# Case

### C1: Innovation

#### Productivity is high now because of GenAi

Basel **Issmail**, 10-5-20**24**, Senior Full-Stack Developer & Tech Lead @ Kepler Team | React, Angular, TypeScript, nodeJS, AWS | Remote Specialist, "What If ChatGPT Disappeared? How Life Without Generative AI Could Turn Our World Upside Down", Medium, <https://medium.com/@basel.issmail/what-if-chatgpt-disappeared-how-life-without-generative-ai-could-turn-our-world-upside-down-4d9a49fda941> doa:2/16/25 as

Imagine this: You wake up tomorrow, reach for your phone, and **ChatGPT is gone**. No more instant answers. No more help with writing or debugging code. *It’s like the world has hit the brakes.* At the WCIT 2024 panel, senior analyst Berge Ayvazian raised a chilling question: *What if AI like ChatGPT just stopped working?* This got me thinking — how deeply do we depend on generative AI? And what would life look like without it? **Generative AI: The Invisible Engine of Our World** From coders to marketers, ChatGPT has become more than just a tool — it’s the lifeblood of modern productivity. It powers creativity and innovation in ways we hardly notice. But take it away, and we’d be left *scrambling like an engine suddenly cut off mid-flight.* **Developers in Crisis Mode** For developers, ChatGPT is the co-pilot they never knew they needed. According to a GitHub Copilot survey, it makes code-writing **55% faster**. Now imagine reverting to the endless rabbit holes of StackOverflow, wasting hours on what was once a quick fix. Deadlines would crumble. Projects would stall. And quality? *It would plummet — dragging companies down with it.* **Content Creation Slows to a Crawl** Writers and marketers are in for a rude awakening. AI boosts writing productivity by **40%** according to a study by MIT researchers. Without it? Content pipelines would grind to a halt. Burnout would soar. Marketing teams would lose their edge, turning out bland, uninspired material that customers would scroll right past. In a world where *attention is everything*, **mediocrity is a death sentence**. **Customer Support Overload** Businesses rely on AI-powered chatbots to handle the flood of customer inquiries. AI can automate up to **70% of routine customer queries**, improving efficiency and reducing response times, as reported by sources like Zendesk and Kore.ai. Without it, call centers would be buried under mountains of requests. Long wait times. Angry customers. It wouldn’t just be frustrating — it would be chaos. **Education Takes a Step Back** In classrooms, AI is reshaping the way students learn. According to multiple studies, it increases engagement by 30–45% and saves teachers up to 40% of their time. Take it away, and students lose the personalized learning that’s shaping the next generation. Teachers, drowning in paperwork, would be forced back into outdated methods. The future of education? **Stuck in reverse**. **Personal Insight: AI as a Lifeline** Before ChatGPT, I was drowning in repetitive tasks — writing reports and fixing small bugs. It drained my energy, leaving me burned out. When ChatGPT entered my workflow, it felt like having an assistant who never sleeps, always there to handle the tedious work. *It freed me from the grind and reignited my spark.* If it vanished tomorrow? Burnout would be waiting for me, ready to pull me back under. **Innovation Slows Without AI** Generative AI has ignited a revolution in creativity. Without it, the pace of innovation would screech to a halt. Industries like music, art, and tech would lose their edge. We’d still move forward, but cautiously — too afraid to take risks. What once took months to build could now take years. **Are We Too Dependent?** Berge Ayvazian’s question still lingers: *Could we survive without generative AI?* Perhaps. But the world would be slower, less efficient, and far less creative. **AI isn’t just a convenience** — it’s the force driving us into the future. Without it, we’d be lost in a slower, less inspired world.

#### GenAi improves learning

[Lixiang **Yan**](https://www.nature.com/articles/s41562-024-02004-5#auth-Lixiang-Yan-Aff1), [Samuel Greiff](https://www.nature.com/articles/s41562-024-02004-5#auth-Samuel-Greiff-Aff2-Aff3-Aff4), [Ziwen Teuber](https://www.nature.com/articles/s41562-024-02004-5#auth-Ziwen-Teuber-Aff2), [Dragan Gašević](https://www.nature.com/articles/s41562-024-02004-5#auth-Dragan-Ga_evi_-Aff1) **ET AL**, 10-21-20**24**, Lixiang Yan is a research fellow at the Centre for Learning Analytics at Monash University, "Promises and challenges of generative artificial intelligence for human learning", Nature, <https://www.nature.com/articles/s41562-024-02004-5> doa:3/6/2025

