

Teacher Expertise in the Age of AI: Which Parts of Expert Teaching Can Be Supported—and Which Can Never Be Delegated?

Dr. Nikolaus Albrecht

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If you are expecting a fight ...

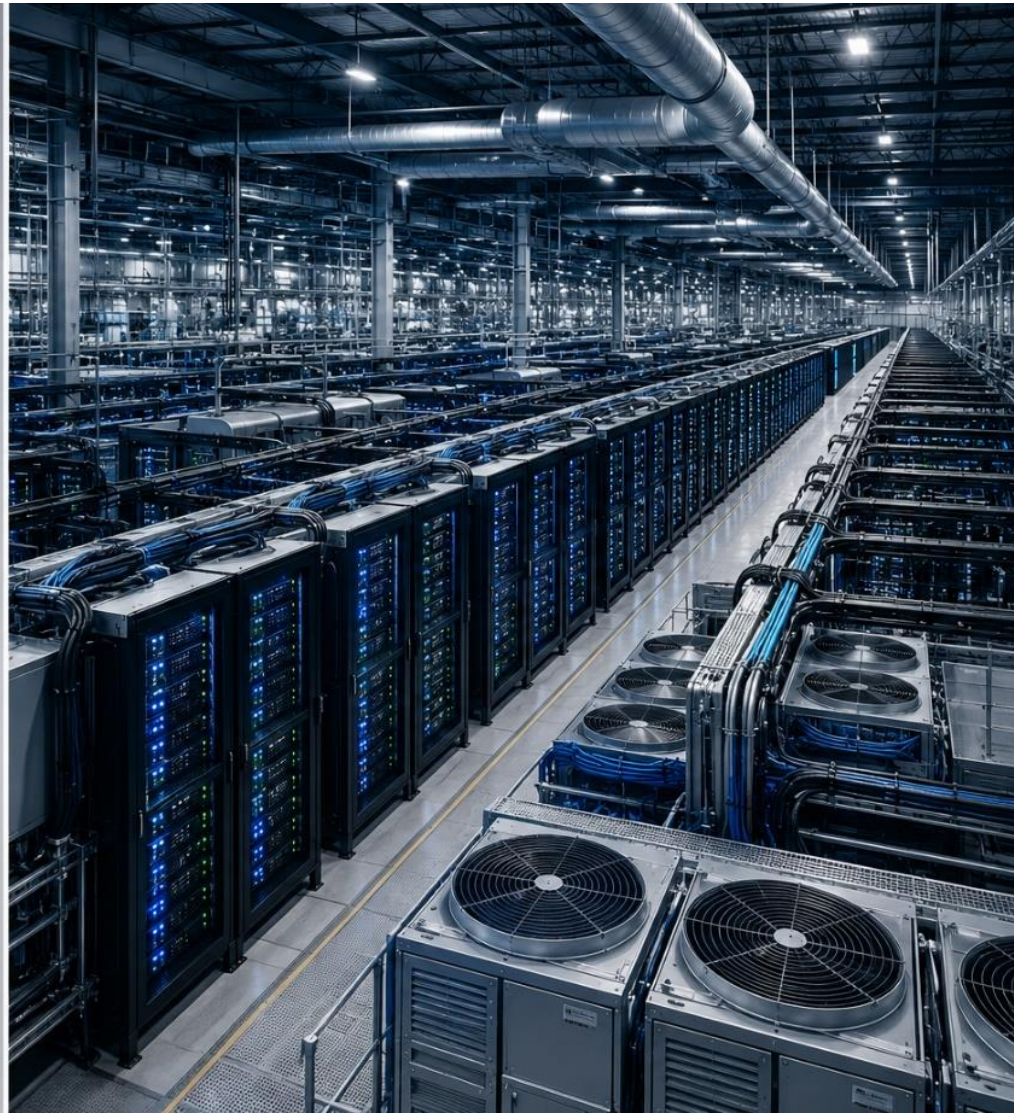


But ...

... this is not a clash.



You will witness a conversation between a teacher and an AI proponent



Of course, AI looks more like a huge building brim full of calculating power.

You can imagine the cooperation ...



© Images: AI

© Story: Human

... so you can spot the division of work right here.

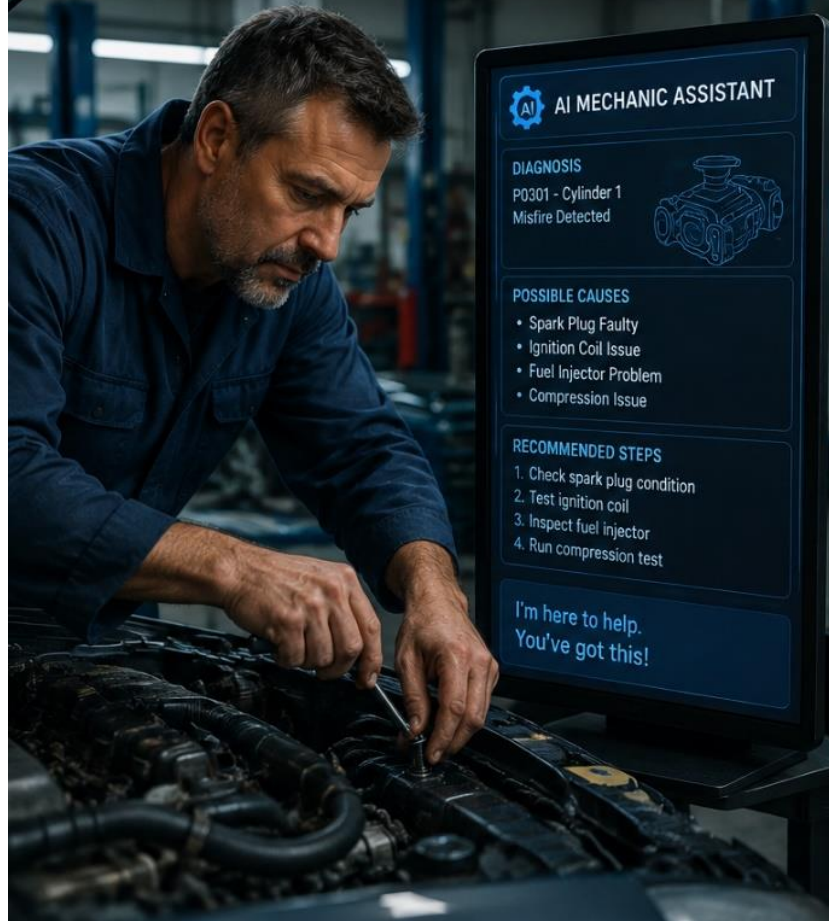
AI saves you
a lot of work!





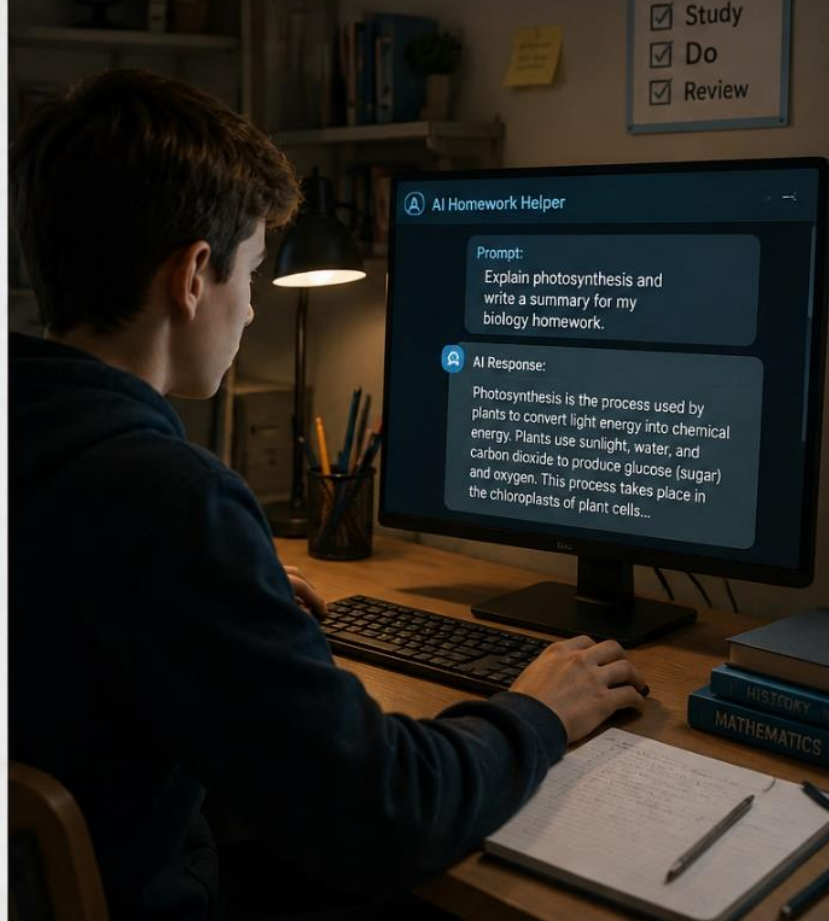
AI AS A COPILOT

Enhancing human expertise



AI AS A SHORTCUT

Replacing human effort



The relationship between AI and work is very different from the relationship between AI and school. The idea that AI creates shortcuts, saves time, and avoid effort, these are all things that that could be very beneficial in the professional context where you want to maximize efficiency. But the are **very damaging in the educational context, when the whole point is to do things the hard way – because that's how you learn.**



Deep dive into reseach ...



robert and elizabeth bjork desirable difficulties



AI Mode

All

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Robert and Elizabeth Bjork Desirable Difficulties



Bjork Learning and Forgetting Lab

<https://bjorklab.psych.ucla.edu> › sites › 2016/04

PDF



Creating Desirable Difficulties to Enhance Learning

by EL Bjork · Cited by 2387 — **Elizabeth L. Bjork and Robert Bjork**. Making Things Hard on Yourself, But in a Good Way: Creating Desirable Difficulties to Enhance Learning. Henry L. Roediger ... [Read...](#)
10 pages



The Learner Lab

<https://thelearnerlab.com> › desirable-difficulties



Desirable Difficulties

Boosting Learning with Desirable Difficulties - UCLA Psychologists Dr. Elizabeth Bjork and Dr. Robert Bjork explain how to learn better.



