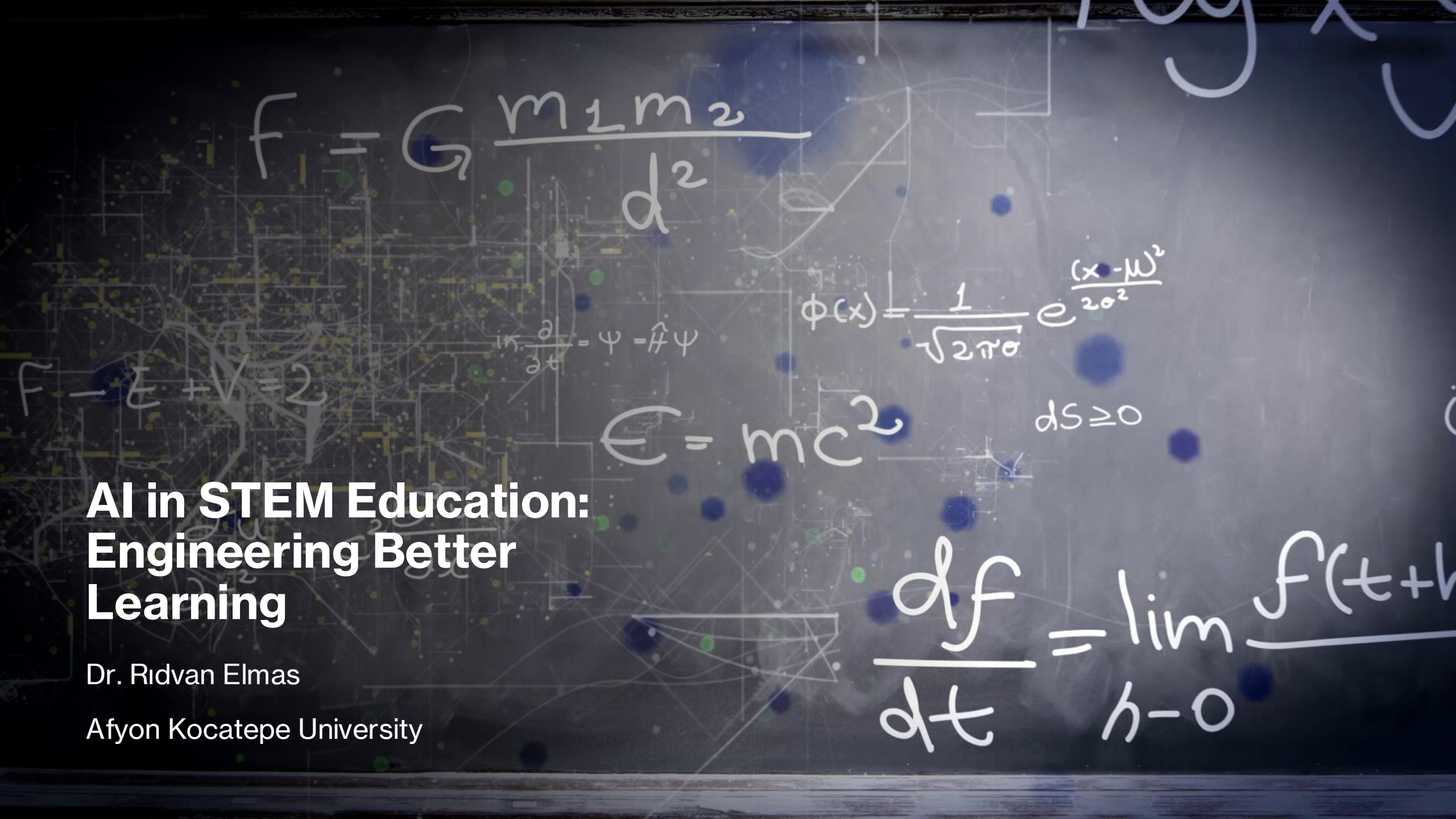


AI in STEM Education: Engineering Better Learning

Dr. Rıdvan Elmas

Afyon Kocatepe University

PART 1

AI is powerful, but it is insufficient as a tool by itself

Chatbots answer, but do not necessarily educate

AI Changed the Toolset - STEM Must Change the Learning Design

- **Access to AI is no longer the issue**
- **Meaningful use is the real challenge**
- **Pedagogy determines educational value**

Probable Potential Areas

- **AI-driven systems***

– such as adaptive learning platforms, intelligent tutoring systems, and automated assessment tools

– offer unprecedented opportunities to personalize instruction, boost student engagement, and narrow educational disparities.