Abstract Generative artificial intelligence (GenAI) holds the potential to transform the delivery, cultivation, and evaluation of human learning. This Perspective examines the integration of GenAI as a tool for human learning, addressing its promises and challenges from a holistic viewpoint that integrates insights from learning sciences, educational technology, and human-computer interaction. GenAI promises to enhance learning experiences by scaling personalised support, diversifying learning materials, enabling timely feedback, and innovating assessment methods. However, it also presents critical issues such as model imperfections, ethical dilemmas, and the disruption of traditional assessments. Cultivating AI literacy and adaptive skills is imperative for facilitating informed engagement with GenAI technologies. Rigorous research across learning contexts is essential to evaluate GenAI’s impact on human cognition, metacognition, and creativity. Humanity must learn with and about GenAI, ensuring it becomes a powerful ally in the pursuit of knowledge and innovation, rather than a crutch that undermines our intellectual abilities. Keywords: Generative Artificial Intelligence, Human Learning, AI Agent, Large Language Models, Diffusion Models 1 Main Human learning is a journey that shapes minds, fosters innovation, and builds the foundations of society. Beyond merely acquiring knowledge and skills, learning is a path towards fostering critical thinking, creativity, collaboration, and social cohesion. By nurturing the ability to question, analyse, and innovate, learning empowers individuals to navigate complex challenges and contribute to societal progress. While education encompasses formalised systems that structure learning processes, learning represents the dynamic and personal process that occurs within this framework (Table 1). The history of human learning presents a narrative of continuous evolution and adaptation to technological breakthroughs. For example, the printing press democratised access to knowledge and opened the opportunity of learning to many, while the Internet and digital technologies transformed information dissemination and collaborative learning across time and space. In this continuum of innovation, recent advancements in artificial intelligence (AI) present another transformative opportunity to rethink learning processes and educational methodologies [1]. Generative AI (GenAI) technologies, such as large language models (LLMs) and diffusion models (Table 2), have shown promise in automating various learning tasks [2], delivering feedback on human efficacy [3], outperforming average students in reflective writing [4], innovating conversational assessments [5], creating dynamic learning resources [6], and supporting multimedia learning [7]. However, these technologies also present challenges and ethical considerations that could outweigh their benefits [2, 8]. One major concern is the digital divide, where unequal access to these powerful technologies can exacerbate existing inequalities in learning opportunities [9]. Additionally, overreliance on GenAI may negatively impact learners’ agency, critical thinking, and creativity, warranting caution [10]. Consequently, it is essential to balance technological advancement and humancentred values in learning. This perspective paper aims to delve into the promises and challenges of advancing human learning in the age of GenAI. By integrating human-centred theories of learning and instruction, we emphasise the importance of designing AI-driven educational tools that prioritise the needs of learners in contemporary societies. We elaborate on how this technology can transform learning and teaching practices while remaining critical of the ethical and practical challenges it poses, contributing to a future research agenda for investigating human-AI interaction and the adoption of GenAI as a tool for learning (Fig. 1). 2 Promises GenAI promises to transform human learning by scaling personalised support, diversifying learning resources, enabling timely feedback, and innovating assessment methods. The realisation of these promises depends on the roles and interactions GenAI has with learners and educators (Fig. 2). Specifically, GenAI technologies can act as cognitive facilitators within learners’ Zone of Proximal Development, providing adaptive support at scale. GenAI can also enrich learning experiences by assisting in the creation of diverse multimedia resources. In feedback, GenAI systems offer timely and multimodal insights, surpassing traditional methods in depth and efficiency. For Fig. 1 Overview of the impacts of generative artificial intelligence on human learning. The left side of the figure lists various learning impacts, which are categorised into promises (green), challenges (red), and needs (blue). The middle column presents key components associated with each learning impact. These components detail specific aspects that need to be addressed or leveraged to use generative AI as a tool for learning. The matrix on the right shows the five main groups involved in implementing these key components: learners, educators, researchers, policymakers, and technologists. The dots in each column indicate that the relevant group needs to make a substantive contribution to achieving the goals of the key component in the corresponding row. assessment, GenAI enables adaptive and authentic evaluations using generative agents and multimodal models. The following sections explore each of these promises, illustrating their potential to transform the delivery, cultivation, and evaluation of human learning. 2.1 Learning Support The unique contribution of GenAI, particularly LLMs, to learning support lies in its scalability and adaptability. GenAI can function as a master teacher at scale, providing personalised and adaptive support to a wide range of learners across various subjects and languages. Unlike conventional intelligent tutoring systems that require extensive knowledge engineering to design rule-based responses [11], GenAI can achieve superior and more naturalistic interactions, such as personalised feedback, adaptive questioning, and conversational engagement, with minimal prior training. These enhanced interactions facilitate more effective and intuitive tutoring experiences, making the learning process more engaging and tailored to individual student needs [8]. This capability holds the potential to democratise access to high-quality learning support, making it accessible to learners globally. GenAI’s role aligns with Vygotsky’s sociocultural theory of learning, where more knowledgeable others guide learners within their Zone of Proximal Development [12]. By integrating novel technologies like ChatGPT into intelligent tutoring systems, GenAI can offer personalised and adaptive support based on each learner’s unique knowledge [13]. These language models have demonstrated remarkable proficiency in processing semantic and contextual information [14], a key aspect of their effectiveness as a tool for learning. By accurately interpreting and responding to the linguistic and contextual nuances in learners’ queries, LLMs ensure that the learning experience is interactive and thought-provoking. Rather than merely dispensing solutions, they can be used to encourage learners to engage cognitively with the material. This engagement is achieved by prompting students to think critically, unpack problems, and understand underlying concepts. A representative case of how GenAI can support learning comes from Khan Academy’s ”Khanmigo” chatbot, powered by GPT-4 and designed to assist with mathematical queries [15]. Khanmigo exemplifies the shift from providing direct answers to a more nuanced, guided learning approach that offers constructive feedback and step-by-step instruction. For example, when students present Khanmigo with a problem on fractions, it guides them through the underlying concepts of denominators and numerators, encouraging them to apply these concepts to solve the problem through a series of guiding questions. Khanmigo functions as a facilitator, aligning with the principles of inquiry-based learning [16], a human-centred learning theory that emphasises the importance of active learning through inquiry. This theory encourages students to ask questions, explore, and engage deeply with the learning material to develop deep knowledge. This iterative methodology reflects Vygotsky’s emphasis on the importance of the learning journey over the destination by fostering deep conceptual comprehension and retention [12, 16]. By engaging learners in a dialogic process, GenAI-driven systems such as Khanmigo aim to enhance learners’ critical thinking and problem-solving skills. Despite the promising design of systems like Khanmigo and students’ positive attitudes towards using such technologies for personalised learning support [17], it is important to acknowledge the current limitations in empirical evidence regarding their short- and long-term impacts on learning outcomes [18]. Emerging evidence indicates that the impact on learning engagement, agency, and performance can paint a complicated and mixed picture (e.g., lack of learning gains after removing GenAI supports) [19, 20]. Therefore, further research is needed to substantiate GenAI’s long-term benefits to human learning. This includes conducting longitudinal and randomised controlled studies that compare the effectiveness of GenAI tutoring with conventional rule-based tutoring systems over several academic terms and across different subjects to contextualise its impacts within various educational settings. 2.2 Learning Resource Effective learning relies on the quality and diversity of resources, yet developing highquality materials is often time-consuming and resource-intensive. GenAI promises to ease this burden by creating diverse and engaging content, fostering curriculum innovation and enhancing learning experiences. Studies on human-AI collaboration indicate Fig. 2 Examples of human-AI interactions in human learning. a, Learners receive personalised and adaptive support from generative AI tutors, which are co-designed with educators and have access to prior learner data and domain knowledge. b, Educators use generative AI to create multimodal learning resources, incorporating text, audio, and video content. c, Educators collaborate with generative AI to deliver multimodal feedback to learners. d, Generative AI agents use input requirements from educators, prior learner data, and domain knowledge to create assessment activities that evaluate learners. that co-creating content with GenAI can meet diverse learning needs, providing students with relevant and accessible materials to support their individual paths efficiently and creatively [21–23]. For instance, early explorations have shown that GPT-4 can automatically generate instructional materials, such as explanations of programming concepts, examples, and quiz questions, thereby boosting learner engagement and satisfaction [24]. Additionally, GPT-4 has demonstrated proficiency in generating college-level biology questions for lower levels of Bloom’s Taxonomy (e.g., remember and understand) but struggles with higher levels (e.g., apply and create) [25]. These findings suggest that while GenAI can produce learning resources, educators’ expertise remains crucial for ensuring the accuracy, relevance, and pedagogical soundness of the material. This highlights the need for a human-AI collaborative approach to create meaningful resources that meet diverse learning objectives and learner needs. GenAI can also enrich learning resources by generating interactive activities, multimedia content, and real-world problem-solving scenarios. Text-to-image models like Stable Diffusion, Midjourney, and DALL-E [26, 27] enable educators to create visual learning materials from textual content. These tools can foster students’ creative thinking by engaging them in activities such as using AI to generate images. For instance, students can create imaginative visuals with AI and write inspired diaries based on these images, a practice found to reduce gender disparities in interest in art during Science, Technology, Engineering, the Arts and Mathematics (STEAM) classes [28]. This innovative approach has also been shown to enhance primary school students’ extrinsic motivation, problem-solving awareness, critical thinking, and learning performance in ancient Chinese poetry [29]. Similarly, text-to-video generation tools like Runway’s Gen-3 Aphla and OpenAI’s Sora can support educators in creating video narratives from textual content, further diversifying learning modalities. This capability is particularly valuable for teaching students with specific disabilities, such as providing multisensory instruction to students with dyslexia [30]. A preliminary study found no significant differences in learning gains and perceived experiences between GenAI-generated videos with synthetic instructors and traditional recorded instructor videos, suggesting that GenAI could make high-quality learning resources more accessible globally [31]. By offering a range of pedagogical possibilities through efficient and diversified resource development, GenAI can help educators create more dynamic and engaging learning environments. This enables learners to interact with content in more informed, creative, and personalised ways. Such an approach aligns with constructivist learning principles, which emphasise the importance of learners actively constructing knowledge through exploration and interaction [32]. However, more research is needed to balance this integration of GenAI in developing resources for human learning [21, 33], such as determining the optimal level of automation versus human control, the extent of expert validation required, and the degree of alignment with learning objectives. 2.3 Learning Feedback Another promise of GenAI in supporting human learning is its potential to provide timely, specific, and constructive feedback, a key element of high-quality instruction and essential for effective learning [34–36]. Providing detailed feedback regularly is laborious and time-consuming, adding to educators’ workloads, especially since students perceive timely feedback as the most effective [37]. GenAI can assist by analysing student work and delivering instant, personalised feedback with minimal prior training. For example, a recent study found that ChatGPT generates more in-depth and fluent feedback, coherently summarising students’ performances compared to human educators [3]. This AI-generated feedback also includes process-focused elements, which are more effective in shaping learning strategies [36]. Emerging studies show similar benefits in various learning contexts, such as formative feedback in secondary school essay writing [38, 39], programming assignments in introductory computer science courses [40, 41], and collaborative second language writing [42]. GenAI-generated feedback has led to enhanced task performance and positive experiences [39, 40, 42]. Additionally, chatbots powered by GenAI models with natural and visual language understanding capabilities (e.g., GPT-4 with Vision and Gemini 1.0 Pro) can help students navigate and comprehend insights from learning analytics dashboards [43], which combine data, analytics, and visualisations to provide feedback on learning processes and outcomes [44]. These chatbots could facilitate dialogic feedback, which is associated with improved learner productivity and engagement [45]. GenAI could also expand feedback delivery beyond text and graphics to include narrated audio and video, addressing the scalability challenges of these formats and leveraging their benefits for enhanced feedback efficiency and student engagement [46]. For example, by combining 3D diffusion models [47] and text-to-speech models [48], educators can create digital avatars to convey feedback through a narrated voice rather than text alone. This diversity in feedback modalities can increase engagement and effectiveness [46]. Prior research indicates that audio and video feedback is often perceived as more personal and dynamic, enhancing understanding and engagement compared with traditional written feedback [49–51]. The integration of GenAI technologies promises to facilitate timely and multimodal feedback, providing more informative feedback and fostering improved effectiveness and engagement in the learning process. However, it is essential to evaluate the cost and benefits, as these models, especially video generation models, require high computational power, potentially widening the inequality in learning opportunities. 2.4 Learning Assessment GenAI is transforming the assessment of learning, shifting from traditional, often onerous methods to more adaptive and authentic processes [52]. Central to this shift is GenAI’s potential to create personalised and adaptive assessments, enhancing the understanding of each student’s needs and progression. This is enabled by advancements in generative agents – autonomous and adaptive AI entities that operate independently, pursuing objectives without continuous user interaction, as exemplified by tools like AutoGen (preprint) [53]. These agents exhibit human-like cognitive and metacognitive abilities, including task planning, situational assessment, progress monitoring, and collaborative efforts among agents. For instance, a group of 25 generative agents in a dynamic sandbox environment successfully organised and conducted a Valentine’s Day celebration based on a single user input [54]. By leveraging a similar agent architecture, encompassing observation, planning, and reflection, and integrating these with process-centred methodologies (e.g., modelling self-regulated learning from learners’ digital traces [55]) from the field of learning analytics [56, 57], learning scientists and researchers can develop generative agents capable of autonomously evaluating human learning. These agents can identify areas of knowledge deficiency and provide tailored learning resources and adaptive assessments. Recent educational technology studies highlight the potential of automated assessments through multi-agent frameworks that leverage multiple LLM agents. These GenAI systems are being used to grade coding assignments in online learning [58], conduct cognitive assessments to identify students’ strengths and weaknesses according to Bloom’s taxonomy in e-learning environments [59], and assess educators’ mathematical content knowledge for professional development programs [60]. These applications demonstrate strong potential for generalisability, precision, and dependability. GenAI also holds promise for advancing authentic assessments [52]. It can enhance learning tasks in both virtual and physical simulations to more accurately mirror realworld situations, making assessments more meaningful and contextualised. Previous studies have shown the effectiveness of combining LLMs with knowledge graphs to create virtual standard patients, aiding the training and evaluation of medical students’ diagnostic skills [61]. Knowledge graphs are structured representations that integrate diverse data sources, providing a comprehensive understanding of a domain [62]. When used with LLMs, they can simulate complex learning and assessment scenarios requiring critical thinking and problem-solving skills, such as in driving education [63], programming education [64], and laboratory safety courses [65]. Integrating multimodal generative models, such as GPT-4 Vision for text and image generation, Meta’s Voicebox for audio creation from text, and generative adversarial networks for digital avatar production, can further enhance the authenticity of simulated assessment environments [66]. These enhancements allow students to interact naturally and perform procedural actions as if they were in real professional settings, a concept proven effective in virtual internships [67] and healthcare simulations [68]. However, much effort is required to develop valid and reliable behavioural and psychological indicators in these novel assessment settings to accurately capture genuine human learning.