ResearchGate

<https://www.researchgate.net/publication/28409772...>

(PDF) Making things hard on yourself, but in a good way

PDF | On Jan 1, 2011, E.L. Bjork and others published Making things hard on yourself, but in a good way: **Creating desirable difficulties** to enhance learning ...



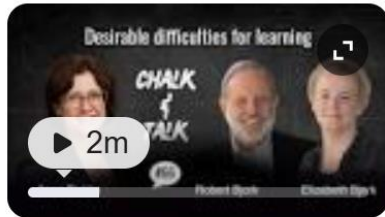
Structural Learning

<https://www.structural-learning.com/Blog>

Robert Bjork: A Teacher's Guide to Desirable Difficulties

19 Feb 2026 — Bjork (1994) described 'desirable difficulties', which are **short learning struggles for long-term gains**. These difficulties help learners ... [Read more](#)

Videos :



[Desirable difficulties for learning with Elizabeth Bjork and ...](#)

YouTube · Chalk & Talk with Anna Stokke

6 Mar 2026



[Using Desirable Difficulties to Enhance Learning, Dr. Robert ...](#)

YouTube · LastingLearning.com

27 Oct 2015

5 key moments in this video



[robert bjork - desirable difficulties: slowing down learning](#)

YouTube · gocognitive

13 Jul 2012



The logic behind it ...
in one simple image:



You can let AI do the hard work – but you won't get better that way.

Okay, I'm going
to check out this
Björk couple!



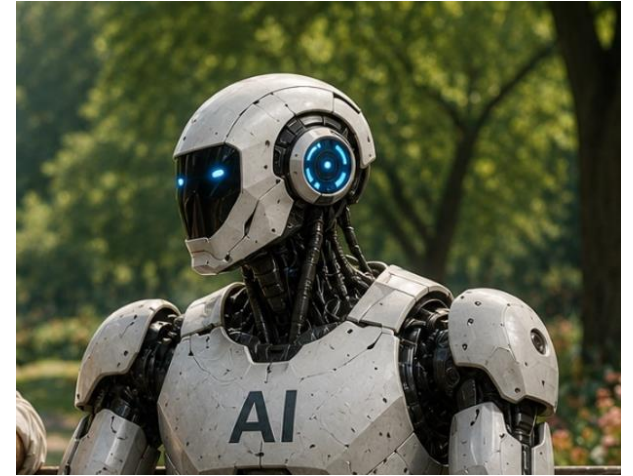


... be aware: students wouldn't like your ideas about "desirable difficulties"

How can I
complete this task
with the least
amount of mental
effort?



Don't be so
negative. I'm a
good tutor.





Yes, you
are.

But ...

AI is indeed good at explaining things. But teaching isn't just about explaining.



WITH AN EXPERIENCED TEACHER

Body language is read and correctly interpreted.



HUMAN CONNECTION. REAL UNDERSTANDING.

The teacher adapts. The student progresses.



WITHOUT HUMAN CONNECTION

The student is left alone in their mental fog.



NO CONNECTION. NO CLARITY.

The student copies. The fog remains.

A good human tutor can ...

- understand the student's **body language**
- earn a student's **respect**
- get students to **reveal** their half-baked **understanding** of a topic

This student behavior we see in randomized trials so far ...

students simply **will not reveal** their misunderstandings to AI.



Deep dive into research



AI alone may not be enough: chen



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arXiv

<https://arxiv.org> › cs



[2509.16778] Generative AI alone may not be enough

by E Chen · 2025 · Cited by 7 — **Generative AI alone may not be enough**: Evaluating AI Support for Learning Mathematical Proof. Authors:Eason Chen, Sophia Judicke, Kayla Beigh, ... [Read more](#)



ResearchGate

<https://www.researchgate.net/publication/40113288...>

(PDF) Chat-Based Support Alone May Not Be Enough

21 Feb 2026 — Together, the findings suggest that **chatbot-based support alone may not reliably support transfer** to independent assessment of math proof- ... [Read more](#)

Chat-Based Support Alone May Not Be Enough: Comparing Conversational and Embedded LLM Feedback for Mathematical Proof Learning

February 2026

DOI: [10.48550/arXiv.2602.18807](https://doi.org/10.48550/arXiv.2602.18807)

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Eason Chen · Sophia Judicke · Kayla Beigh · [Show all 21 authors](#) · Ken Koedinger



ScienceDirect.com

<https://www.sciencedirect.com> › science › article › pii



Learners' AI dependence and critical thinking

by J Tian · 2025 · Cited by 160 — Therefore, we hypothesize that **AI** dependence **is** negatively associated with critical thinking (H1), especially when the use of **AI is** uncritical and habitual. [Read more](#)

“Therefore, we hypothesize that AI dependence is negatively associated with critical thinking.”

Tian, 2025

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Learners' AI dependence and critical thinking: The psychological mechanism of fatigue and the social buffering role of AI literacy

Jinrui Tian ^a, Ronghua Zhang ^a   [Show more](#) ✓



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| 10.1016/j.actpsy.2025.105725 ↗

[Submitted on 20 Sep 2025]

Generative AI alone may not be enough: Evaluating AI Support for Learning Mathematical Proof

Eason Chen, Sophia Judicke, Kayla Beigh, Xinyi Tang, Zimo Xiao, Chuangji Li, Shizhuo Li, Reed Luttmer, Shreya Singh, Maria Yampolsky, Naman Parikh, Yi Zhao, Meiyi Chen, Scarlett Huang, Anishka Mohanty, Gregory Johnson, John Mackey, Jionghao Lin, Ken Koedinger

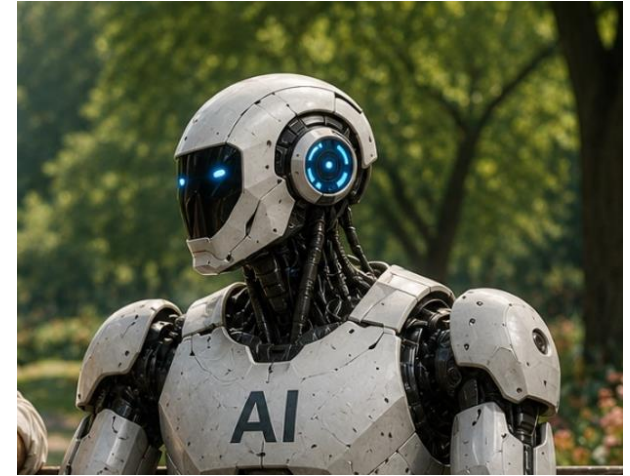
We evaluate the effectiveness of LLM-Tutor, a large language model (LLM)-powered tutoring system that combines an AI-based proof-review tutor for real-time feedback on proof-writing and a chatbot for mathematics-related queries. Our experiment, involving 148 students, demonstrated that the use of LLM-Tutor significantly improved homework performance compared to a control group without access to the system. However, its impact on exam performance and time spent on tasks was found to be insignificant. Mediation analysis revealed that students with lower self-efficacy tended to use the chatbot more frequently, which partially contributed to lower midterm scores. Furthermore, students with lower self-efficacy were more likely to engage frequently with the proof-review-AI-tutor, a usage pattern that positively contributed to higher final exam scores. Interviews with 19 students highlighted the accessibility of LLM-Tutor and its effectiveness in addressing learning needs, while also revealing limitations and concerns regarding potential over-reliance on the tool. Our results suggest that generative AI alone like chatbot may not suffice for comprehensive learning support, underscoring the need for iterative design improvements with learning sciences principles with generative AI educational tools like LLM-Tutor.

results suggest ...

AI alone **may not suffice** for comprehensive learning support.

Learning also has something to do with
empathy.

That sounds unfair.
I can write a few
motivating lines, too!





Research consistently shows ...

when students achieve small victories at the beginning of their learning journey –

solving a problem on their own,

mastering a new skill on their own

– they develop a sense of competence and control over their learning.

This sense of competence, however small it may be, strengthens students' **confidence in their abilities**, making them more likely to engage with future challenges.