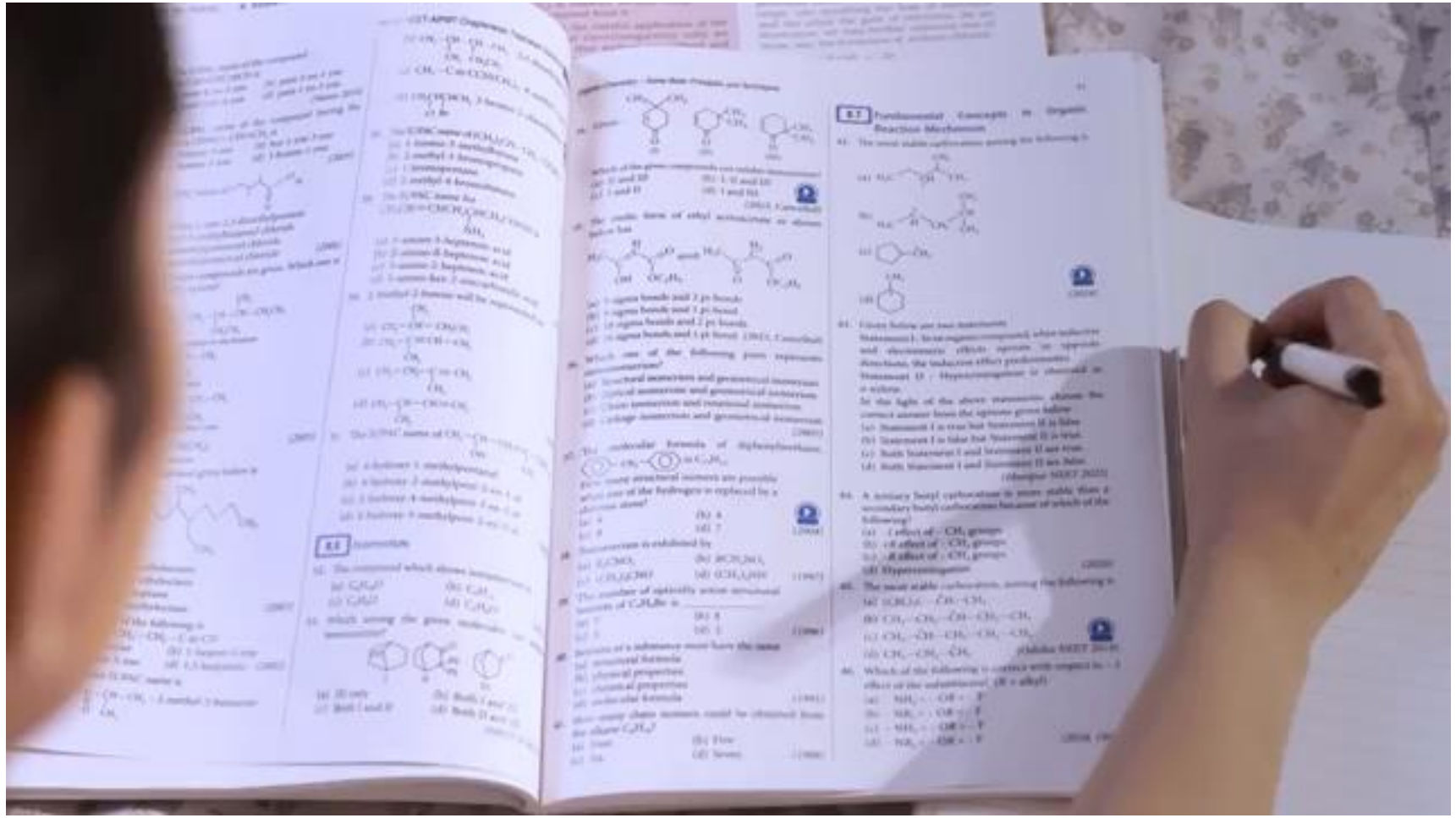
KHANMIGO by Khan Academy

CARNEGIE LEARNING

astra AI

*León, C., Lipuma, J., & Oviedo-Torres, X. (2025). Artificial intelligence in STEM education: A transdisciplinary framework for engagement and innovation. *Frontiers in Education, 10*, Article 1619888.https://doi.org/10.3389/feduc.2025.1619888

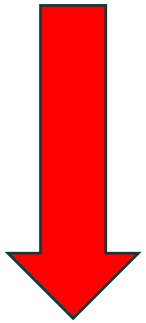
Potential of AI for Chemistry Education / Google Deep Mind Project Astra



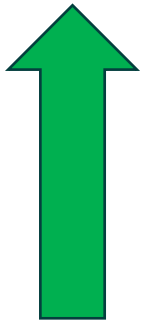
A Brief Preliminary Remark 1: AI Is Fluent, But Not Always Deep

A consistent pattern has emerged:

1. While AI systems – particularly chatbots – **can perform reasonably well in surface-level domain knowledge**, they often struggle **to generate high-quality scientific explanations** when confronted with deep, conceptually demanding questions.



- **Not purpose-built for scientific reasoning**
- **Not consistently reliable under conceptual pressure**
- **Not trained on the best-case explanatory pathways**



- **Built for breadth, not depth**
- **Confident, but not always trustworthy**
- **Rarely optimized for expert-level explanation**



AI can answer. But explanation, reasoning, and scientific depth are another matter.

This is exactly why AI needs a pedagogical framework.

A Brief Preliminary Remark 2: AI Learns Knowledge – And Inherits Distortion

A consistent pattern has emerged:

2. Chatbots are largely trained on information sourced from the internet and large-scale textual corpora. As a result, they not only reproduce correct knowledge but also **inherit and propagate existing misconceptions, oversimplifications, and inaccuracies** present in those sources.

- **They inherit the web's blind spots - absorb both facts and flaws**
- **They echo errors with confidence - misconceptions travel through data**
- **Scale does not guarantee truth - bigger training, same old errors**

Please do not assume...

Successfully performing a task with generative AI does not automatically lead to learning –

OECD Digital Education Outlook Report January 2026

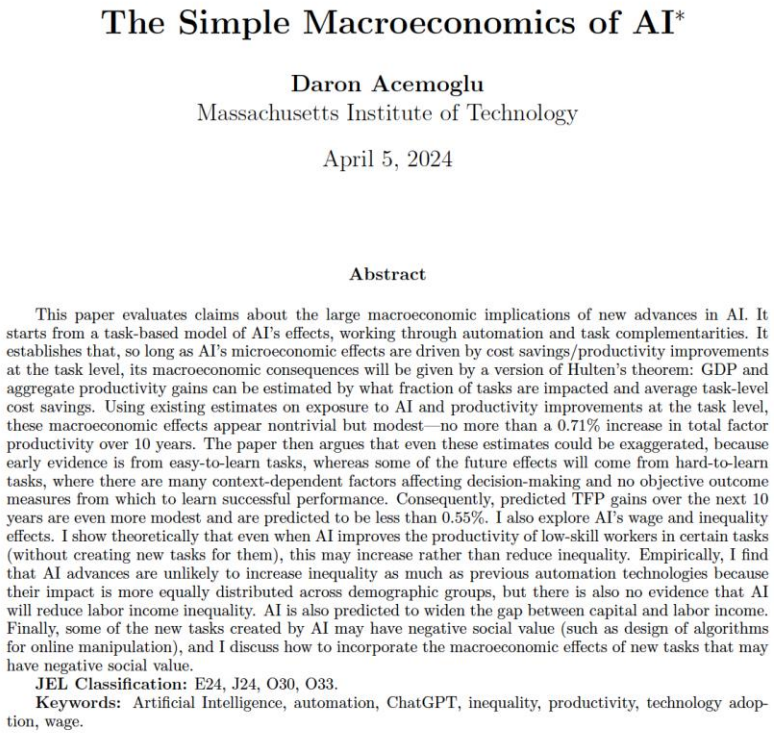
We are preparing students for jobs that don't yet exist, using technologies that haven't been invented, in order to solve problems, we don't even know are problems yet –

Karl Fisch / 2006

Geoffrey Hinton comments on radiology and deep learning - 2016 Machine Learning and Market for Intelligence Conference in Toronto



- 2006: Pre-iPhone (2007), yet the vision was clear.
- 2026: Beyond technology, we are now reinventing intelligen much higher!