#### Independently, GenAi data trading is good for models’ improvement

Kaif **Shaikh**, 12-12-20**24**, Kaif Shaikh is a journalist and writer passionate about turning complex information into clear, impactful stories. His writing covers technology, sustainability, geopolitics, and occasionally fiction. Kaif's bylines can be found in Times of India, Techopedia, and Kitaab. Apart from the long list of things he does outside work, he likes to read, breathe, and practice gratitude. "Publishers sell data for millions as AI faces imminent data shortage", Interesting Engineering, <https://interestingengineering.com/culture/publishers-sell-data-ai-earn-millions> doa:2/16/25 as

I systems, particularly large language models (LLMs), require extensive and diverse information to train, function, and naturally grow. However, these ever-hungry systems also require a constant influx of data to satisfy their insatiable appetite, leading to data shortage, with [predictions indicating](https://epoch.ai/trends#:~:text=Training%20data&text=The%20median%20projected%20year%20in,confidence%20interval%3A%202026%20to%202033.) that AI models will soon exhaust the available public online text. This reliance has positioned rich, detailed, scholarly content, which has vetted information, as an extremely valuable resource for [training these advanced AI](https://interestingengineering.com/innovation/ai-training-data-privacy) systems. Consequently, scholarly publishers, custodians of vast archives of detailed research, have entered into multimillion-dollar licensing agreements with technology companies. These deals provide tech firms with the critical data needed to [train their AIs](https://interestingengineering.com/innovation/ai-training-data-privacy) while offering publishers a lucrative revenue stream. While financially beneficial, these partnerships also pose complex questions of ethics, ownership, and the broader implications for the accessibility of knowledge. **The multi-million dollar AI agreements** In recent months, some of the most significant deals in the AI data domain have featured partnerships between leading tech companies and scholarly publishers. One of the most notable transactions involved [Microsoft and the UK academic publisher Taylor & Francis](https://www.thebookseller.com/news/academic-authors-shocked-after-taylor--francis-sells-access-to-their-research-to-microsoft-ai). Microsoft secured a $10-million agreement to utilize the publisher’s extensive repository of papers to train its AI systems. Similarly, the academic publisher Wiley has also entered lucrative agreements, having reported to its investors a $23 million earning from a deal with an unnamed technology firm, with an additional $21 million expected within the financial year. From the publishers’ perspective, these deals represent a significant revenue opportunity, a crucial factor in an industry often grappling with financial constraints. However, alongside the profit potential, these agreements raise ethical considerations. Publishers must address the complex intellectual property rights considerations and ensure responsible use of academic content. The primary concern is that commercial deals should not jeopardize the integrity or accessibility of scholarly work. **The looming data drought in AI development** As AI systems, particularly large language models (LLMs), continue to grow, their insatiable hunger for data has led to an unprecedented consumption of available online text. This trend is pushing the limits of the internet’s text resources, with a striking projection suggesting that by 2028, AI models may exhaust the stock of public online text available for training purposes. Data scarcity is real for a system that [constantly needs data](https://www.nature.com/articles/d41586-024-03990-2) to fuel growth and intelligence, a pivotal challenge facing the AI research community. Content providers, wary of unauthorized use, are tightening restrictions on how their data can be accessed and used. Major news outlets like The New York Times have initiated [legal actions against AI](https://interestingengineering.com/culture/openai-hits-back-at-new-york-times-lawsuit) companies, advocating for compensation and tighter control over their intellectual property. These developments indicate a shift in the ‘data commons,’ where freely available resources are becoming more guarded and access more contested. In response to these constraints, AI developers are exploring alternative strategies. Leading AI firms, including OpenAI and Anthropic, acknowledge the issue while investing in innovative solutions to circumvent potential data shortages. These strategies include forming partnerships to access non-public data, generate synthetic data, and tap into unconventional data sources that have not been traditionally utilized for AI training. This includes scholarly articles and academic data. These adaptive measures are crucial for sustaining the pace of AI advancement and navigating complex copyright laws and ethical considerations. This scenario presents a dual challenge and opportunity for the scholarly community. On one hand, the tightening of data access could inhibit the free exchange of knowledge and complicate academic research. On the other hand, it offers a chance for academia to redefine its role in the AI ecosystem and potentially lead the way in creating and curating high-quality datasets that respect both copyright and ethical standards, thereby contributing to [responsible AI development](https://interestingengineering.com/culture/chatgpt-gets-ethical-nod-from-g7). **The Generative AI Licensing Agreement Tracker** In response to the growing trend of licensing agreements, Roger Schonfeld and his colleagues at Ithaka S+R, a consulting service focusing on higher education, initiated the Generative [AI Licensing Agreement Tracker](https://sr.ithaka.org/our-work/generative-ai-licensing-agreement-tracker/). Schonfeld observed, “We were seeing announcements of these deals, and we got to thinking that this is starting to become a pattern.” The tracker primarily aims to enhance transparency and is a crucial resource for the academic community. It sheds light on the nature and scope of these deals, catalogs individual agreements, and sketches a broader pattern within the industry by documenting both confirmed and forthcoming deals between major academic publishers and technology firms. **Publishers’ strategic decisions in AI licensing** While entities like Wiley and Taylor & Francis have rapidly adapted to and embraced the opportunities presented by AI technology, others show more caution. In contrast, the American Association for the Advancement of Science (AAAS), a non-profit academic publisher that publishes the journal *Science*, has adopted a more responsible stance. Meagan Phelan, communications director for the Science family of journals, indicated that AAAS might consider licensing its content to technology companies if they meet certain criteria, assessing the firm’s trustworthiness and the usefulness of the tools created with the content. These differing approaches highlight the strategic dilemmas facing publishers. The decision to enter into AI licensing deals involves weighing potential revenue against the risks of losing control over the use of scholarly content. The health of the scholarly ecosystem depends on [balancing intellectual property](https://interestingengineering.com/science/balancing-data-and-human-knowledge-could-fuel-scientist-like-ai) rights with open access while factoring in the possibility of replication. Publishers must balance innovation and profit with ethical responsibility. **Authorship and ownership in the age of AI** Integrating AI into scholarly publishing has provoked mixed reactions from authors whose works are central to these licensing deals. While some authors are supportive, viewing these partnerships as opportunities to amplify the reach and impact of their research, others remain skeptical or even unaware of the implications these agreements may have on their work. Concerns mainly revolve around the control over their [intellectual property](https://interestingengineering.com/innovation/new-exhibition-explores-whether-ai-robots-should-own-intellectual-property) and the potential misuse of their scholarly content. To address these concerns and ensure that authors are not left in the dark, some publishers have implemented various strategies for involving authors in the licensing process. For instance, Cambridge University Press & Assessment (CUPA) has adopted an opt-in approach, actively reaching out to around 20,000 authors for permission before licensing their content to technology companies developing LLMs.