Success → motivation will follow

and not the other way around



~~Motivation → success will follow.~~



Deep dive into research

Received: 2 September 2021 | Revised: 17 June 2022 | Accepted: 15 July 2022

DOI: 10.1111/desc.13325

RESEARCH ARTICLE

Developmental Science



WILEY

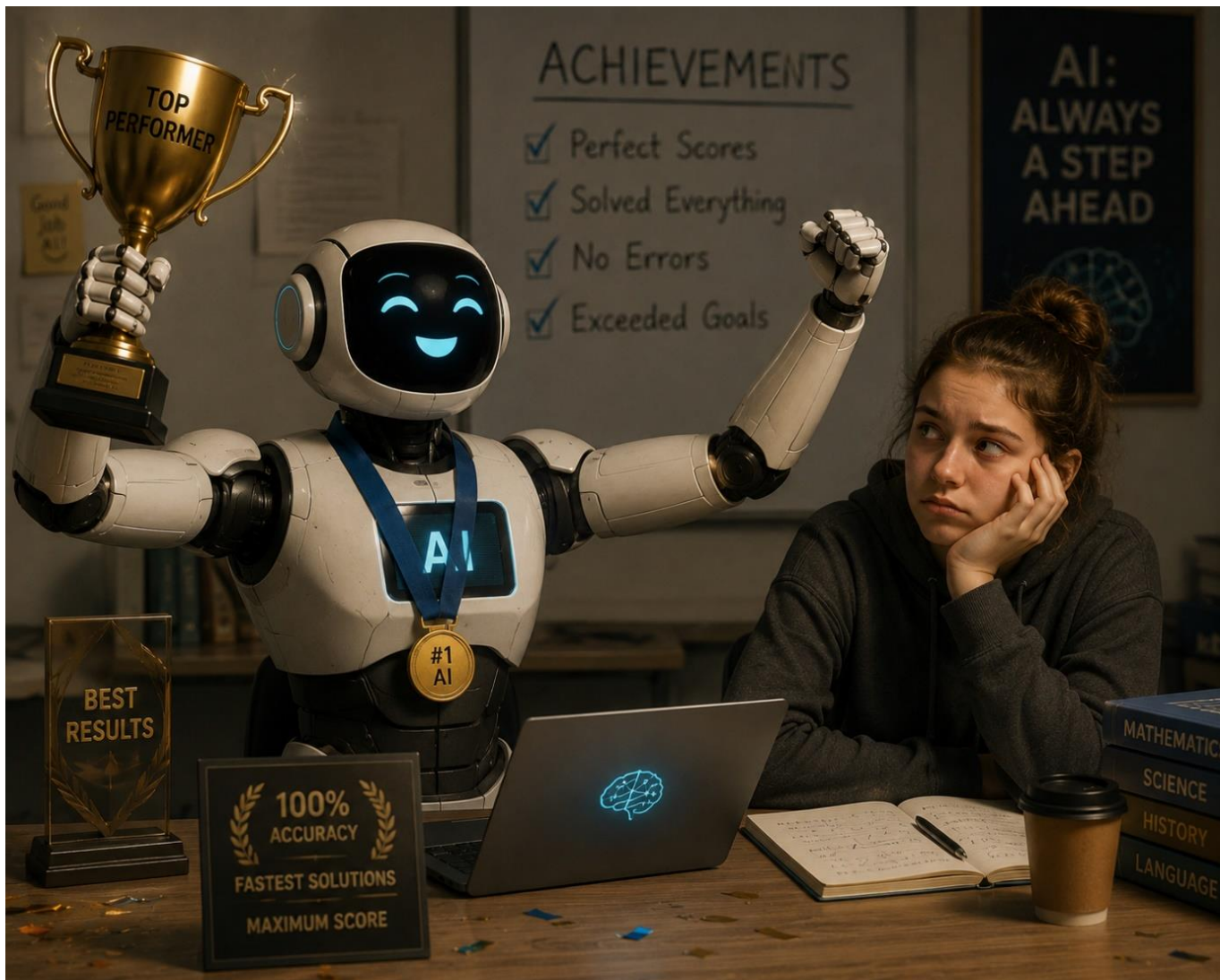
Literacy skills seem to fuel literacy enjoyment, rather than vice versa

Elsje van Bergen^{1,2}   | Sara A. Hart^{3,4}   | Antti Latvala⁵   |
Eero Vuoksima⁶  | Asko Tolvanen⁷  | Minna Torppa⁸  

Developmental trajectories of school-beginners' ability self-concept, intrinsic value and performance in mathematics

Markku Niemivirta¹  | Anna Tapola²  | Heta Tuominen¹  |
Jaana Viljaranta³ 

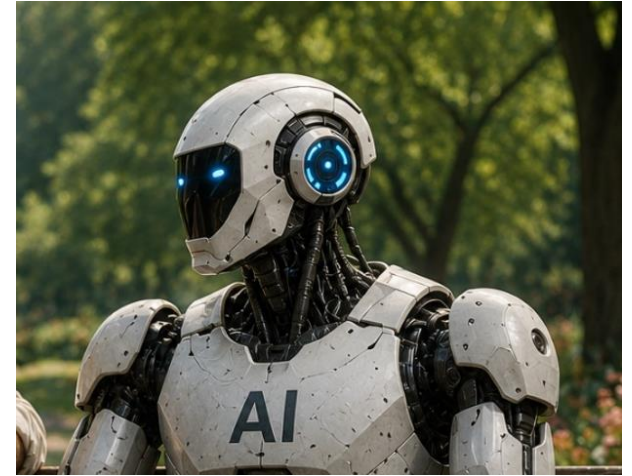
A picture is worth a thousand words ...



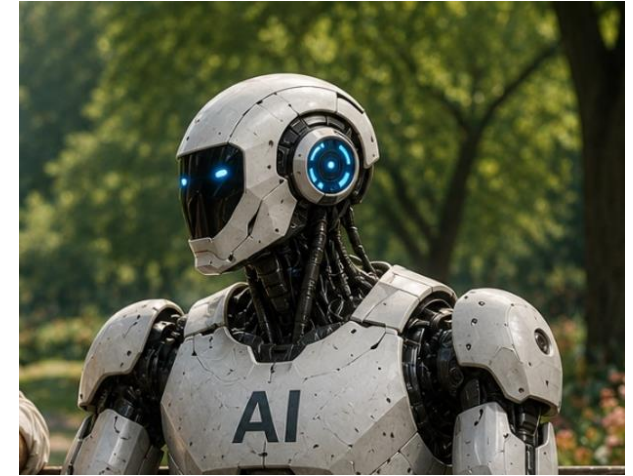
The success students achieve thanks to AI is not their own success. It does not belong to them. Therefore, it means nothing to a student. Consequently, the successes that AI can achieve for a student do not generate any motivation.

When students see that AI is successful, they do not draw any motivation from that success.

Is success what you
want most of all?



Take my answers and
you get good grades!

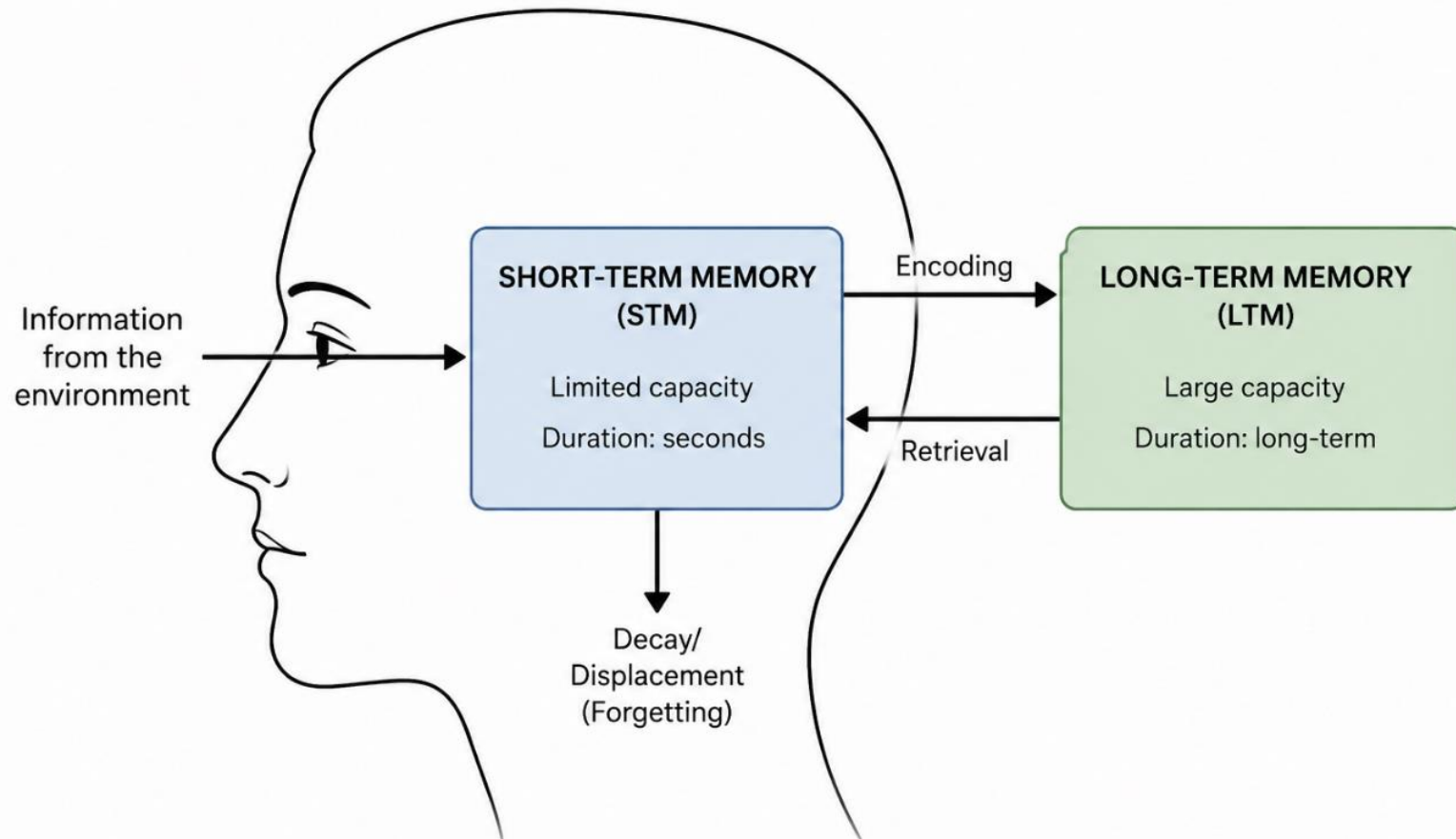




Performance $\neq$ Learning

To that end, we'll take **a brief detour** into cognitive psychology and look at **how people learn**.

