChatGPT into the NAO robot notably enhanced its capacity for interaction. An interesting recent study by Sacco et al.[67] sought to examine the representations of teachers at different grade levels regarding the use of robot NAO with ChatGPT, its potential and its limitations in educational settings. In this regard, Sacco et al.[68] examined the impact of incorporating ChatGPT in NAO on teachers' perceptions. The study drew insights from 17 teachers across kindergarten to middle school levels and comprised two sessions. In the initial phase, each teacher was interviewed individually and interacted with the NAO robot without ChatGPT integration. This phase also included role-playing activities to explore potential educational scenarios with the robot. The second session included group discussions following interactions with the NAO robot both without and with ChatGPT integration. These sessions aimed to gather detailed information on the use of the NAO robot in educational settings, both in its pre-programmed state and with ChatGPT integration. The results showed that the integration of ChatGPT into NAO was perceived as a useful tool for improving reading, writing, and

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[65] Cf BERGE Ola, *Rethinking Digital Literacy in Nordic School Curricula*, in *Nordic Journal of Digital Literacy* 12(2017)1-2, 5-7, in https://doi.org/10.18261/issn.1891-943x-2017-01-02-01.
[66] Cf BOCCONI et al., *The nordic approach to introducing computational thinking and programming in compulsory education.*
[67] Cf SACCO Federica - ROSSINI Gisella - MANZI Federico - DI DIO Cinzia - AQUILINO Letizia - CANGELOSI Angelo - RAGGIOLI Luca - MASSARO Davide - MARCHETTI Antonella, *An Antropomorphic Robot with ChatGPT for Learning Activities: The Teachers' Perspective. 2023 IEEE International Conference on Metrology for eXtended Reality, Artificial Intelligence and Neural Engineering (MetroXRAINE)*, (2023)1166-1170, in https://doi.org/10.1109/MetroXRAINE58569.2023.10405596.
[68] Cf *ivi.*

research tasks, and as a valuable aid for students to better understand and contextualize instructional material. In addition, educators perceived NAO as both a tutor and a peer and underscored the potential of the robot in facilitating personalized instruction, particularly for students with disabilities and learning difficulties. In contrast to concerns about distraction, teachers perceived that the presence of NAO improved interactivity and engagement in learning activities. However, despite generally positive perceptions, concerns emerged during the role-playing activities and focus groups, particularly regarding confidence in using NAO with ChatGPT in classrooms. Teachers also expressed concerns that students might abuse the tool, impairing critical thinking and research skills. Although the initial programming of NAO was perceived as challenging, the integration of ChatGPT simplified its usability, allowing for more spontaneous interaction in line with students' needs.[69] Integrating AI-powered chatbots into physical embodiments, such as humanoid robots like NAO, opens up new avenues for interaction and engagement in educational settings. The combination of AI chatbots with physical bodies could further enhance the immersive learning experience, providing students with a tangible presence to interact with and learn from.

Future research is needed to fully comprehend how to successfully integrate AI into the educational systems in a way that maximizes their benefits while mitigating potential risks. The initial step is the investment in the training of teachers and educators to effectively integrate AI technologies into classroom settings, which is essential for unlocking the full potential of these tools. The importance of prioritizing the training of teachers and educators in the effective integration of AI technologies within classroom settings cannot be underestimated. Teachers must be equipped with the knowledge and expertise to navigate the complexities of integrating AI tools into their pedagogical practices to ensure that they can effectively support students in developing the necessary digital literacy skills. By understanding how to leverage AI chatbots for personalized learning experiences, teachers can empower students to become critical thinkers, problem solvers, and effective communicators in an increasingly digitalized world. However, this is not enough: in addition to teachers, parents must also be trained in the effective and responsible use of AI technologies. On the one hand, training is beneficial for parents to gain an understanding of how these technologies can actually or potentially be used in their children's education and to address any reservations or prejudices they may have about AI. When parents are aware of the ways in which these technologies are used in classrooms, they are more likely to support AI implementation, thereby strengthening the link between home and school. Indeed, it is well known that the closer the collaboration

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[69] Cf *ivi.*

between school and parents, the richer the student learning experience. This is because when parents are involved and informed, they can work together with teachers to support their children's learning both in the classroom and at home.

Conclusion

The integration of Artificial Intelligence systems into educational settings presents both challenges and opportunities for transforming learning experiences. As evidenced by the widespread adoption of AI agents in classrooms, there is a growing recognition of their potential to enhance teaching and learning practices. By incorporating Theory of Mind capabilities, AI chatbots like ChatGPT can become more credible interlocutors, facilitating medium- to long-term interactions and personalized learning experiences. Furthermore, the integration of computational thinking and programming activities into curricula from an early age establishes a foundation for the development of essential transversal and cognitive skills. Looking ahead, equipping AI chatbots with physical embodiments, as demonstrated by the integration of ChatGPT into the NAO robot, opens up new possibilities for dynamic and fluid interactions in educational settings. While legitimate concerns about trust and misuse exist, which require attention, the potential benefits of AI-powered chatbots for innovative educational methods cannot be overlooked.

AI systems will continue to have a significant impact on several domains. In this context, schools play a crucial role in providing transversal and soft skills suited to a digitally pervasive world and a rapidly evolving job market. The importance of fostering skills like critical thinking, problem-solving, communication, and teamwork are essential for both the effective use of AI systems and for preparing current and future citizens and workers.