(this gives funding for unis to innovate as well)

#### Otherwise, a slowdown in innovation makes us vulnerable to extinction

**William MacAskill, 2022.** William MacAskill is a philosopher and professor at the University of Oxford, known for his work on effective altruism and longtermism. His writing explores ethics, economics, and the moral responsibilities of future generations. *What We Owe the Future* discusses the long-term impact of present-day decisions. **"Chapter 5: Are We at the Beginning of History?"** Basic Books, https://www.basicbooks.com/titles/william-macaskill/what-we-owe-the-future/9781541618633/. **Doa:3/6/25**

What is different about the **modern growth** era is that technological progress and economic growth have been sustained to reach much greater heights. With the Industrial Revolution, the world moved to unprecedentedly rapid rates of growth and technological progress, which continue to this day. But will this continue? In Chapter 4, we saw that there was a case for thinking that, by automating the process of technological innovation, artificial intelligence could bring about even faster technological progress than we’ve seen to date. In this chapter we’ll consider the opposite possibility. Perhaps future historians will look back on our era just as a really big efflorescence that, like other efflorescences before us, was followed by stagnation. My concern here is not just with a **slowdown in innovation** but with a near halt to growth and a plateauing of technological advancement. Though indefinite stagnation seems unlikely to me, it seems entirely plausible that we could stagnate for hundreds or thousands of years—a sort of civilisational interregnum. That would be of great longtermist importance for two reasons. First, the society that emerges from the interregnum might be guided by very different values than society today. Second, and more clearly, **a period of stagnation could increase the risks of extinction and permanent collapse.** To see this second point, consider what would have happened if we had plateaued at 1920s technology. We would have been stuck relying on fossil fuels. Without innovations in green technology, we would have kept emitting an enormous amount of carbon dioxide. Not only would we have been unable to stop climate change, but we would also have simply run out of coal, oil, and gas eventually. The 1920s’ level of technological advancement was unsustainable. **It’s only with the technological progress of the last hundred years that we have the capability to transition away from fossil fuels.** Our next level of technological advancement might be unsustainable, too. **We could face easy-to-manufacture pathogens and other potent means of destruction without sufficient technology to defend against them**. There would be a **constant risk of a civilisation-ending catastrophe**. If we stayed stuck at this unsustainable level for long enough, such a catastrophe would be essentially **inevitable.** To safeguard civilisation, we therefore need to make sure we get beyond that unsustainable level and reach a point where we have **the technology to effectively defend against such catastrophic risks.** The idea of sustainability is often associated with trying to slow down economic growth. But if a given level of technological advancement is unsustainable, then that is not an option. We may be like a climber scaling a sheer cliff face with no ropes or harness, with a significant risk of falling. In such a situation, **staying still is no solution**; that would just wear us out, and we would fall eventually. Instead, we need to keep on climbing: only once we have reached the summit will we be safe.9

### C2: Antimicrobial Resistance

#### AMR is becoming a globally pervasive issue

**Guang-Yu Liu et. al 24**, Guang-Yu Liu, Dan Yu, Mei-Mei Fan, Xu Zhang, Ze-Yu Jin, Christoph Tang & Xiao-Fen Liu, Guang-Yu Liu is an assistant director of product and solution and has a degree from the National University of Singapore, 1-22-2024, "Antimicrobial resistance crisis: could artificial intelligence be the solution?", SpringerLink, <https://link.springer.com/article/10.1186/s40779-024-00510-1#Sec26> // DOA: 2/9/2025 AT