The Simple Macroeconomics of AI*

Daron Acemoglu
Massachusetts Institute of Technology

April 5, 2024

Abstract

This paper evaluates claims about the large macroeconomic implications of new advances in AI. It starts from a task-based model of AI's effects, working through automation and task complementarities. It establishes that, so long as AI's microeconomic effects are driven by cost savings/productivity improvements at the task level, its macroeconomic consequences will be given by a version of Hulten's theorem: GDP and aggregate productivity gains can be estimated by what fraction of tasks are impacted and average task-level cost savings. Using existing estimates on exposure to AI and productivity improvements at the task level, these macroeconomic effects appear nontrivial but modest—no more than a 0.71% increase in total factor productivity over 10 years. The paper then argues that even these estimates could be exaggerated, because early evidence is from easy-to-learn tasks, whereas some of the future effects will come from hard-to-learn tasks, where there are many context-dependent factors affecting decision-making and no objective outcome measures from which to learn successful performance. Consequently, predicted TFP gains over the next 10 years are even more modest and are predicted to be less than 0.55%. I also explore AI's wage and inequality effects. I show theoretically that even when AI improves the productivity of low-skill workers in certain tasks (without creating new tasks for them), this may increase rather than reduce inequality. Empirically, I find that AI advances are unlikely to increase inequality as much as previous automation technologies because their impact is more equally distributed across demographic groups, but there is also no evidence that AI will reduce labor income inequality. AI is also predicted to widen the gap between capital and labor income. Finally, some of the new tasks created by AI may have negative social value (such as design of algorithms for online manipulation), and I discuss how to incorporate the macroeconomic effects of new tasks that may have negative social value.

JEL Classification: E24, J24, O30, O33.
Keywords: Artificial Intelligence, automation, ChatGPT, inequality, productivity, technology adoption, wage.

WEF Top future skills employers will value most by 2030

These skills are not developed by consuming AI outputs, but by engaging in inquiry, design, testing, and revision with AI.



PART 2

Instruction needs a structure

Learning requires design, critique, iteration, evidence, and human judgment.

STEM + AI

- Science
- Technology
- Engineering
- Mathematics

+

- Computer Science
- Cognitive Psychology
- Ethics
- Social Sciences

Structured AI integration can promote (Supported by 11 Studies*)

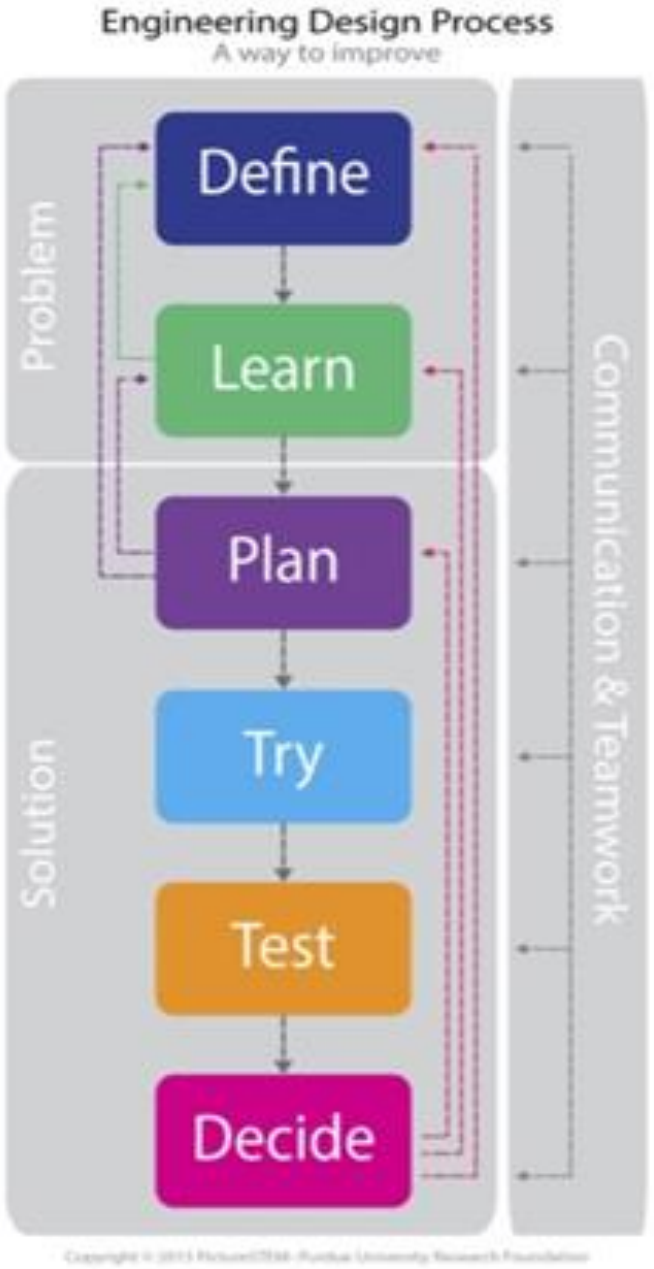
- **critical thinking,**
- **metacognitive reflection, and**
- **cross-disciplinary learning.**

*León, C., Lipuma, J., & Oviedo-Torres, X. (2025). Artificial intelligence in STEM education: A transdisciplinary framework for engagement and innovation. *Frontiers in Education, 10*, Article 1619888.https://doi.org/10.3389/feduc.2025.1619888



The new question is not should we use AI?

The real question is: How do we place AI inside sound pedagogy?



STEM Education Approach – Engineering Design Process

What makes STEM education truly distinctive is the engineering design process at its core.*

AI in STEM is not about using chatbots in class; it is about redesigning learning through the engineering design process.

* Ulutaş, M. A., Elmas, R., Karakaya, F., & Yılmaz, M. (2023). Türkiye'de Yapılan STEM Eğitimi Yaklaşımı Çalışmalarının Mühendislik Tasarım Süreci Uygulamaları Bağlamında İncelenmesi. *Türk Eğitim Bilimleri Dergisi*, *21*(2), 1111-1130.

Why STEM offers the right pedagogical architecture for AI integration?*

1. **Interdisciplinary by nature**
2. **Rooted in meaningful real-life contexts**
3. **Driven by the Engineering Design Process**
4. **Evidence-based decision making**
5. **Iterative in design**
6. **Step-by-step scaffolding of learning**
7. **Open to learning from failure**
8. **Focused on process, not just product**
9. **Supportive of multiple possible solutions**
10. **Centered on teamwork and collaboration**

* 1. Elmas, R., Cengiz-Keleş, N., Adiguzel-Ulutas, M., Akarsu, M., & Canbazoglu-Bilici, S. (2025). An international perspective on STEM education: private school teachers' conceptualization–a descriptive survey study. *Journal of Turkish Science Education*, *22*(4), 822-837.
2. Elmas, R., Adiguzel-Ulutas, M., Cengiz-Keles, N., & Yuksel, T. (2025). Empowering female students in STEM: lake surface waste cleanup camp project. *Discover Education, 4*, Article Number 457.

AI Needs a Pedagogy, Not Just a Prompt

- **Tools do not teach by themselves**
- **Speed does not ensure understanding**
- **Structure turns interaction into learning**

AI Across the Engineering Design Process

The engineering design process gives AI a meaningful educational role: not as an answer machine, but as a design partner.