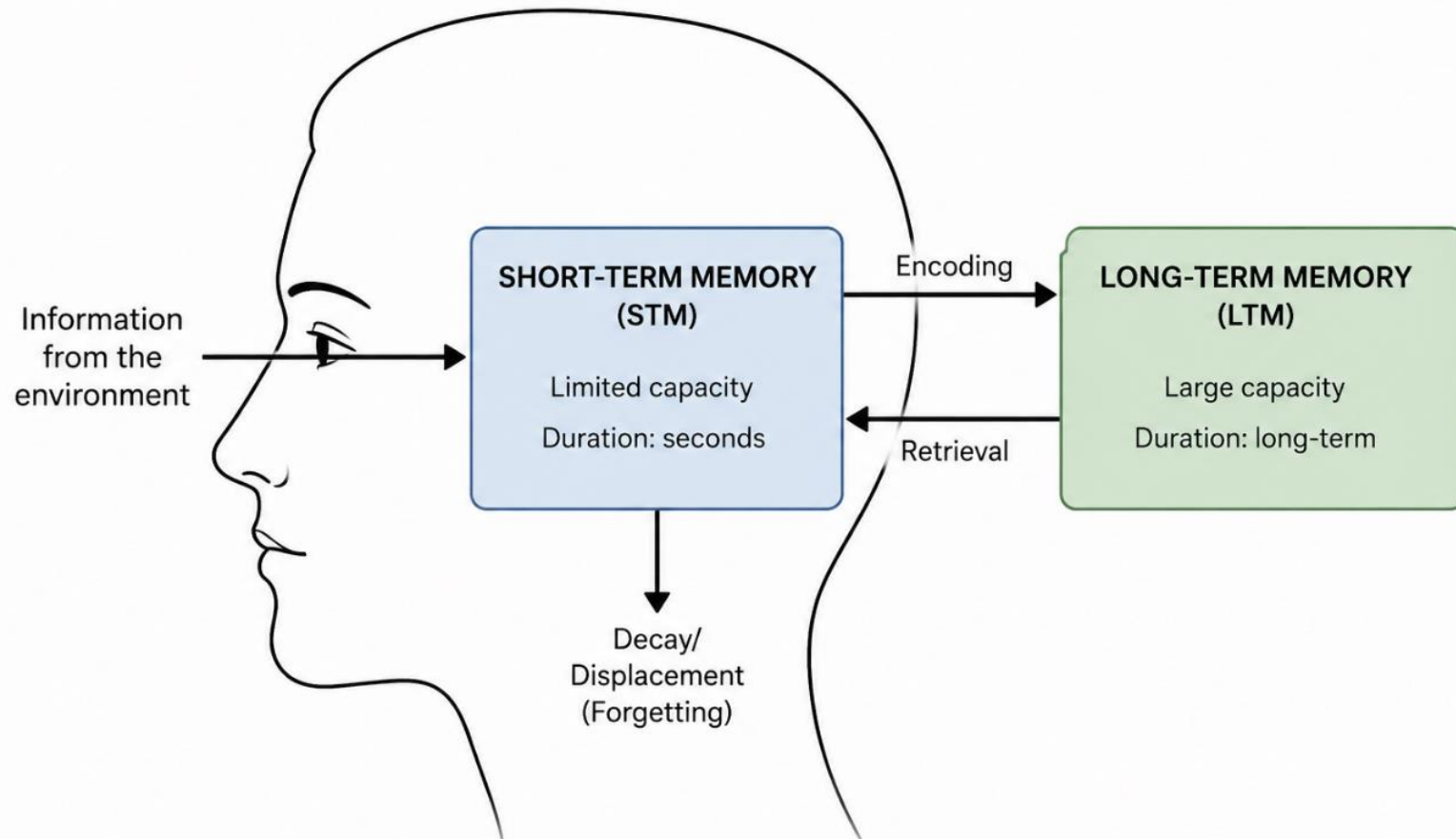
Atkinson and Shiffrin's Multi-Store Model of Memory



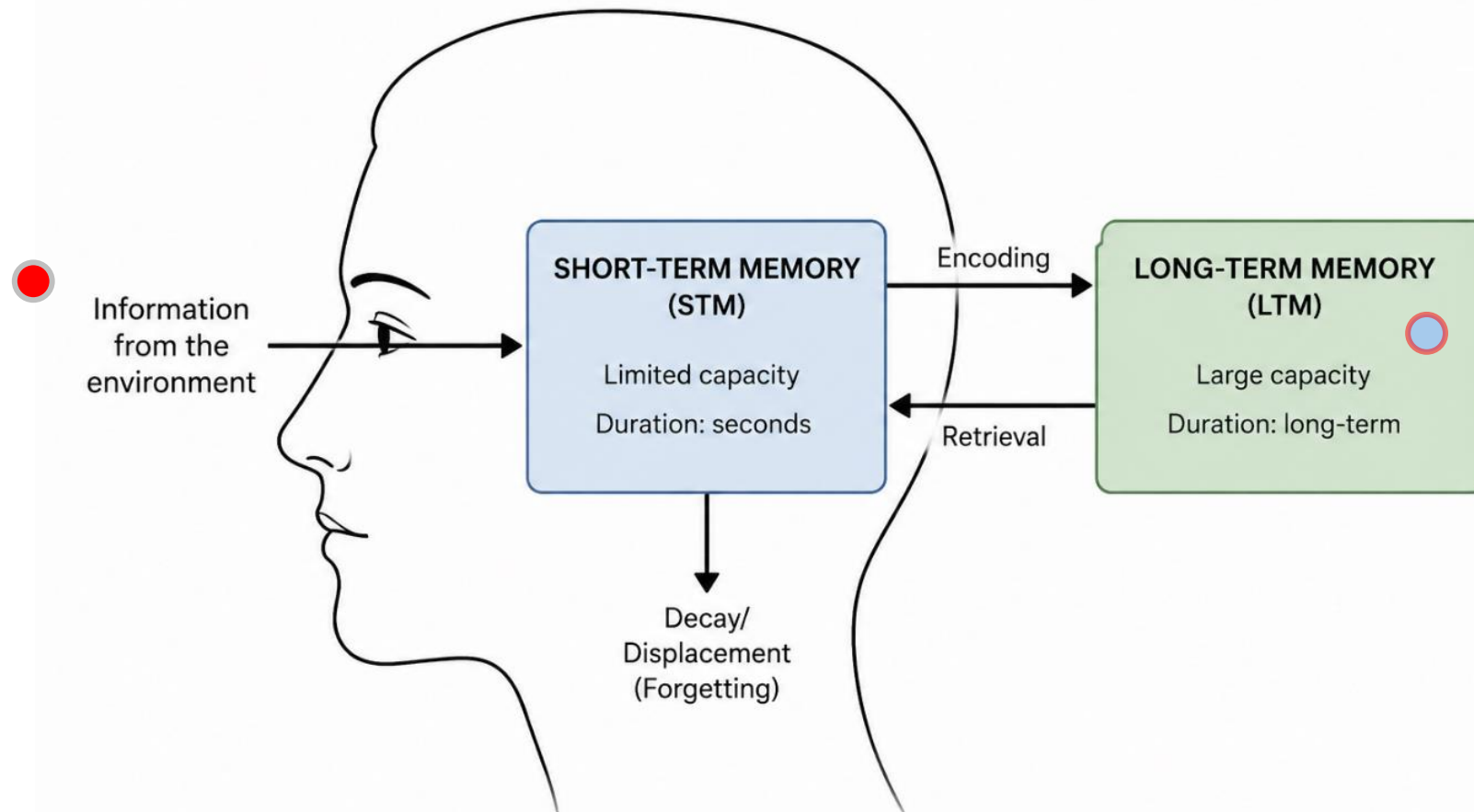
Lasting learning requires ...

- Information from the environment
- Schemas (i.e., interconnected units of knowledge) that you have already stored in your long-term memory – **that's the playground of a good teacher**
- enough working memory (short-term memory) to perform the mental task.