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Download PDF Guang-Yu Liu, Dan Yu, Mei-Mei Fan, Xu Zhang, Ze-Yu Jin, Christoph Tang & Xiao-Fen Liu 13k Accesses 12 Citations 18 Altmetric 2 Mentions Explore all metrics Abstract Antimicrobial resistance is a global public health threat, and the World Health Organization (WHO) has announced a priority list of the most threatening pathogens against which novel antibiotics need to be developed. **The discovery and introduction of novel antibiotics are time-consuming and expensive**. According to WHO’s report of antibacterial agents in clinical development, only 18 novel antibiotics have been approved since 2014. Therefore, novel antibiotics are critically needed. Artificial intelligence (AI) has been rapidly applied to drug development since its recent technical breakthrough and has dramatically improved the efficiency of the discovery of novel antibiotics. Here, we first summarized recently marketed novel antibiotics, and antibiotic candidates in clinical development. In addition, we systematically reviewed the involvement of AI in antibacterial drug development and utilization, including small molecules, antimicrobial peptides, phage therapy, essential oils, as well as resistance mechanism prediction, and antibiotic stewardship. Similar content being viewed by others The role of artificial intelligence in the battle against antimicrobial-resistant bacteria Article 13 February 2021 Antibiotic Drug Development Methods Chapter © 2024 Harnessing Artificial Intelligence and Machine Learning in the Battle Against Antimicrobial-Resistant Infections Chapter © 2024 Explore related subjects Discover the latest articles, news and stories from top researchers in related subjects. Artificial Intelligence Background Antimicrobial resistance (AMR) is a natural phenomenon wherein microorganisms, including bacteria, viruses, fungi, and parasites, develop the ability to survive the drugs designed to kill them. The misuse and overuse of antibiotics in human medicine, animal agriculture, and the environment have accelerated the emergence and spread of AMR. This phenomenon renders once-effective treatments ineffective, leading to prolonged illnesses, increased mortality rates, and higher healthcare costs. Thus, AMR is a serious and foremost global threat to human health that requires practical actions urgently. The Global Antimicrobial Resistance and Use Surveillance System launched by the World Health Organization (WHO) revealed that AMR is on the rise and already a leading cause of death [1, 2]. Globally, it was estimated that, in 2019 alone, approximately 4.95 million deaths were linked to bacterial AMR, with 1.27 million deaths specifically attributed to bacterial AMR [1]. The highest all-age death rate due to resistance was observed in Western sub-Saharan Africa, with 27.3 deaths per 100,000 individuals (20.9–35.3) [1]. According to the data from the Centers for Disease Control and Prevention report, AMR to at least first-line antibiotics accounts for more than two million infections in the US alone each year and at least 23,000 deaths [3]. There were more than 2.8 million infections caused by antibiotic-resistant bacteria in the US in 2019 [4]. **It is estimated that AMR will cause 10 million deaths each year by 2050** [5]. The Infectious Disease Society of America has highlighted 6 pathogens including Enterococcus faecium, Staphylococcus aureus (S. aureus), Klebsiella pneumoniae (K. pneumoniae), Acinetobacter baumannii (A. baumannii), Pseudomonas aeruginosa (P. aeruginosa) and Enterobacter spp. as “ESKAPE” organisms, which pose the highest threat to human lives, owing to their fast-growing antibiotic resistance [6]. The WHO has published an antibiotic-resistant “priority pathogen” list to help drug developers target the pathogens that urgently need novel antibiotics. AMR has also become a public health concern in China. According to data from the Chinese Antimicrobial Surveillance Network, the resistance rate of carbapenem-resistant Gram-negative bacteria has shown a significant increase. Notably, carbapenem-resistant A. baumannii has risen from 39.0 to 71.9%, while carbapenem-resistant K. pneumonia has surged from 2.9 to 24.2% from 2005 to 2022 [7]. Additionally, methicillin-resistant S. aureus has been consistently detected at a high rate of approximately 30% in recent years (www.chinets.com) [7]. The number of novel antibiotics developed and approved has gradually decreased over the past decade, with only 4 novel antibiotics approved between 2010 and 2014 [8], resulting in limited treatment options for antibiotic-resistant bacterial infections in clinics. Historically, antibiotics were mostly discovered by screening secondary metabolites with antibacterial activities from soil microbes [9]. Unfortunately, the discovery of novel antibiotics is becoming increasingly difficult due to the rediscovery problem where identical compounds were isolated repeatedly [10]. **Thus, new drug development is insufficient to meet the demands of clinical treatment**, especially for those pathogens on the WHO priority list. Artificial intelligence (AI), a field of computer science, refers to the development of intelligent machines capable of executing tasks typically requiring human-like intelligence in an objective fashion [11]. AI technologies present innovative approaches and have increasingly integrated into a wide range of disciplines to accelerate scientific discoveries, especially in medicine where AI has empowered the discovery of novel drugs and expedited the overall drug development and clinical research process [12,13,14]. Without exceptions, AI has constituted a central part of concerted interdisciplinary efforts to tackle the crisis of AMR [15]. In this review, we will discuss the progress and challenges of antibacterial drugs in clinical and preclinical development, as well as novel AI-based methodologies in antibacterial drug development, with a particular focus on new drug design, structure optimization, and exploration of new mechanisms of action (MOA).

#### GAI has been used by Stanford researchers to develop drugs against AMR.

Rachel **Tompa**, 3-28-20**24**, Rachel Tompa is an award-winning science and health writer, editor, and podcaster. A molecular biologist turned writer, she's been telling science stories since 2007, "Generative AI develops potential new drugs for antibiotic-resistant bacteria", News Center, <https://med.stanford.edu/news/all-news/2024/03/ai-drug-development.html> // DOA: 2/4/24 AT

With nearly 5 million deaths linked to antibiotic resistance globally every year, new ways to combat resistant bacterial strains are urgently needed. **Researchers at Stanford Medicine and McMaster University** are tackling this problem with **generative artificial intelligence. A new model, dubbed SyntheMol** (for synthesizing molecules), **created structures and chemical recipes for six novel drugs aimed at killing resistant strains of Acinetobacter baumannii**, **one of the leading pathogens responsible for antibacterial resistance-related deaths**. The researchers described their model and experimental validation of these new compounds in a study published March 22 in the journal Nature Machine Intelligence. "There's a huge public health need to develop new antibiotics quickly," said James Zou, PhD, an associate professor of biomedical data science and co-senior author on the study. "Our hypothesis was that there are a lot of potential molecules out there that could be effective drugs, but we haven't made or tested them yet. That's why we wanted to use AI to design entirely new molecules that have never been seen in nature." Before the advent of generative AI, the same type of artificial intelligence technology that underlies large language models like ChatGPT, researchers had taken different computational approaches to antibiotic development. They used algorithms to scroll through existing drug libraries, identifying those compounds most likely to act against a given pathogen. This technique, which sifted through 100 million known compounds, yielded results but just scratched the surface in finding all the chemical compounds that could have antibacterial properties. testKyle Swanson "Chemical space is gigantic," said Kyle Swanson, a Stanford computational science doctoral student and co-lead author on the study. "People have estimated that there are close to 1060 possible drug-like molecules. So, 100 million is nowhere close to covering that entire space." Hallucinating for drug development Generative AI's tendency to "hallucinate," or make up responses out of whole cloth, could be a boon when it comes to drug discovery, but previous attempts to generate new drugs with this kind of AI resulted in compounds that would be impossible to make in the real world, Swanson said. The researchers needed to put guardrails around SyntheMol's activity - namely, to ensure that any molecules the model dreamed up could be synthesized in a lab. "We've approached this problem by trying to bridge that gap between computational work and wet lab validation," Swanson said. The model was trained to construct potential drugs using a library of more than 130,000 molecular building blocks and a set of validated chemical reactions. **It generated not only the final compound but also the steps it took with those building blocks, giving the researchers a set of recipes to produce the drugs.** The researchers also trained the model on existing data of different chemicals' antibacterial activity against A. baumannii. **With these guidelines and its building block starting set, SyntheMol generated around 25,000 possible antibiotics and the recipes to make them in less than nine hours.** **To prevent the bacteria from quickly developing resistance to the new compounds, researchers then filtered the generated compounds to only those that were dissimilar from existing compounds.** testJames Zou "Now we have not just entirely new molecules but also explicit instructions for how to make those molecules," Zou said. A new chemical space The researchers chose the 70 compounds with the highest potential to kill the bacterium and worked with the Ukrainian chemical company Enamine to synthesize them. **The company was able to efficiently generate 58 of these compounds, six of which killed a resistant strain of A. baumannii when researchers tested them in the lab**. These new compounds also showed antibacterial activity against other kinds of infectious bacteria prone to antibiotic resistance, including E. coli, Klebsiella pneumoniae and MRSA. The scientists were able to further test two of the six compounds for toxicity in mice, as the other four didn't dissolve in water. The two they tested seemed safe; the next step is to test the drugs in mice infected with A. baumannii to see if they work in a living body, Zou said. The six compounds are vastly different from each other and from existing antibiotics. The researchers don't know how their antibacterial properties work at the molecular level, **but exploring those details could yield general principles relevant to other antibiotic development.** "This AI is really designing and teaching us about this entirely new part of the chemical space that humans just haven't explored before," Zou said. **Zou and Swanson are also refining SyntheMol and broadening its reach. They're collaborating with other research groups to use the model for drug discovery for heart disease and to create new fluorescent molecules for laboratory research.** The study was funded by the Weston Family Foundation, the David Braley Centre for Antibiotic Discovery, the Canadian Institutes of Health Research, M. and M. Heersink, the Chan-Zuckerberg Biohub, and the Knight-Hennessy scholarship.