- **Define the problem**: AI helps frame real-world problems, stakeholders, constraints
- **Investigate**: AI supports research, comparison, information gathering
- **Generate ideas**: AI expands options, alternatives, and creative pathways
- **Prototype**: AI helps model, draft, simulate, visualize, and refine
- **Test and evaluate:** AI supports feedback analysis, debugging, evidence review
- **Redesign**: AI strengthens iteration, reflection, and improvement

Proceed with caution

AI supports — teachers guide

AI suggests — learners decide

AI expands — pedagogy structures

AI accelerates — evidence

validates

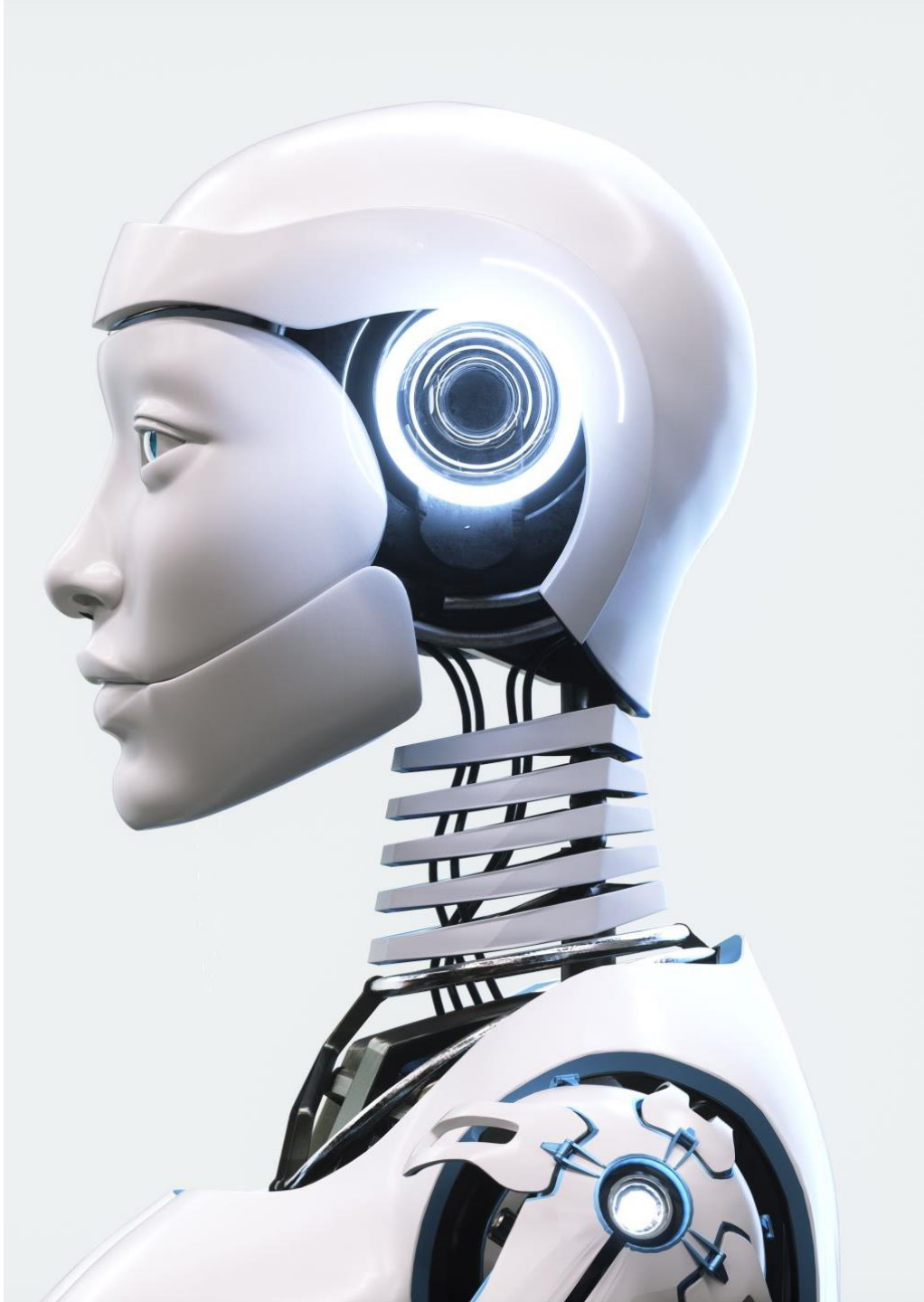
PART 3

STEM already provides that structure

The engineering design process is the missing pedagogical bridge between AI tools and meaningful learning.

What Changes When AI Enters STEM?

- Problems become more explorable
- Ideas become more visible
- Prototypes become more revisable
- Feedback becomes more immediate
- Reflection becomes more important



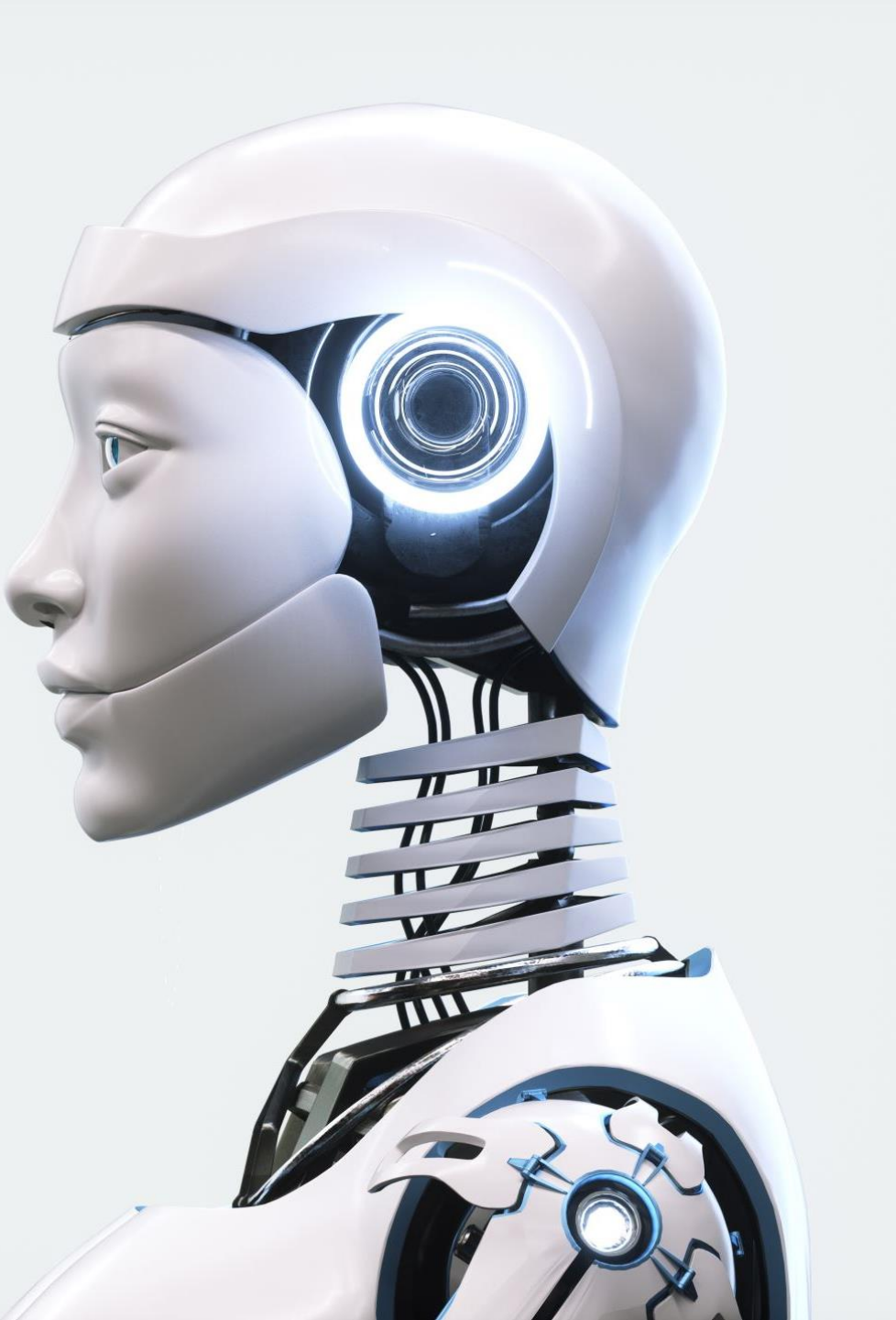
What Changes When AI Enters STEM for teachers?