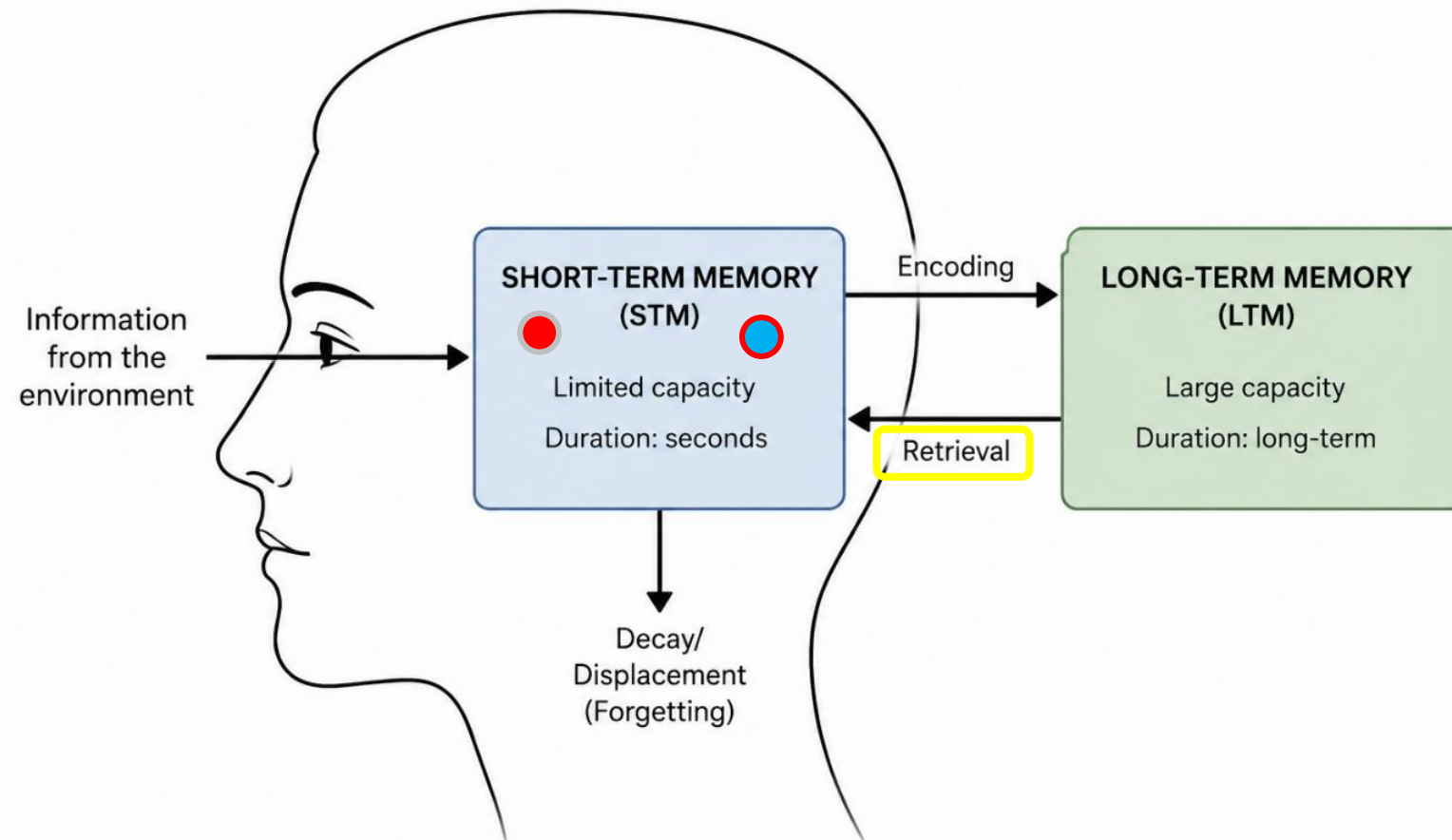
Atkinson and Shiffrin's Multi-Store Model of Memory



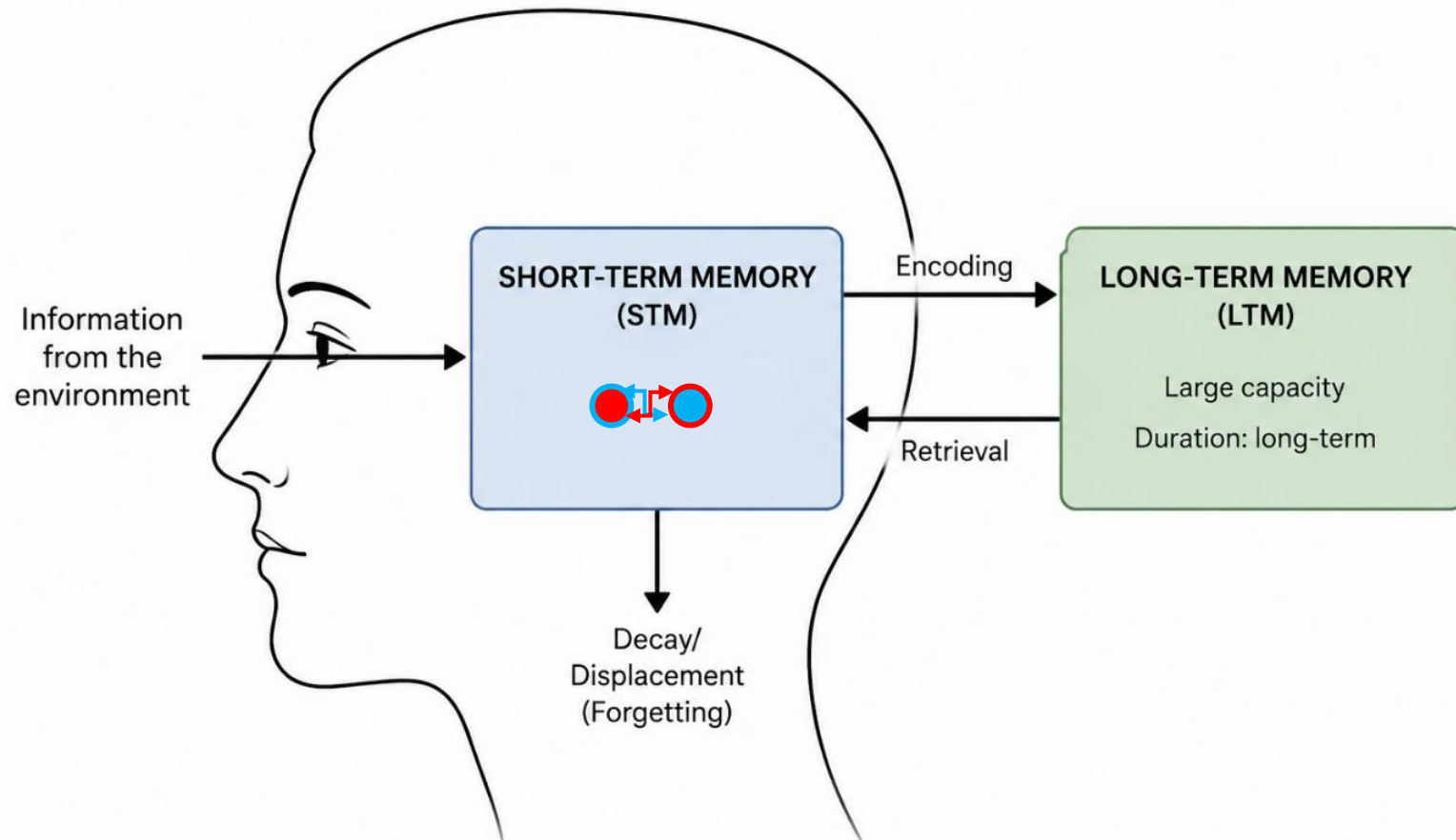
Atkinson and Shiffrin's Multi-Store Model of Memory



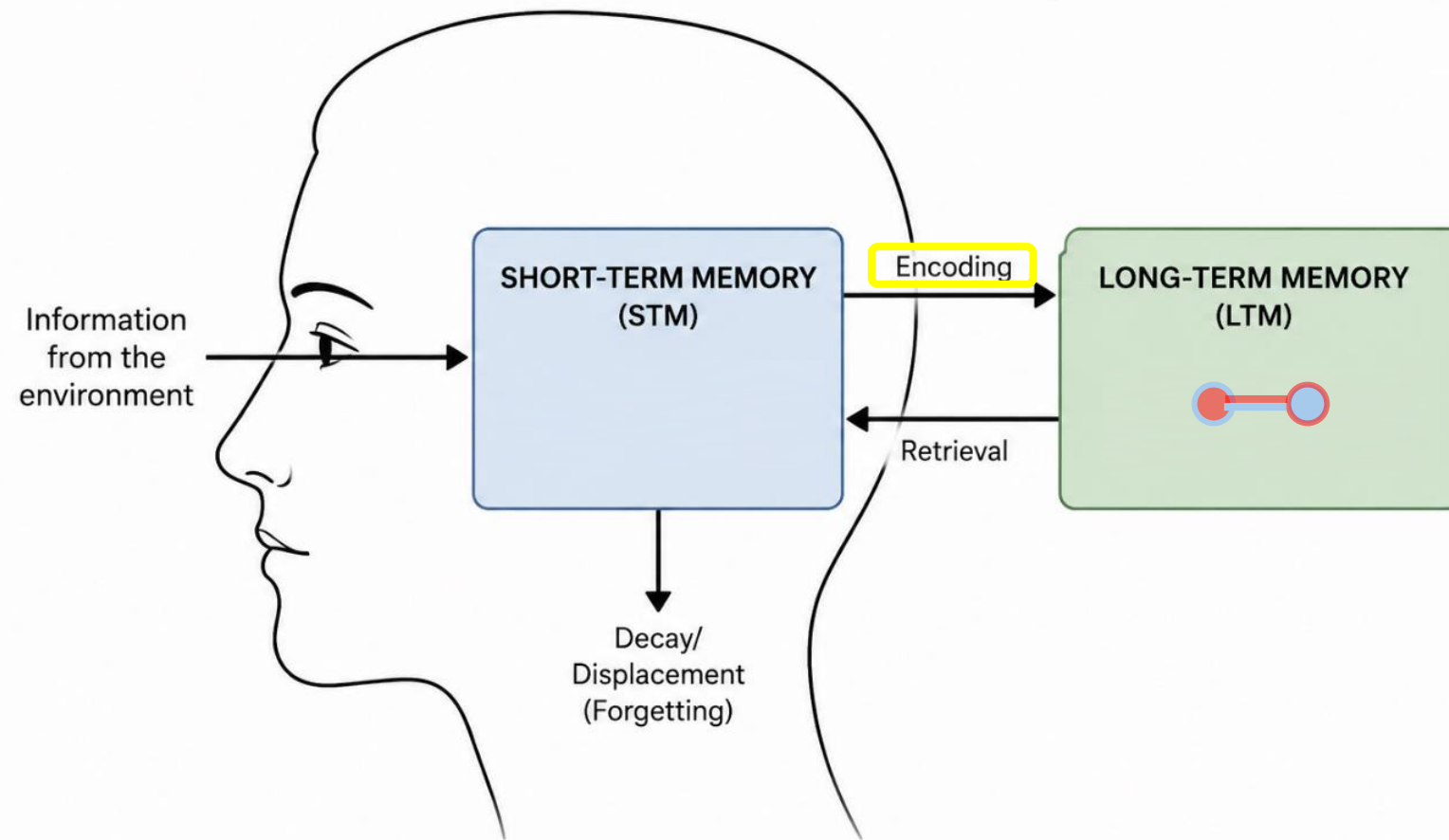
Atkinson and Shiffrin's Multi-Store Model of Memory