#### In medical research it can prevent resistance in the first place

[Francesco **Branda**](https://pubmed.ncbi.nlm.nih.gov/?term=%22Branda%20F%22%5BAuthor%5D) **and** [Fabio **Scarpa**](https://pubmed.ncbi.nlm.nih.gov/?term=%22Scarpa%20F%22%5BAuthor%5D), 5-29-20**24**, PhD in Information and Communication Technologies, 2023University of Calabria M.Sc. in Computer Engineering, 2019 University of Calabria B.Sc. in Computer Engineering, 2016 University of Calabria,"Implications of Artificial Intelligence in Addressing Antimicrobial Resistance: Innovations, Global Challenges, and Healthcare’s Future", PubMed Central (PMC), <https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/> doa:3/6/25 as

8. Discussion Antimicrobial resistance represents one of the greatest threats to global public health. This complex phenomenon is due to a combination of biological factors intrinsic to bacteria, such as genetic mutation, as well as external factors related to the misuse of antibiotics in medical, veterinary, and agricultural settings. The rapid and adaptive evolution of pathogens requires a multidisciplinary approach to effectively counter this crisis. The integration of AI in the fight against antimicrobial resistance presents a promising and innovative solution. AI can contribute significantly in several areas: 1. Genomic analysis: AI can accelerate the analysis of genomic data to identify resistance markers early on, thereby improving surveillance and monitoring of resistant infections. This enables timely and targeted interventions. For example, the use of machine learning algorithms to analyze genomic sequences can help to quickly identify specific mutations associated with antibiotic resistance. Such tools can be integrated into clinical microbiology laboratories to provide faster results than traditional methods, allowing clinicians to intervene earlier. 2. Optimizing antibiotic use: AI-based decision support systems can guide clinicians in choosing the most appropriate antibiotics, reducing inappropriate use and minimizing the risk of resistance development. This can significantly improve clinical management of infections. For example, the implementation of a CDSS can help to analyze real-time patient data and microbiological information in order to suggest the most effective therapies while taking into account clinical history and local patterns of resistance. In addition, such systems can be continuously updated with newly collected data to improve their recommendations over time. 3. Discovery of new antibacterial agents: AI facilitates the discovery and design of new antibacterial drugs through predictive modeling and computational simulation, accelerating the drug development process and potentially reducing associated costs. Using deep learning techniques, large libraries of chemical compounds can be analyzed to identify those with potential antibacterial activity. These approaches can also predict the likelihood of success of new drugs at later stages of development, thereby reducing the risks and costs associated with pharmaceutical research and development. 4. AI-controlled delivery and action of antibiotics: AI technologies are increasingly being used to improve the delivery and efficacy of antibiotics. These advanced systems can optimize dosing regimens, improve drug targeting, and monitor patient responses in real time. Significant examples of antibiotics for which administration and action have been successfully managed by artificial intelligence systems include: - Optimizing vancomycin dosing with AI: Vancomycin is a key antibiotic for the treatment of serious infections caused by Gram-positive bacteria, including methicillin-resistant Staphylococcus aureus (MRSA). Traditional vancomycin dosing requires careful monitoring to avoid toxicity and ensure therapeutic efficacy. Several studies have shown how AI models can optimize vancomycin dosing to improve efficacy and reduce the risk of toxicity. For example, an approach based on ensemble learning strategies has shown high accuracy and specificity in predicting initial and subsequent doses of vancomycin, making treatment safer and more effective [[63](https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/#B63-antibiotics-13-00502),[64](https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/#B64-antibiotics-13-00502)]. - AI-driven delivery of amikacin: Amikacin, an aminoglycoside antibiotic, is commonly used to treat severe Gram-negative infections. Its therapeutic window is narrow and requires precise dosing to avoid ototoxicity and nephrotoxicity. Artificial intelligence systems have been developed to monitor blood levels of amikacin in real time and adjust dosing accordingly. These artificial intelligence-driven delivery systems use pharmacokinetic and pharmacodynamic models to ensure that optimal drug concentrations are maintained, thereby improving treatment efficacy and safety. For example, Adbulla et al. [[65](https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/#B65-antibiotics-13-00502)] conducted a prospective evaluation of a model-based amikacin dosing regimen in infants which showed significant improvements in achieving target drug concentrations compared with traditional methods. Similarly, advances in biosensor technology have enabled real-time monitoring and dose adjustment of antibiotics such as amikacin, leading to improved outcomes in the treatment of critically ill patients [[66](https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/#B66-antibiotics-13-00502),[67](https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/#B67-antibiotics-13-00502)]. - AI-driven targeted delivery of colistin: Colistin is an antibiotic of last resort for multidrug-resistant Gram-negative bacterial infections; however, its use is limited by significant nephrotoxicity. Researchers have employed artificial intelligence to develop targeted colistin delivery systems, such as nanoparticle-based delivery vehicles, that can be targeted to the site of infection. Artificial intelligence algorithms can optimize the design and release profiles of these nanoparticles to maximize therapeutic effects and minimize systemic toxicity. Early studies indicate that AI-guided targeted delivery significantly reduces adverse effects and improves treatment outcomes. For example, silver nanoparticles conjugated to colistin (Col-AgNPs) have shown enhanced antimicrobial activity and reduced toxicity compared to colistin alone, demonstrating the potential of AI-optimized nanoparticle systems for improving the colistin therapeutic index [[68](https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/#B68-antibiotics-13-00502)]. - AI-personalized antibiotic regimens: AI can help to personalize antibiotic regimens by analyzing large amounts of patient data, including genetic information, aiding in the prediction of individual responses to different antibiotics. For example, Zagajewski et al. [[69](https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/#B69-antibiotics-13-00502)] have demonstrated the use of AI to detect antibiotic resistance and tailor treatments accordingly. This study highlighted rapid detection capabilities and the potential for personalized antibiotic regimens, particularly with ciprofloxacin, showcasing how AI can revolutionize treatment strategies to combat antibiotic resistance. Weaver et al. [[70](https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/#B70-antibiotics-13-00502)] focused on using reinforcement learning to develop optimal treatment strategies that limit antibiotic resistance. Personalized approaches for various antibiotics, including ciprofloxacin and azithromycin, formed part of their research. A study on personalized dosing of antibiotics at the bedside for severe sepsis and septic shock included ciprofloxacin among the tested antibiotics. Artificial intelligence systems based on pharmacokinetic models were used to optimize dosing, demonstrating potential for improved efficacy and safety in antibiotic administration [[71](https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/#B71-antibiotics-13-00502)]. Despite significant progress, there are still critical challenges facing the effective implementation of AI in the fight against AMR. One major challenge is the availability of high-quality, properly annotated, and standardized data. In order to develop accurate and reliable machine learning models, it is critical to have large amounts of data representing a wide range of clinical and biological scenarios. However, data from different sources often vary in terms of format, annotation, and quality. This heterogeneity can compromise the performance and generalizability of AI models. Standardizing data and creating centralized repositories with high-quality data are key steps towards improving the effectiveness of AI algorithms in the medical field. Another significant obstacle is ensuring the interpretability and transparency of AI models. Many machine learning algorithms, particularly those based on deep neural networks, are often described as black boxes, as their decisions are difficult to understand and explain. This lack of transparency can create mistrust among healthcare providers and patients, hindering large-scale adoption of these technologies. It is essential that researchers and AI developers adopt explainability practices, such as using interpretable models and implementing post hoc interpretation techniques, to make their algorithms more transparent. Techniques such as LIME (Local Interpretable Model-agnostic Explanations) and SHAP (SHapley Additive exPlanations) [[72](https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/#B72-antibiotics-13-00502)] can help to explain the predictions of complex models by providing insights into which features most influenced a particular decision. In addition, transparency is critical to ensure that AI models are used ethically and responsibly. Algorithms must be designed to avoid bias and discrimination, which can occur if the training data are not representative of the population or contain bias. Ongoing evaluation and independent validation of AI models are necessary to ensure that they work properly in different populations and clinical settings. Finally, it is important to consider the regulatory and legal aspects of AI use in healthcare. Regulators need to establish clear guidelines for the approval and oversight of AI systems to ensure that they meet standards of safety, efficacy, and privacy. Collaboration among AI developers, healthcare providers, and regulators is essential in order to create an environment of trust and security that facilitates the adoption of AI technologies in the fight against AMR. Looking forward, the integration of AI with other emerging technologies, such as synthetic biology and nanomedicine, could open up new perspectives in the fight against antimicrobial resistance. For example, AI-based intelligent drug delivery systems could improve the efficacy of antibiotic treatments while reducing the risk of side effects and the development of resistance. In addition, the application of AI to computational epidemiology and predictive modeling could make it possible to anticipate the emergence of new forms of resistance, thereby promoting large-scale prevention and containment strategies. International collaboration is essential to addressing the global challenges of antimicrobial resistance. Sharing data, resources, and knowledge across institutions and countries can improve the effectiveness of AI-based interventions and accelerate progress in combating AMR. In this context, global initiatives such as establishing research consortia and promoting international standards for data collection and analysis can play a key role in overcoming both current and future challenges.