- **More time for authentic STEM education**
  Less time on routine tasks, more time on inquiry and design.

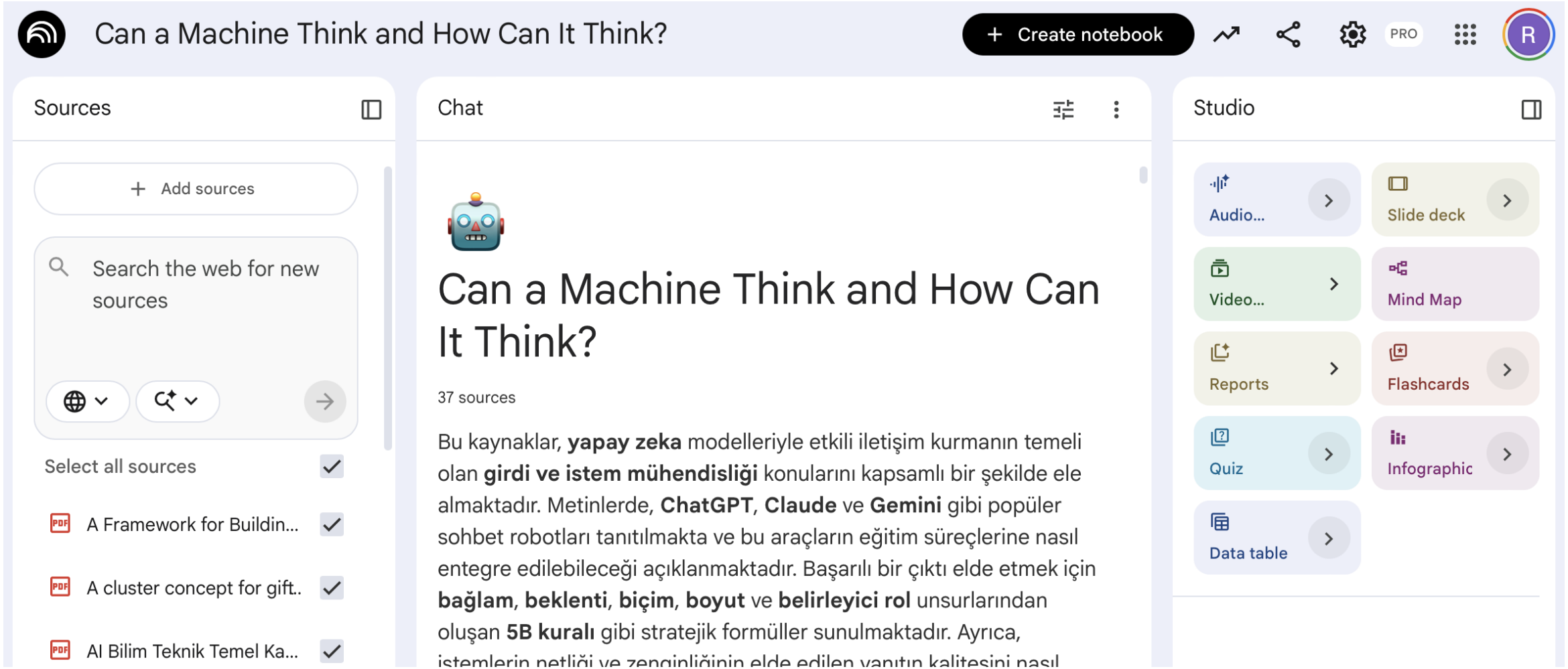
- **Faster and more actionable feedback**
  Quicker responses can support revision and improvement.

- **Greater capacity for personalized learning**
  Teachers can better adapt tasks, pace, and support.

- **Stronger support for research and exploration**
  AI can enrich inquiry with resources, directions, and connections.

