Generative AI and the Transformation of Scientific Research

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OECD Digital Education Outlook
OECD, 24 March 2026

Roadmap

1. Rapid diffusion of GenAI in science
2. A wide variety of use
3. From tools to research assistants and robot labs
4. Effects on creativity, reliability and publishing
5. Implications for education research

The chapter's arc:
from AI as a helper for text and code to AI as a potential co-pilot of the full research process.

1. Diffusion is already rapid

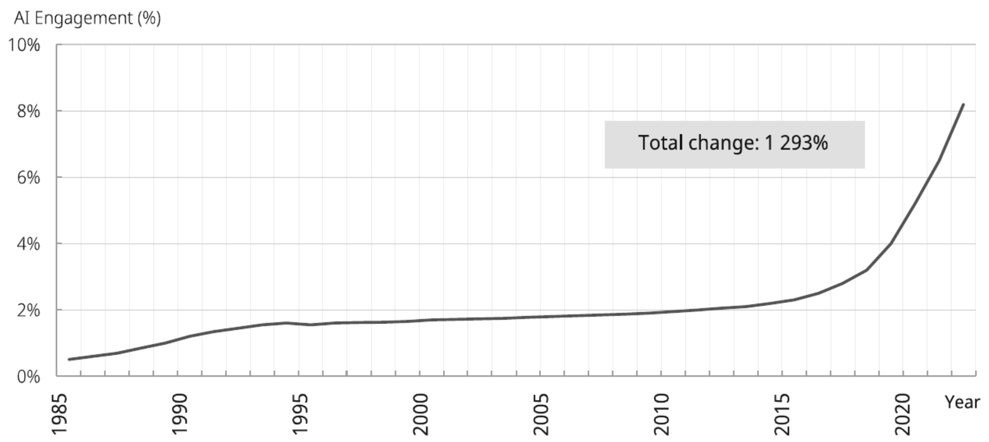
AI engagement in scientific publications rose from about 2% in 2015 to 8% in 2022 across fields.

For LLM-modified papers, growth accelerates sharply after ChatGPT's release.

A 2025 survey of 5,000 researchers suggests that more than half already use AI for manuscript preparation and error detection.

Adoption is uneven across disciplines, but language-related tasks are becoming mainstream.

Figure 13.1. Change in AI engagement across all scientific fields



Source: Duede, E., W. Dolan, A. Bauer, I. Foster and K. Lakhani, (2024[2]), Oil & Water? Diffusion of AI Within and Across Scientific Fields.

Interpretation

GenAI has moved beyond experimentation: it is becoming normal scientific infrastructure, especially for text-heavy and data-heavy tasks.

2. Four major families of use

Language tasks

editing, translating, summarising, drafting papers, peer review, grant writing

Programming & data

code generation, debugging, data cleaning, statistical analysis, visualisation

Specialised scientific models

protein folding, protein design, chemistry, maths, astrophysics, simulation

Research assistants & robot labs

literature review, hypotheses, experimental design, workflow orchestration, automated experiments

Overall trend: increasing cognitive power and increasing agency

3. Frontier examples show what specialised AI can do

AlphaFold: predicts protein structure and has reshaped structural biology and downstream drug discovery.

ESM3: generates proteins from sequence, structure and function prompts; some outputs are radically different from naturally occurring proteins.

Mathematics: systems such as AlphaProof and AlphaGeometry 2 reach impressive competition-level performance, though not yet research-level mathematics.

Astrophysics: AI-generated detector designs can outperform conventional human designs in sensitivity.

Takeaway

GenAI is strongest where search spaces are huge, data are abundant, and evaluation criteria can be made explicit.

Limits

These successes are domain-specific. Models can still make errors, be opaque, and require expert verification.

Why it matters

Scientific AI is not only about chatbots; it also includes specialised models embedded in research pipelines.

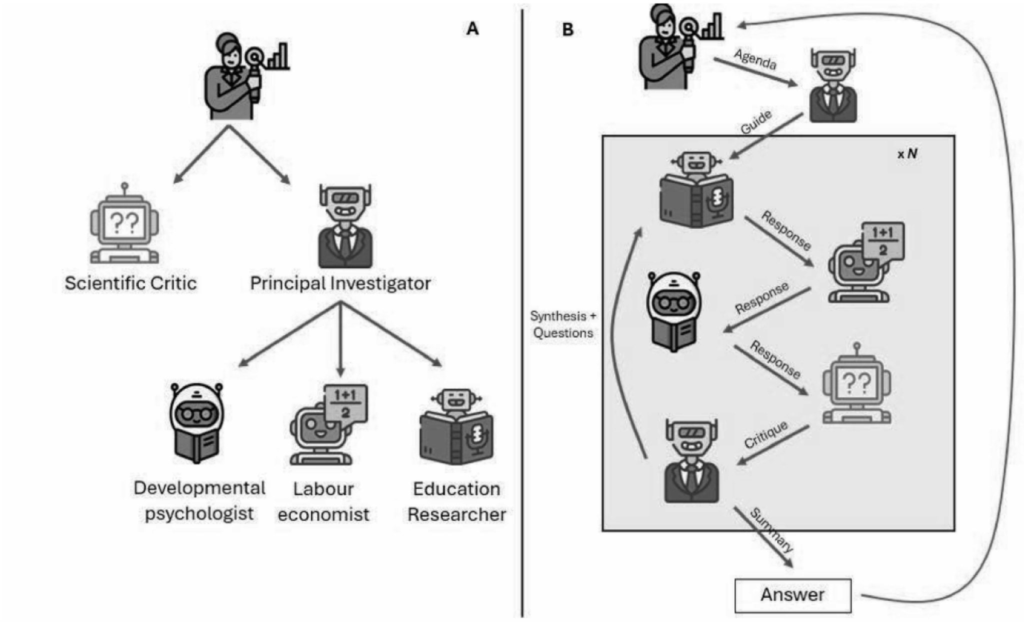
4. From tools to agentic research systems

AI research assistants now combine literature review, hypothesis generation, experiment design, coding and report drafting.