#### AMR causes extinction

**Silverman ’16** (Rachel Silverman – MPhil with Distinction in Public Health @ the University of Cambridge, Senior Policy Analyst and Assistant Director of Global Health Policy @ the Center for Global Development, focusing on global health financing and incentive structures, “Confronting Antimicrobial Resistance: Can We Get to Collective Action?” 19 April 2016, )<https://www.cgdev.org/blog/confronting-antimicrobial-resistance-can-we-get-collective-action> //doa 02/11/25 AT

Antimicrobial resistance is already causing huge harm – and the worst is yet to come. To open the panel, Dr. Chan issued a serious warning about the size and scope of the AMR threat: “everyone will be affected if we do not address this problem.” AMR is already responsible for an estimated **700,000** **global** **deaths each year**, 50,000 of which take place in the US and Europe. Extensively drug-resistant (XDR) tuberculosis—cases where the most effective first- and second-line drugs are rendered useless—infected an estimated 47,000 people worldwide in 2014, only one ‘last-line’ antimicrobial is available to reliably treat gonorrhea, and few new antimicrobial drugs are in the development pipeline. According to the latest review, **AMR could cause 10 million** **deaths** **each year by 2050**, with **knock-on effects** draining many **trillions from the** **global** **economy**. Summers suggested that AMR and potential pandemics, alongside climate change and nuclear proliferation, represent the top three **existential threats to life on earth** as we know it. And as Dr. Chan explained, the worst-case scenario implies **the end of modern medicine** as we know it. Even worse, Summers suggested that AMR seems like a “**quintessential** **non-linear** **phenomenon**, and therefore more dangerous.” Year by year the effects are small and **mostly** **invisible**. But at some point in the future they could **suddenly become catastrophic**, like a “levee that doesn’t hold and unleashes a flood.” Dr. Chan concurred that “**the tipping point is not predictable** because…microbes are invisible. We don’t even know when they’re going to make the switch” to become resistant to existing drugs. Antimicrobial efficacy is a global public good threatened by serious market failures. In response to this huge threat, why don’t pharmaceutical companies invest in new antibiotics? “It does not pay” for them to do so, explained Osborne. Pharmaceutical companies want to invest in technologies that will make a lot of money, and soon; so long **as other** antibiotic**s** **remain** effective, the market for new options will be tiny and unprofitable.

#### AMR is an existential risk multiplier

Maxine **Builder 14**, Research Associate for the Council on Foreign Relations' Global Health Program, “Antimicrobial Resistance as an Emerging Threat to National Security,” The Atlantic Council, December 2014, https://www.atlanticcouncil.org/images/files/Antimicrobial\_Resistance\_as\_an\_Emerging\_Threat\_to\_National\_Security.pdf

At this point, AMR does not pose an immediate and direct threat to national security, but without an **effective and swift response** to the growing problem of AMR, the situation will continue to **deteriorate on a global scale**. This is a **creeping national security crisis**, and underestimates of the problem now may lead to **disaster in the near future**. If current trends continue, the drugs will lose effectiveness. The gains made in fighting infectious diseases **will be reversed,** and a wide range of routine surgeries and easily treatable infections will become much more dangerous and deadly. This will cause the **health of the world’s working population** to **deteriorate** and the **economic productivity** and social cohesion of the globe **to decline**. At any time**,** **a “black swan**” event, triggered by an outbreak of drug-resistant tuberculosis, cholera, or pneumonia, for example, could **prove catastrophic**, endangering the **fabric of societies** and our **globalized economy**, **forcing a halt to international trade** and travel to prevent further spread.As demonstrated by the rapid spread of NDM-1, current trends of international trade and travel are **exacerbating the spread of resistance**, and conflict and displacement of populations only hasten the process. The current conflict in Syria has caused the displacement of millions of people, and preventable communicable diseases, such as cholera and even polio, have run rampant in these populations, crossing borders quickly and often unnoticed. These diseases are neither being treated nor prevented because of a lack of resources and access to proper drugs, in spite of the technical ability to prevent and effectively treat these diseases. If the diseases circulating in these refugee communities become drug-resistant, it could lead to even **higher mortality rates** among this **already vulnerable population**, and it is more than likely that these resistant genes and strains will appear **in the broader population**, at which point the issue becomes more than one of public health, but **also one of development** **and foreign affairs.**Concern about the threat of AMR to US national security has lead the US Department of Health and Human Services (HHS) to fund development of a new drug to address two antibiotic-resistant infections linked to **bioterrorism threats**. HHS announced in February 2014 that a publicprivate partnership will advance the development of Carbavance, a new option to treat bioterrorism threats and antibiotic-resistant infections. Carbavance will address melioidosis, also known as Whitmore’s disease, and glanders–both of which are bacterial infections and can therefore become resistant to existing antibiotics. Already, approximately **40 percent** of people who contract these bacteria **will die**, and **up to 90 percent** of those infected **will die** **if not treated.** “Antibiotic resistance **adversely impacts** our nation’s ability to **respond effectively to a bioterrorism attack** and to everyday public health threats,” said Dr. Robin Robinson, director of the Office of the Assistant for Preparedness and Response’s Biomedical Advanced Research Development Authority, which will oversee the project. “By partnering with industry to develop novel antimicrobial drugs against biothreats that also treat drug-resistant bacteria, we can address health security and public health needs efficiently.”67

# Rebuttal

## Constructive

Dean Dara N. Byrne, Phd, Macaulay Honors College Of The City University Of New York, 9-20-23, "Using AI to help more college students graduate", Google Public Policy, <https://publicpolicy.google/article/ai-helping-college-students-graduate/> DOA:2/19/25 SLK

When I started as Undergraduate Dean of John Jay College, our senior graduation rate was 54%. I knew we could do better for our students. John Jay serves many first generation Americans and nontraditional students. Many are working while studying, some are parents and the main source of income for their families, and have taken different paths to their degrees. We understand that they are dealing with competing priorities in a way that the traditional undergraduate student is not, which often means that many students are unable to complete their degrees on time. Excited John Jay College student dressed up in cap and gown, standing in auditorium at graduation ceremony 01:23 DataKind built an AI model with John Jay College to identify college students most at risk of dropping out To address this problem, we **partnered with DataKind**, a nonprofit that works to tackle the world’s toughest challenges using data science. For two years, we collaborated on a predictive Artificial Intelligence (AI) model to identify students most at risk of dropping out. We looked at indicators including years of enrollment, grades, and number of hours passed to create a risk score for every student, while controlling for bias. **Students identified as high risk of dropping out received extra, proactive support from advisors such as one-on-one coaching.** Hundreds of students benefited from this program, which ultimately drove the College’s senior graduation rate up to 86%. **In two years, the graduation rate for seniors at John Jay College rose from 54% to 86%, with help from AI** In 2021, Google.org gave Datakind a grant to help expand the model to transfer students, a group of students who are at higher risk of not completing their education. I'm proud to announce they are reinvesting in this work. **With this new grant funding from Google.org, Datakind will continue the work to scale our AI-powered intervention program to 6 additional CUNY campuses, and build a roadmap for any school across the US to replicate our success.** Here are my 4 lessons from this experience 1. Earn trust by co-creating the solution During the building process I dedicated as much of my time toward getting to know the tool as I sought feedback from the community that would be impacted by it. This meant **prioritizing conversations with students, academic advisors, and other administrators and faculty and answering questions about the ethical use of a predictive model to support student success.** This transparency and collaboration with our community made space for the culture shifts that we needed to successfully integrate with AI. 2. Start small, dream big **Starting with one college within the CUNY system gave us time to iterate and ensure we got the model right. We had the time to bring the right historical data to the table and to keep a laser focus on results, while closely monitoring for risks like bias in the mode**l. As our focus shifts towards scaling this impact beyond John Jay College and CUNY, we’re able to share the questions we asked ourselves, and encourage others to be ambitious in the goals they set for their own students’ success. 3**. AI amplifies the impact of our academic advisors, it doesn’t replace them** AI has the potential to simultaneously deepen and scale the institutional capacity for care of our students. Each year, John Jay’s academic advisors are assigned upwards of 750 students. The AI model helps identify the ~200 students who could benefit most from a bit of extra support to succeed and make informed decisions about where and how to deploy our limited resources, including the time of advisors. 4. Sharing benefits to all learners The biggest **barrier to scale is often cost**, **particularly for smaller institutions or those with limited funding**. We’re often scraping together a patchwork of solutions. Support from Google.org and organizations like DataKind, not only helps make innovation more accessible, but it also unlocks the potential to scale our impact. The playbook we’re developing to share our learnings will ensure that these learnings not only benefit students at CUNY, but also help students across the country as well. When you bring data and AI into the mix, you reshape the fundamental way that institutions see these students. The data itself can’t tell us who these students are. But what it can do is tell us a story about their barriers and reveal pathways to unlock their success. This project has fundamentally reshaped how I think about building a culture of belonging – informed by data, and powered by community.