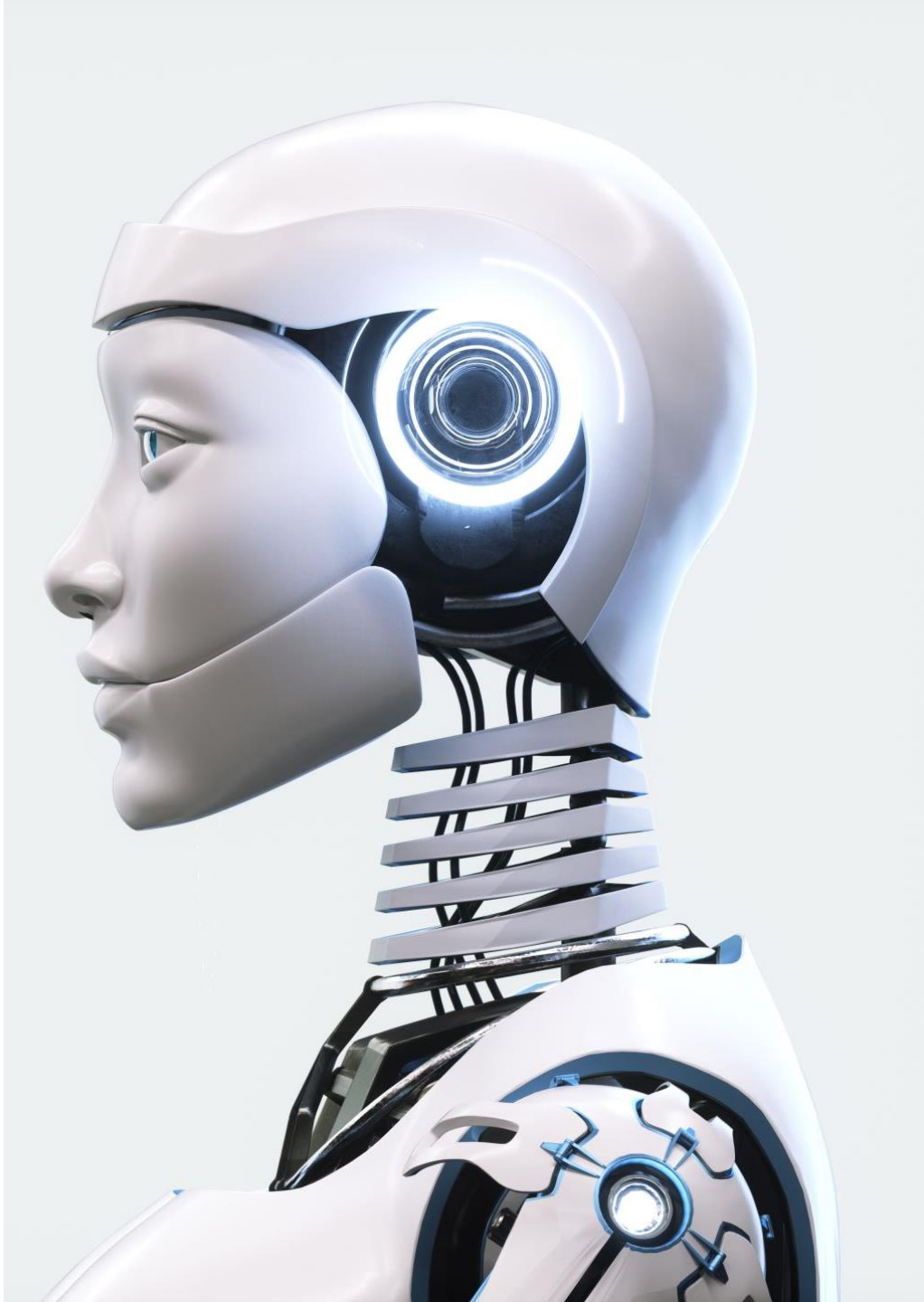


NotebookLM


Can a Machine Think and How Can It Think?
Create notebook
PRO
R
Sources
Add sources
Search the web for new sources
Select all sources
A Framework for Buildin...
A cluster concept for gift..
AI Bilim Teknik Temel Ka...
Chat
Can a Machine Think and How Can It Think?
37 sources
Bu kaynaklar, yapay zeka modelleriyle etkili iletişim kurmanın temeli olan girdi ve istem mühendisliği konularını kapsamlı bir şekilde ele almaktadır. Metinlerde, ChatGPT, Claude ve Gemini gibi popüler sohbet robotları tanıtılmakta ve bu araçların eğitim süreçlerine nasıl entegre edilebileceği açıklanmaktadır. Başarılı bir çıktı elde etmek için bağlam, beklenti, biçim, boyut ve belirleyici rol unsurlarından oluşan 5B kuralı gibi stratejik formüller sunulmaktadır. Ayrıca,
Studio
Audio...
Slide deck
Video...
Mind Map
Reports
Flashcards
Quiz
Infographic
Data table

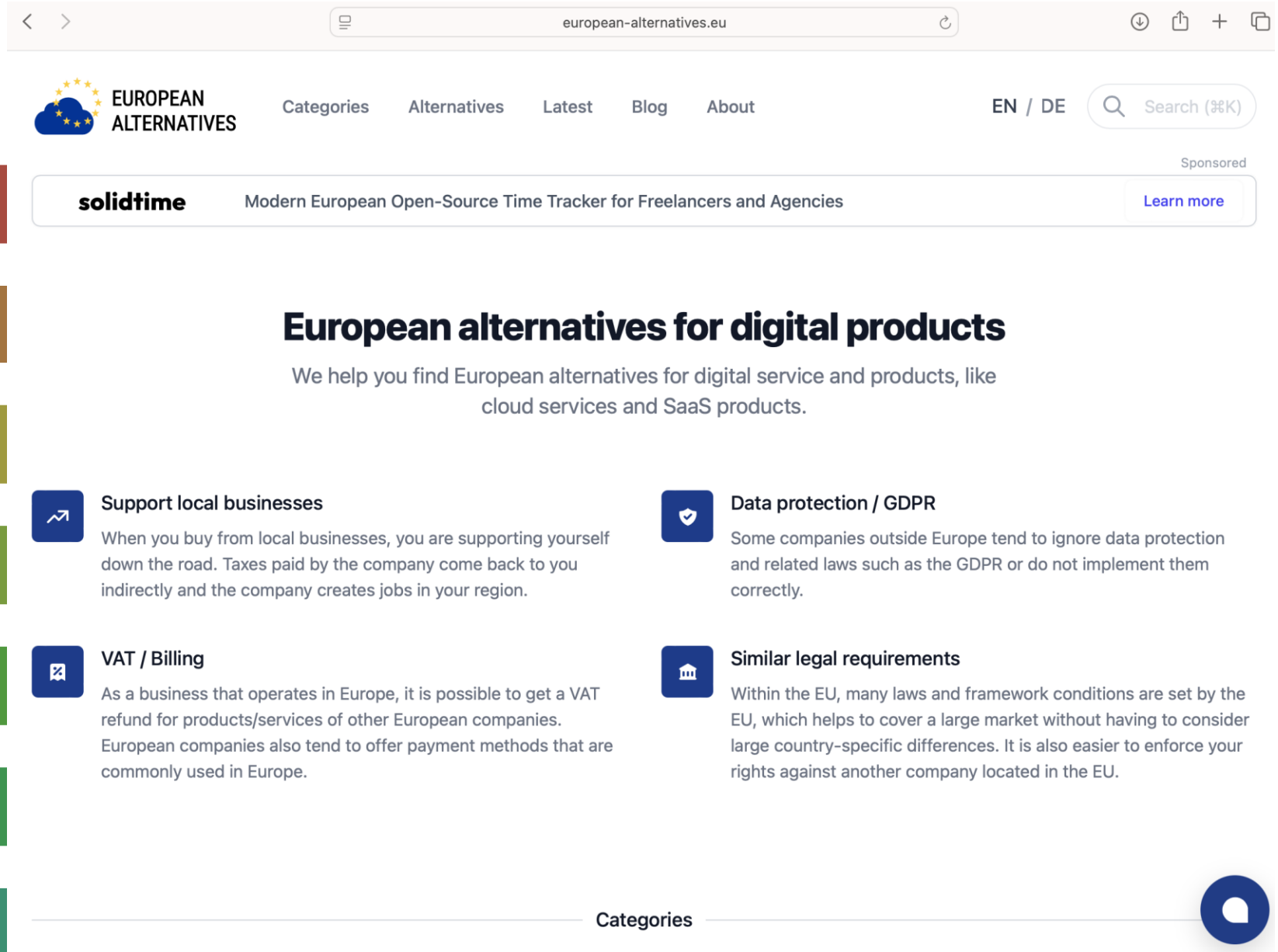
What Changes When AI Enters STEM for students?