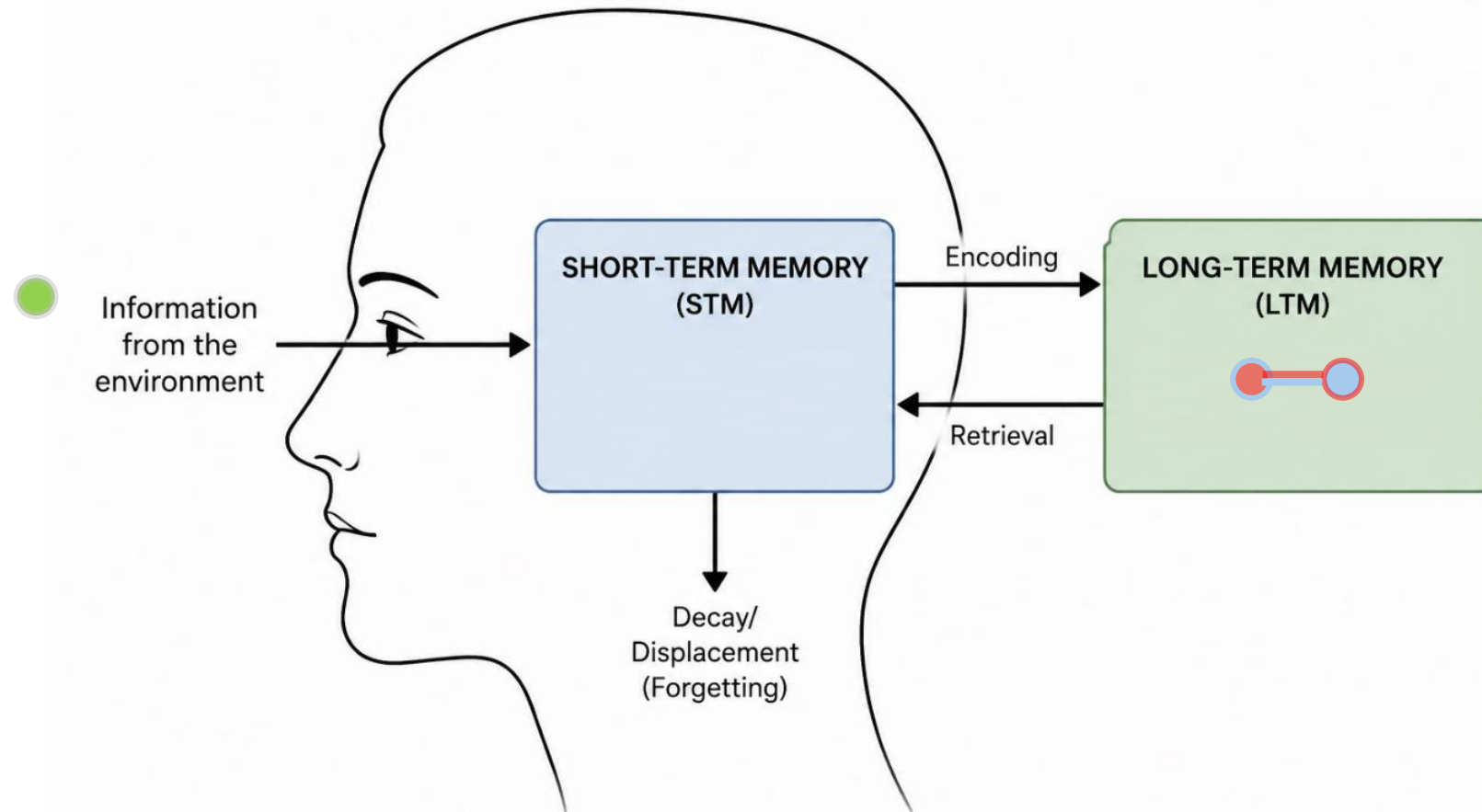
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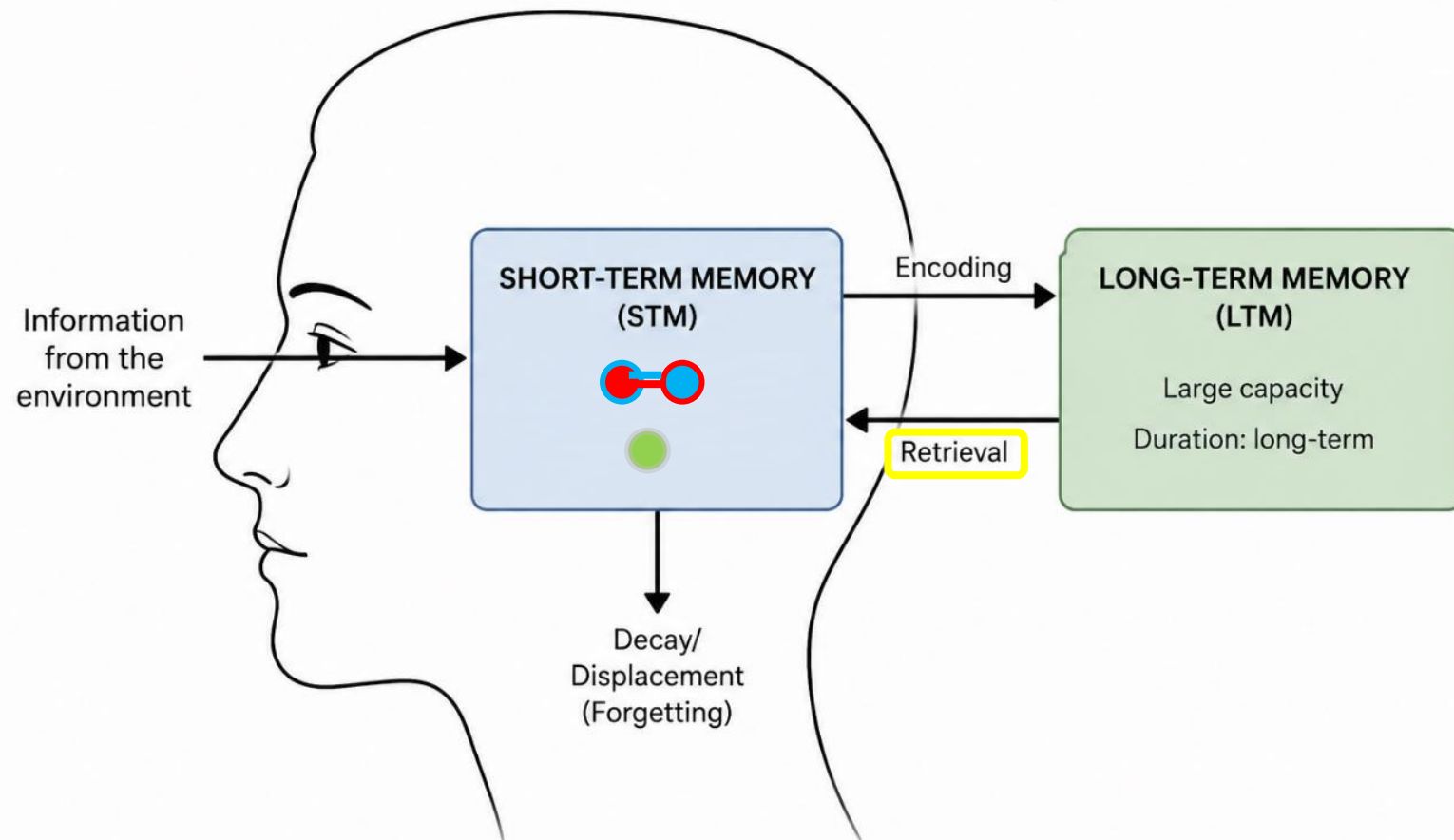
Atkinson and Shiffrin's Multi-Store Model of Memory