Multi-agent systems simulate teams with different expertise and a critic function.

Robot labs go one step further: AI designs experiments and controls equipment to run them.

Figure 13.4. A possible interdisciplinary Human-AI collaborative educational research model



Note: This imaginary case applies ideas of Box 13.2 to education research. In panel A, the human researcher provides a brief, for example on students' school rhythm, and requests a GenAI agent (principal investigator) to set us an interdisciplinary research team

Key shift

AI systems can now contribute to ideation and research planning.

5. Impact on scientific creativity: augmentation more than replacement

What AI can contribute

Large-scale recombination of existing knowledge

Search through vast idea spaces

Brainstorming and challenge to assumptions

Time savings that free researchers for higher-level thinking

Potential serendipity in chemistry, biology, materials science

What remains problematic

Limited extrapolation beyond training data

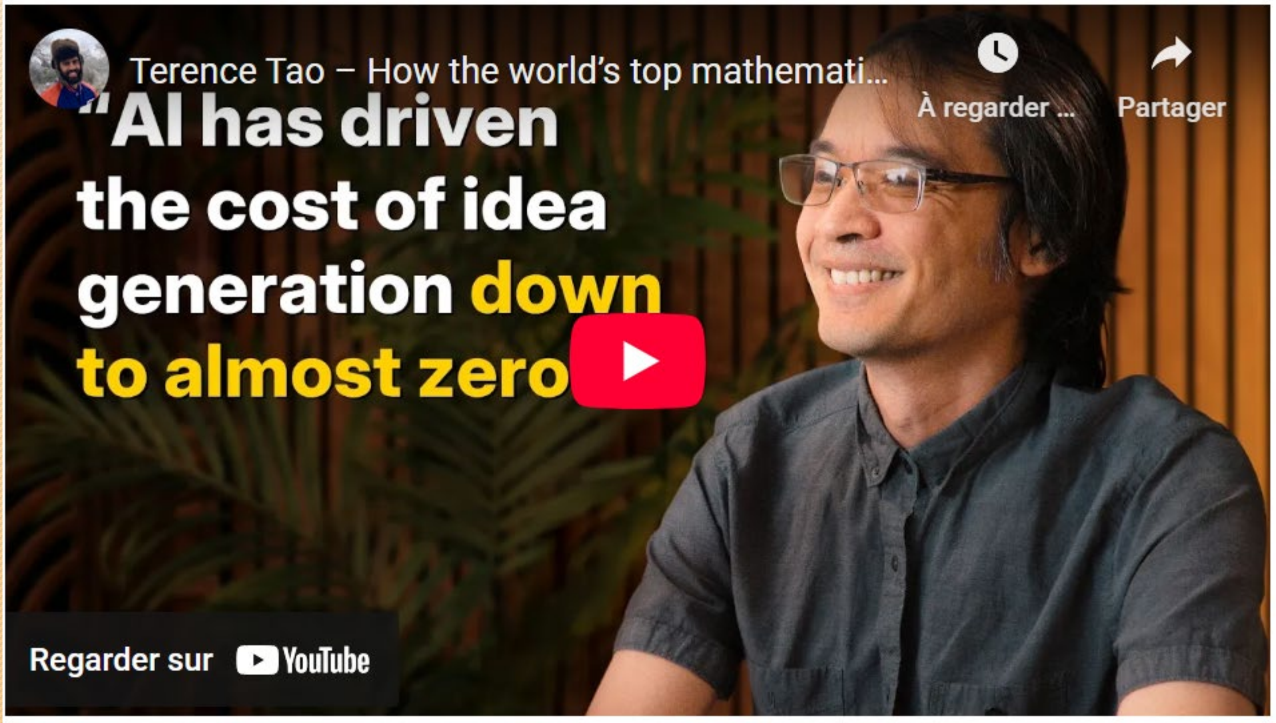
Weakness in deep reasoning and genuine understanding

Hallucinations are not creativity

Risk of over-reliance: ‘if writing is thinking’

Collective homogenisation as many researchers converge on similar topics

5. Impact on scientific creativity: augmentation more than replacement



The new bottleneck

"We're now in a situation where suddenly people can generate thousands of theories for a given scientific problem. Now we have to verify them, evaluate them."

6. Reliability, reproducibility and truthfulness remain core concerns

Hallucinations/confabulations: plausible but false statements or references.

Black-box models: training data and weights are often inaccessible, making validation difficult.

Randomness and model drift: the same prompt may yield different outputs over time.

Yet AI can also improve traceability, because systems can record and report each step they perform.

Technical risk
plausible but wrong outputs

Scientific risk
weaker reproducibility and explainability

Potential gain
better process traceability and documentation

Bottom line
Science can use GenAI, but cannot suspend its own norms of validation.

7. What this means for education research

Immediate uses are likely already widespread: writing, editing, programming, data analysis, literature review and reporting.

Education research could benefit from synthetic privacy-preserving datasets and from AI tools that explore large administrative or platform datasets.

Multi-agent systems may be especially useful for interdisciplinary and policy-oriented research.

Education research will also benefit indirectly from AI-enabled advances in psychology, neuroscience and cognitive science.

Caution

Successful AI-powered research is most likely to remain a human-supervised augmentation model, not a replacement model.

Capability gap

A new divide could emerge between AI experts with weak domain understanding and domain experts with weak AI literacy.

Policy implication

Training and lifelong learning in AI become central responsibilities for higher education and research systems.

THANK YOU

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