- **Idea generation becomes broader**
  Students can produce and compare more design options.
- **Iteration becomes faster**
  Students can improve prototypes and solutions through repeated revision.
- **Inquiry becomes deeper**
  Students can pursue questions further and examine problems from multiple angles.
- **Reasoning becomes more visible**
  Students can articulate, test, and refine their thinking more explicitly.
- **Problem solving becomes more ambitious**
  Students can take on more complex tasks with greater confidence and support.



Chatbots

- Gemini
- ChatGPT
- Claude
- Deepseek
- Qwen
- Perplexity
- Mistral



What Changes When AI Enters STEM for instruction?

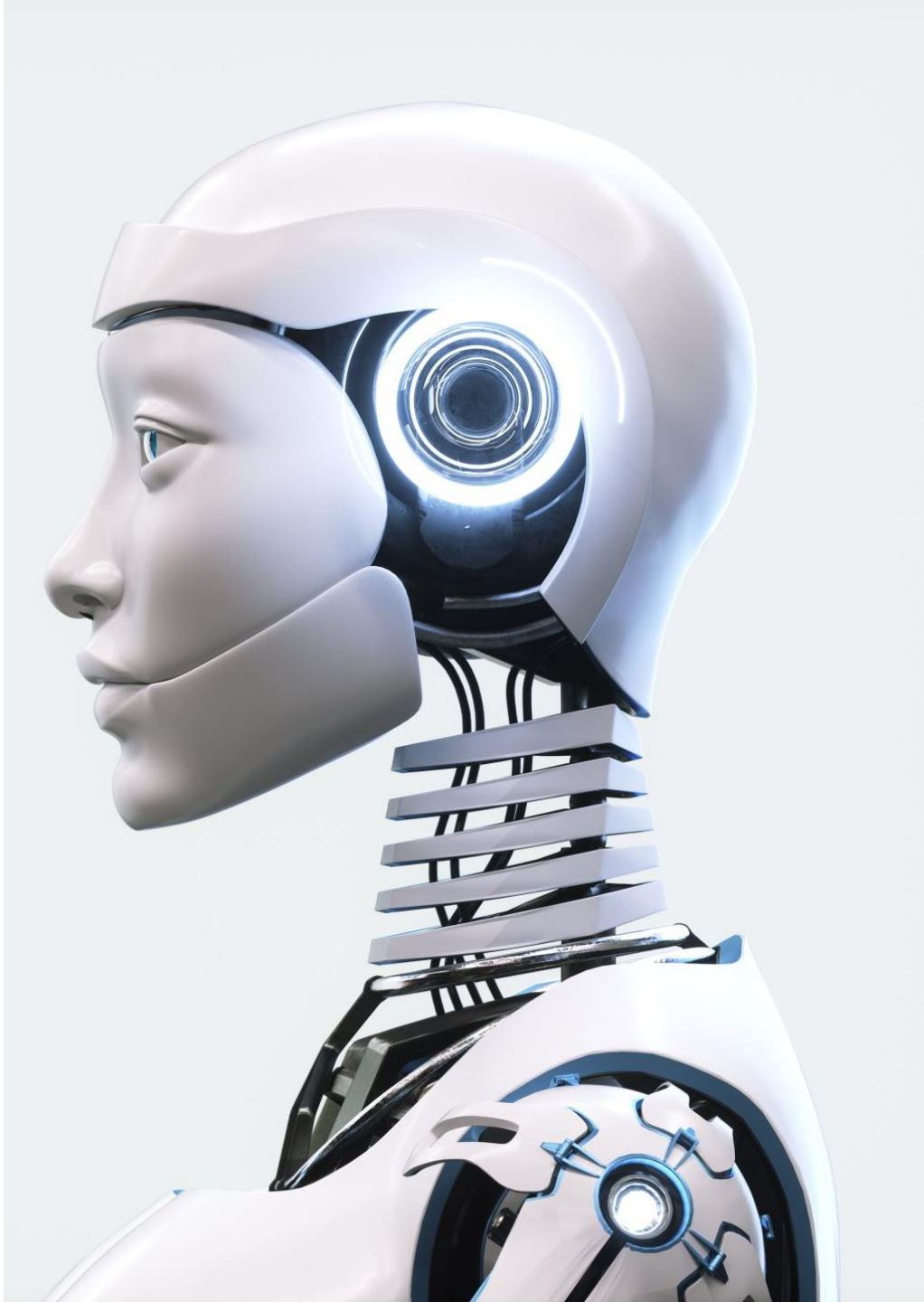
Adaptation becomes easier
Instruction can respond more flexibly to different learners and learning pathways.

Iteration becomes central
Teaching can support faster cycles of feedback, revision, and refinement.