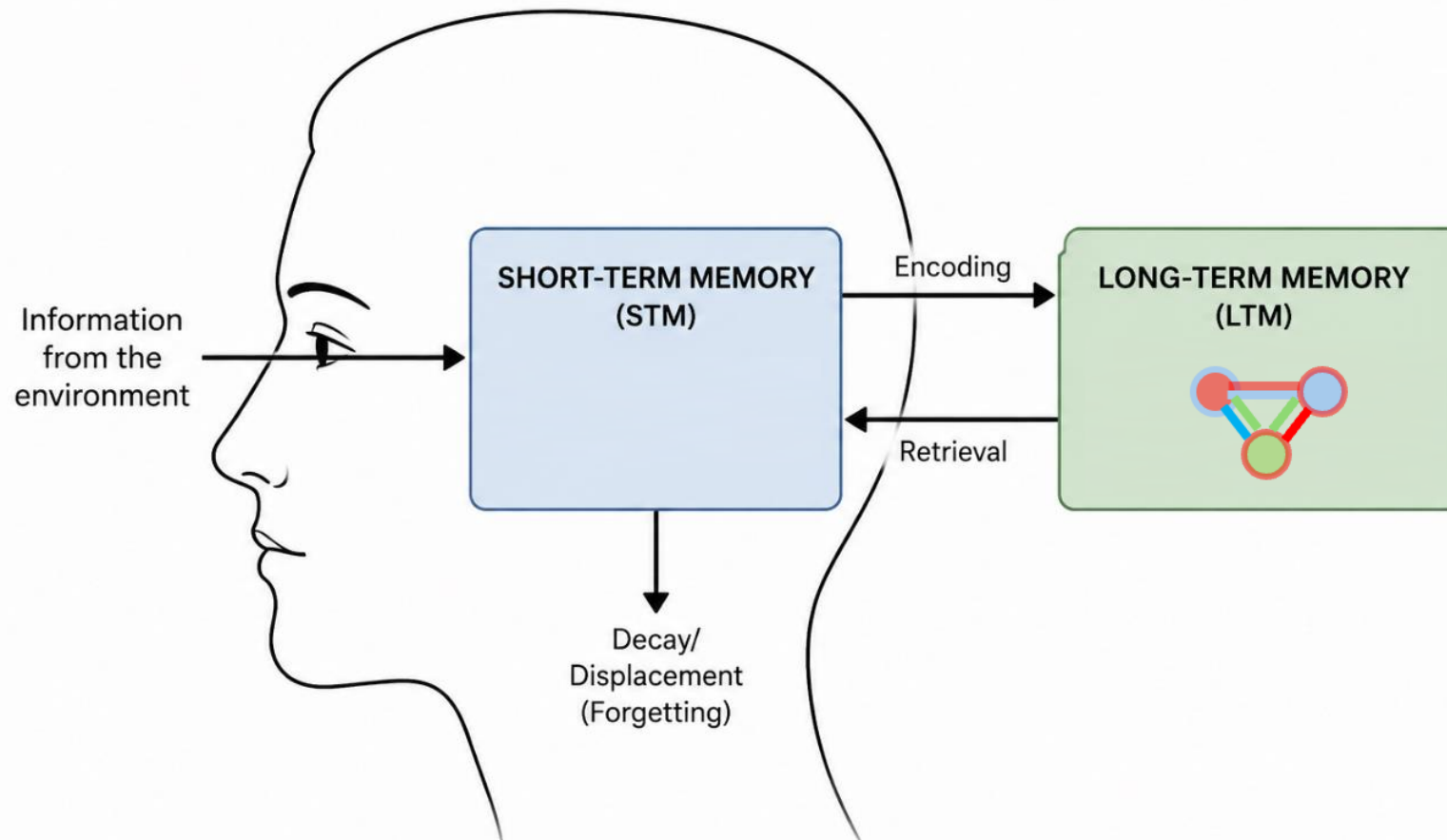
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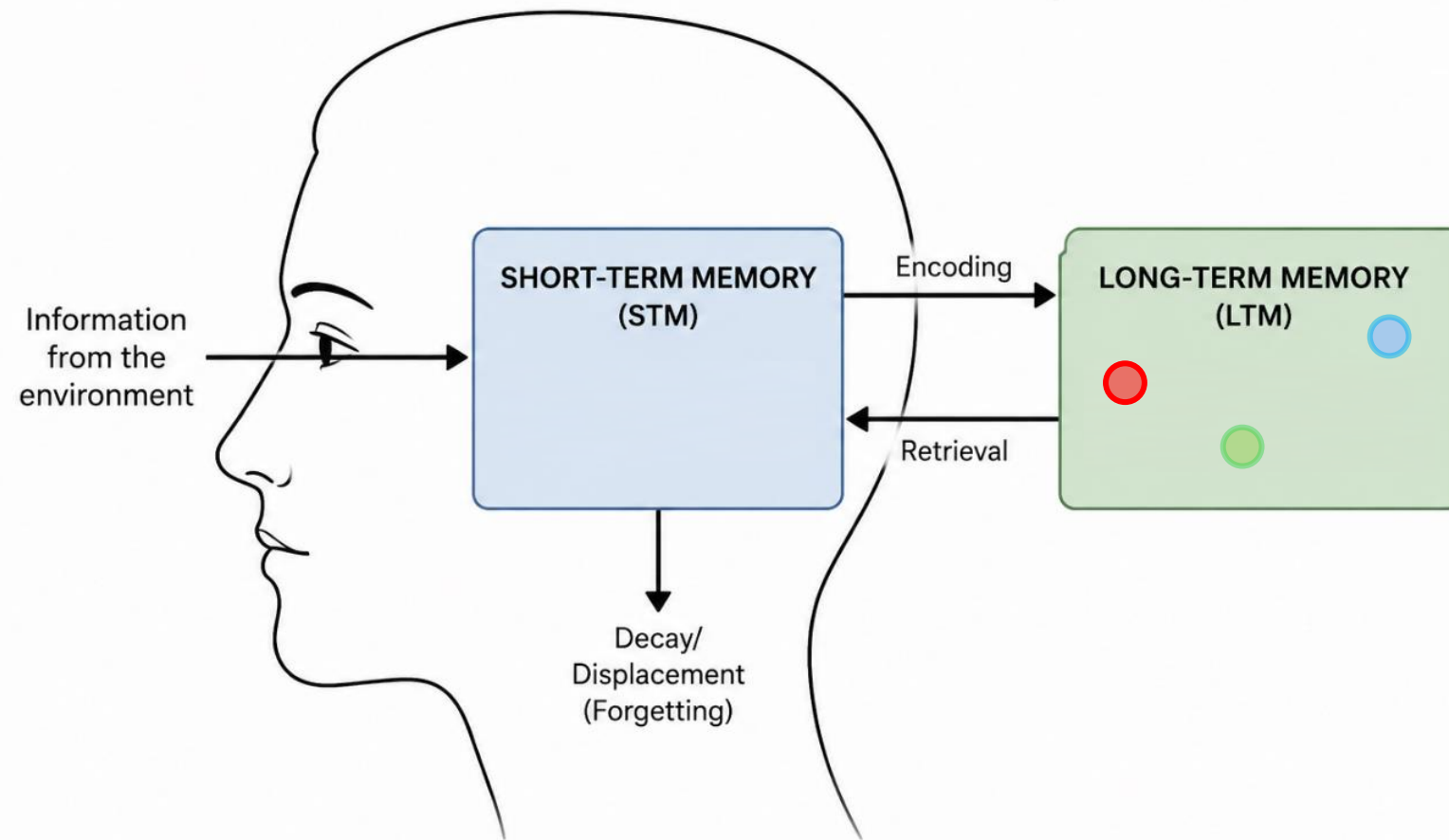
Atkinson and Shiffrin's Multi-Store Model of Memory



Atkinson and Shiffrin's Multi-Store Model of Memory



Atkinson and Shiffrin's Multi-Store Model of Memory



AI-Mode

AI-Mode

Students may performe in the short run. They can recall isolated, fragmented pieces of knowledge. But the connections between these pieces of knowledge are missing. When they encounter the same information again, they have to learn it all over again from scratch. In cognitive science, we would say: No schema formation is taking place here.



Deep dive into research



learning vs performance soderstrom



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National Institutes of Health (NIH) | (.gov)

<https://pubmed.ncbi.nlm.nih.gov> › ...



Learning versus performance: an integrative review

by NC Soderstrom · 2015 · Cited by 1148 — We review the extant literature in the motor- and verbal-
learning domains that necessitates the distinction between **learning** and **performance**. In addition,...



Sage Journals

<https://journals.sagepub.com> › doi



Learning Versus Performance: An Integrative Review

by NC Soderstrom · 2015 · Cited by 1148 — The time-honored distinction between **learning** and
performance dates back decades, spurred by early animal and motor-skills research that revealed that...



Bjork Learning and Forgetting Lab

<https://bjorklab.psych.ucla.edu> › sites › 2016/07

PDF



Learning versus Performance 1

by NC Soderstrom · Cited by 1148 — **Learning, however, must be distinguished from performance**,
which is what can be observed and measured during instruction or training.

41 pages

Learning Versus Performance: An Integrative Review

Nicholas C. Soderstrom and Robert A. Bjork

Department of Psychology, University of California, Los Angeles

Perspectives on Psychological Science
2015, Vol. 10(2) 176–199
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pps.sagepub.com



Generative AI without guardrails can harm learning: Evidence from high school mathematics

[Hamsa Bastani](#) , [Osbert Bastani](#), [Alp Sungu](#)  ,  , and [Rei Mariman](#) [Authors Info & Affiliations](#)

Edited by Emma Brunskill, Stanford University, Stanford, CA; received November 3, 2024; accepted May 5, 2025 by Editorial Board Member Mark Granovetter