Nirit **Cohen**, 9-22-20**24**, Nirit Cohen is a leading HR strategist and thought leader on the Future of Work. With 30 years of global experience at Intel in senior leadership roles across HR and M&A, she bridges emerging trends with practical solutions to help organizations navigate the complexities of the evolving world of work. Nirit holds a master’s degree in Economics, specializing in Technology Policy and Innovation Management. For over a decade, she has written a widely read weekly column on the Future of Work and authored a book on career management in a changing world. Her expertise in workforce transformation, combined with leadership across multiple disciplines, makes her a sought-after speaker and consultant. Follow Nirit for insights into the trends shaping the Future of Work, their impact on workforce transformation, and strategies to future-proof organizations and careers. "Generative AI In Classrooms: Cheating Or The Future Of Education?", Forbes, <https://www.forbes.com/sites/niritcohen/2024/09/22/generative-ai-in-classrooms/> doa:2/12/25 as

If students are using generative AI in their school or academic work, is it considered cheating? A decade ago, the concern was about students "copy-pasting" content from the web. Now, the worry is that they’re letting AI write their assignments, raising concerns about AI plagiarism and leading to the rise of services like [Turnitin](https://www.turnitin.com/) to detect AI-generated text. But perhaps the problem isn’t with students adapting to new tools—it’s with the education system clinging to outdated ones. In the past, education was about teaching students the "right answers" to prepare them for a workforce that required specific skills. But the future world of work is different. We don’t know the right answers, and often, we don’t even know the right questions. What we do know is that students will work alongside technology, not apart from it. So today’s education system needs to evolve, helping students develop the skills to navigate an uncertain future using any tool at their disposal, including generative AI. **Generative AI: A Tool for Enhancing, Not Replacing, Learning** The rapid shift to remote learning during Covid exposed the vulnerabilities of traditional education models and highlighted the potential of digital tools. If students can learn effectively online, why shouldn’t they use generative AI to enhance their education? And it seems that they are. [Turnitin’s writing detector](https://www.turnitin.com/press/press-detail_17793) reviewed 200 million papers and found that only 3% have over 80% AI-written text, and 11% have 20% AI-written text. Additionally, nearly half of the students in their study have used generative AI tools regularly. This should be seen as a positive development, suggesting that the real challenge isn’t whether students use generative AI—it’s how they use it. Instead of viewing AI tools as a shortcut, we should see them as critical tools that reflect the skills students will need in their professional lives. Generative AI should be integrated into education as a way to deepen learning, not replace it. According to the [World Economic Forum](https://www.weforum.org/agenda/2024/04/future-learning-ai-revolutionizing-education-4-0/), the "Education 4.0" framework suggests that education systems must focus on fostering the skills that give humans a distinct advantage over machines to prepare students for the jobs of the future. Similarly, the U.S. [Department of Education](https://tech.ed.gov/ai-future-of-teaching-and-learning/) highlighted the need for curricula to include AI and digital literacy to prepare students for a workforce that will increasingly rely on these technologies. Just as professionals use AI to streamline tasks and generate insights, students can use it to explore complex topics and enhance their problem-solving abilities. The key is to ensure students are actively engaged in the learning process, using generative AI to assist their work, not do it for them. **Preparing Students for an AI-Driven Future** In the workplace, creativity, innovation, and risk-taking are essential for success. No one expects the next breakthrough to come solely from a well-crafted generative AI prompt, but if working with one sparks new ideas, it’s highly valued. We should adopt this same approach in classrooms. Rather than fearing that AI tools will stifle originality, we should focus on how they can foster it. Generative AI tools can generate ideas, but it’s up to students to critically evaluate, refine, and add their unique perspectives. Assignments should require creativity, critical thinking, and personal insight—things these tools cannot replicate. Similarly, AI offers platforms for experimentation and innovation. Today’s employees are expected to use new tools to simulate outcomes, explore scenarios, and push boundaries. Teaching these skills in the classroom is essential, as students will need to solve problems that don’t yet exist. Encouraging this mindset of exploration and curiosity is crucial for success in the future of work. Moreover, AI literacy, which current employees are picking up on the job, can be taught in schools, ensuring ethical technology use. By guiding students on responsible AI use—including understanding its strengths, limitations, and biases—educators can prepare them to navigate the ethical challenges they will face in the workforce, equipping them with critical digital literacy and an awareness of AI’s broader societal implications. **Evolving Education to Meet Tomorrow's Challenges** Just as managers must adapt their strategies in the workplace, educators must evolve what they teach, assign, measure, and evaluate. Instead of focusing on detecting and preventing generative AI use, the emphasis should be on designing AI-enhanced learning experiences. If a task can be fully completed by AI, it likely isn’t challenging enough to foster deep learning. Educators should create assignments that require human input—whether through critical analysis, creativity, or ethical reasoning—so AI serves as a tool for learning, not a replacement for intellectual effort. Ultimately, the role of education in the future of work is to provide a foundation for students to build their careers and lives. It must evolve to meet the demands of an unpredictable world where traditional answers are no longer sufficient. Generative AI should be viewed as a partner in education, helping students develop not only technical proficiency but also the critical thinking, problem-solving, and ethical decision-making skills needed in a rapidly changing world. By thoughtfully integrating generative AI into education, we can prepare students to thrive in an AI-driven future, ensuring they are not just consumers of technology but creators and innovators in their own right.

**Pham et al 24** Hoang Pham, Tanvi Kohli, Emily Olick Llano, Imani Nokuri, and Anya Weinstock. Hoang Pham is the Director of Education and Opportunity at the Stanford Center for Racial Justice at Stanford Law School, Tanvi Kohli is a first-year law student at Stanford with a BA in International Affairs from Washington University in St. Louis. Imani Nokuri is a student at Stanford Law School with a BA in Government and Politics from University of Maryland College Park. Emily Olick Llano is a masters student from Cambridge with a BA in psychology form Bowdoin College. Anya Weinstock has a JD from Stanford Law School. 6-29-2024, "How will AI Impact Racial Disparities in Education?", Stanford Center for Racial Justice at Stanford Law School, <https://law.stanford.edu/2024/06/29/how-will-ai-impact-racial-disparities-in-education/> DOA:2/14/25 SLK

**As AI usage in education expands, stakeholders should consider how AI tools can become more accessible**, particularly in rural and urban **communities that have larger populations of low-income students and students of color**. Several organizations are already working to address AI access **issues. For example, the Stanford Classroom-Ready Resources About AI For Teaching (CRAFT) is a co-design initiative combining the expertise of high school teachers with Stanford researchers and students to provide “free AI Literacy resources about AI for high school teachers, to help students explore, understand, question, and critique AI.” Programs like these can be particularly impactful for communities where technology access is especially low, such as the rural south.**