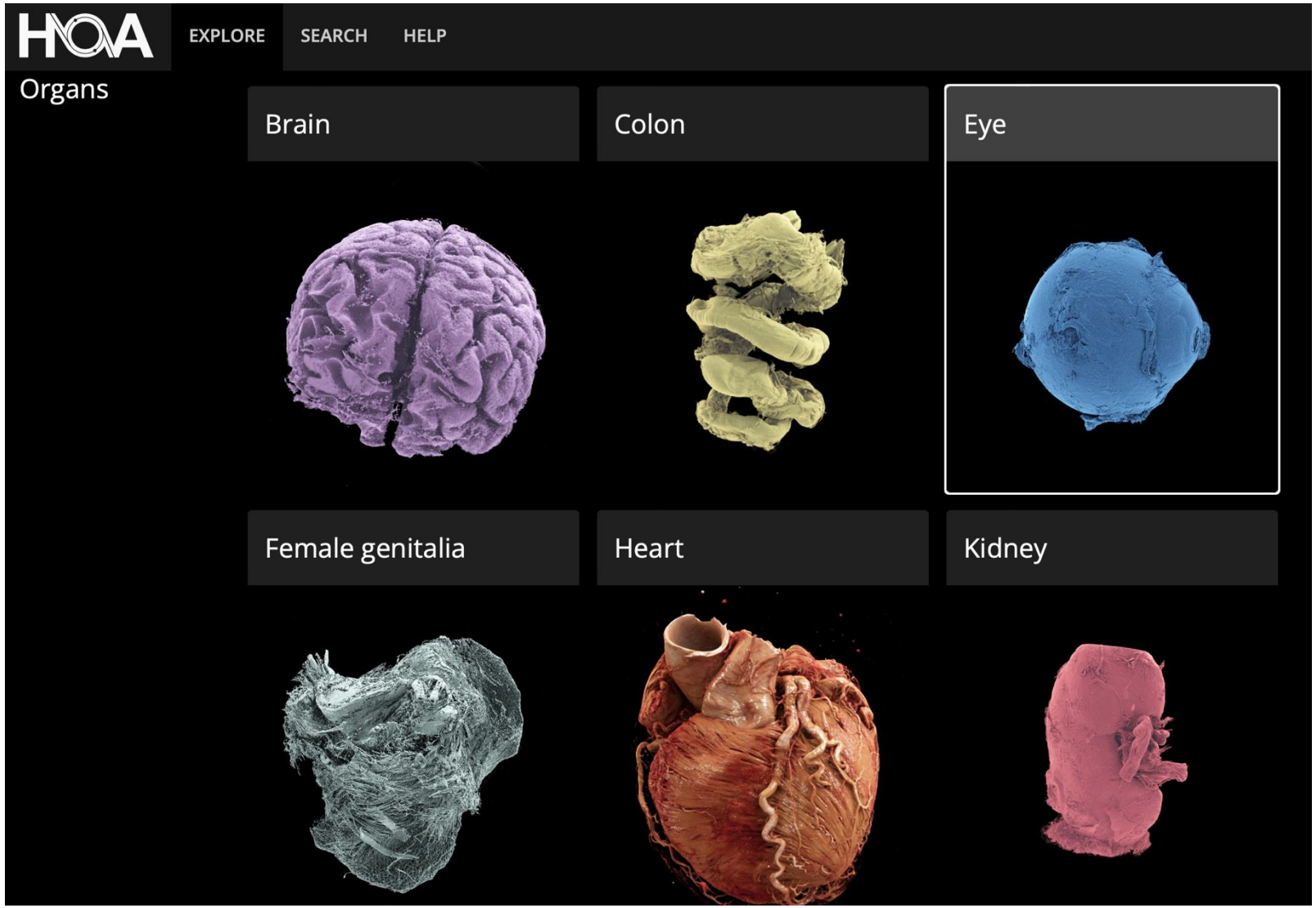
Inquiry becomes more sustained
Students can spend more time exploring questions and less time waiting for direction.

Design becomes more visible
Instruction can foreground problem solving, prototyping, and redesign more explicitly.

Responsiveness becomes stronger
Teachers can adjust instruction more quickly based on evidence from the learning process.



Human Organ Atlas – Google Earth of Human Body



https://human-organ-atlas.esrf.fr

What Must Remain Human?

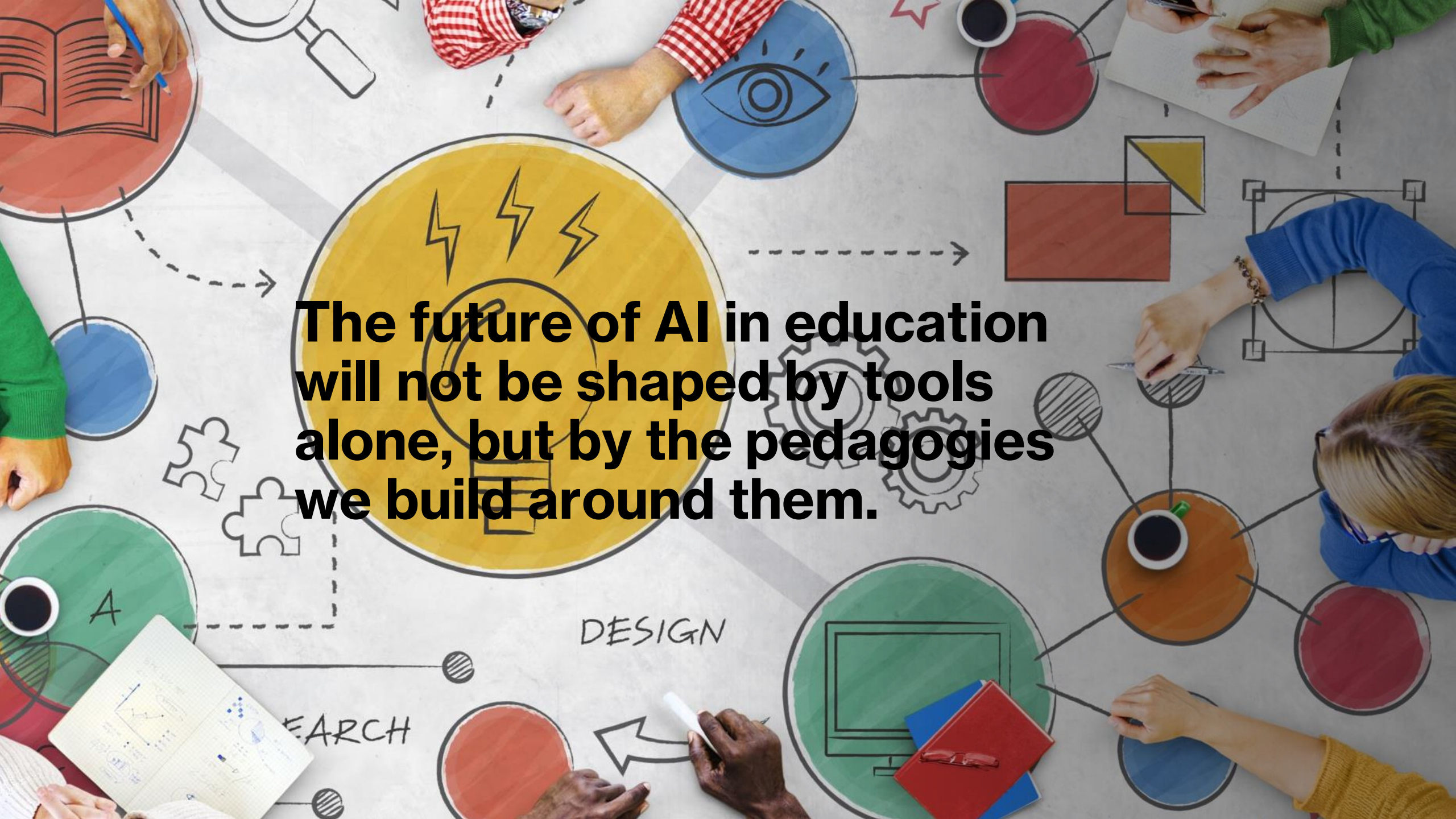
- **Judgment**
- **Ethics**
- **Context**
- **Scientific reasoning**
- **Responsibility**
- **Pedagogical intention**

AI Access, Maturity, and Educational Responsibility

Open AI ChatGPT User Manual:

13+ with permission, 18+ with full autonomy

Children under 13 should use AI only with full parental or adult supervision


The future of AI in education will not be shaped by tools alone, but by the pedagogies we build around them.
DESIGN