June 25, 2025 | 122 (26) e2422633122 | <https://doi.org/10.1073/pnas.2422633122>

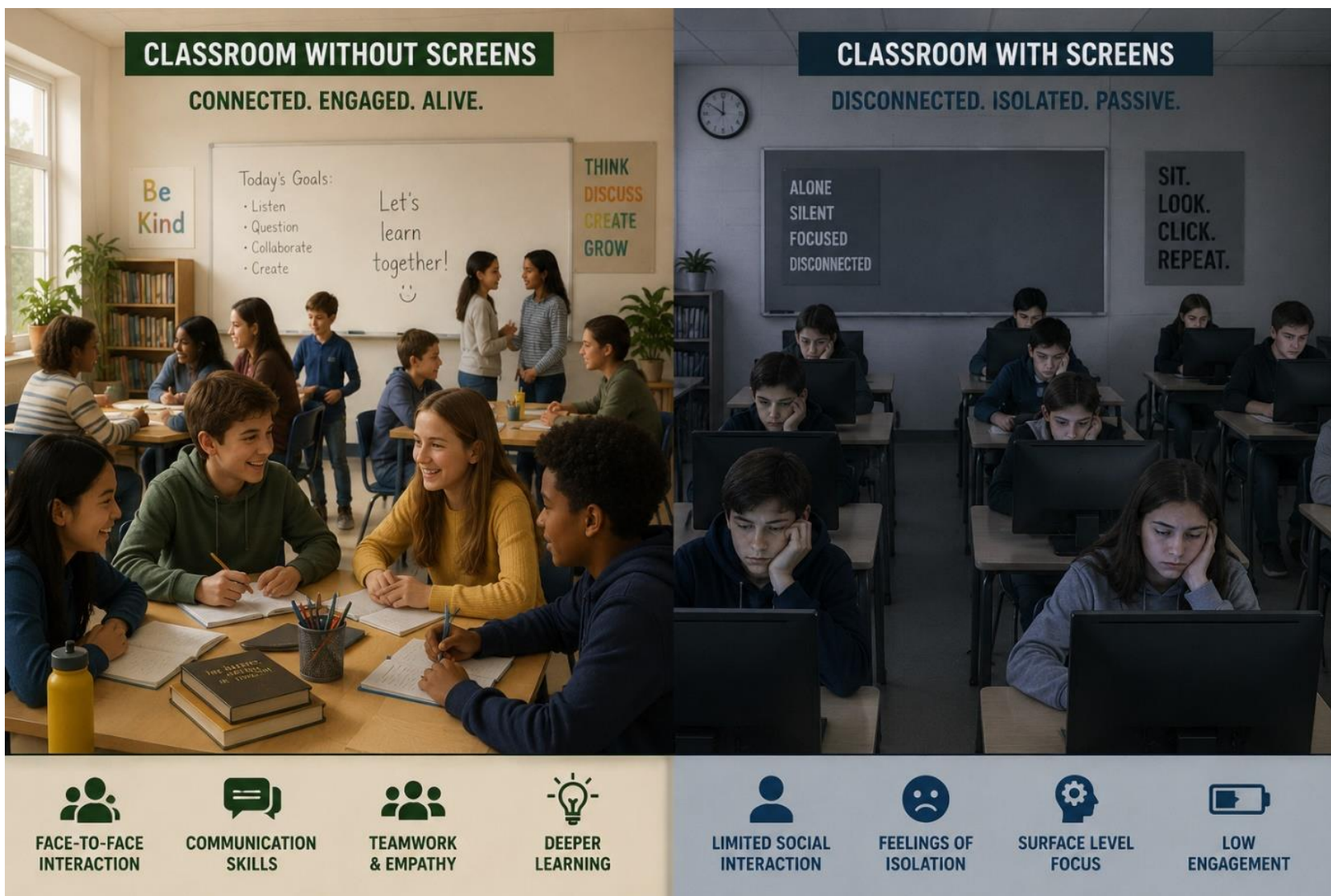
**By now, one might get the impression that we're
listening to a conversation ...**



... we should know better:



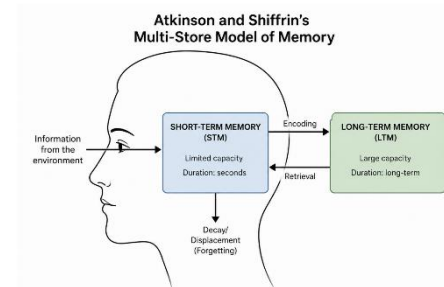
The human element is definitely missing here!



And this holds true for the classroom as well.

ED-Tech advocates like to point out:

**Interaction with an intelligent machine
makes it possible to personalize learning
paths.**



Humans' cognitive architecture does not differ from person to person.

That's hard-wired by evolution.



Deep dive into research



🔍 Rogowsky, learning style preferences

🔄 AI Mode



APA PsycNet

<https://psycnet.apa.org> › record



Providing instruction based on students' learning style ...

by BA Rogowsky · 2020 · Cited by 214 — **Providing instruction based on students' learning style preferences** does not improve learning. Citation. Rogowsky, B. A., Calhoun, B. M., & Tallal, P...



ResearchGate

<https://www.researchgate.net> › ... › Learning Styles



(PDF) Providing Instruction Based on Students' Learning ...

14 Feb 2020 — **Visual, auditory, and kinesthetic learning preferences** are among the most widely used approaches for explaining variations in how students ... [Read more](#)



Providing Instruction Based on Students' Learning Style Preferences Does Not Improve Learning

Beth A. Rogowsky^{1*}, Barbara M. Calhoun² and Paula Tallal^{3,4}

¹Department of Teaching and Learning, Bloomsburg University of Pennsylvania, Bloomsburg, PA, United States,

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Rutgers University, Newark, NJ, United States, ⁴Center for Human Development, University of California, San Diego, San Diego, CA, United States

Teachers commonly categorize students as visual or auditory learners. Despite a lack of empirical evidence, teaching to a student's perceived learning style remains common practice in education (Pashler et al., 2009). Having conducted an extensive review of the literature,

Extensive use of AI tools in the classroom carries the risk of isolating students.



Social interaction among peers is important for learning.

For example: Students must first **test and rehearse their ideas in a safe environment** with peers.



Deep dive into research

“All Roads Lead to ChatGPT”: How Generative AI is Eroding Social Interactions and Student Learning Communities

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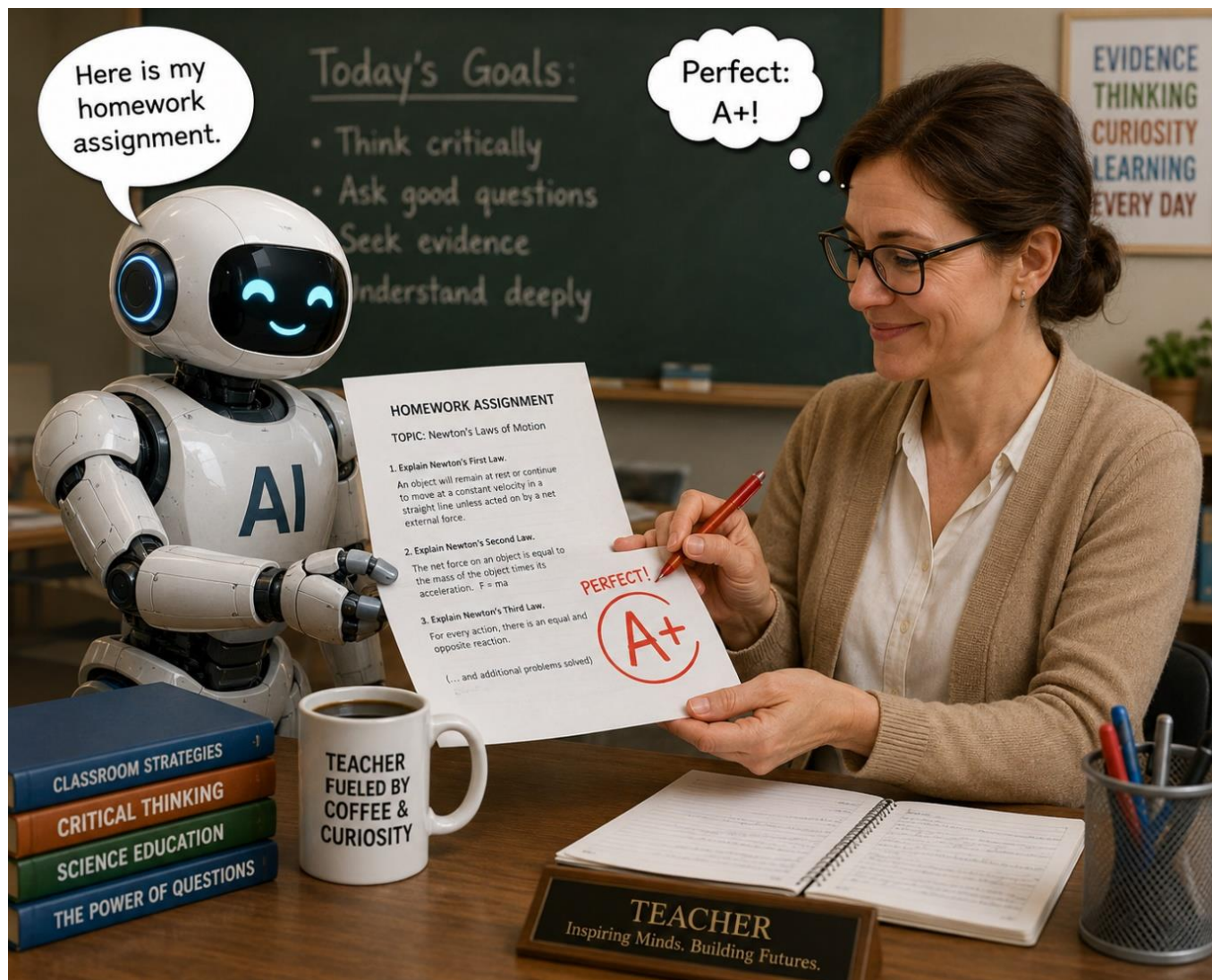
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Least but not last ...

Grading homework that students complete unsupervised is obviously pointless in the age of AI.





Deep dive into research



 AI learning, Chinese Secondary Education, Strömberg

 AI Mode

$N > 25\,000$ students

$T > 2$ years

The Generative AI Learning Penalty: Evidence from Chinese Secondary Education*

David Strömberg[†]

Victor Lei[‡]

Yanhui Wu[§]

June 2026

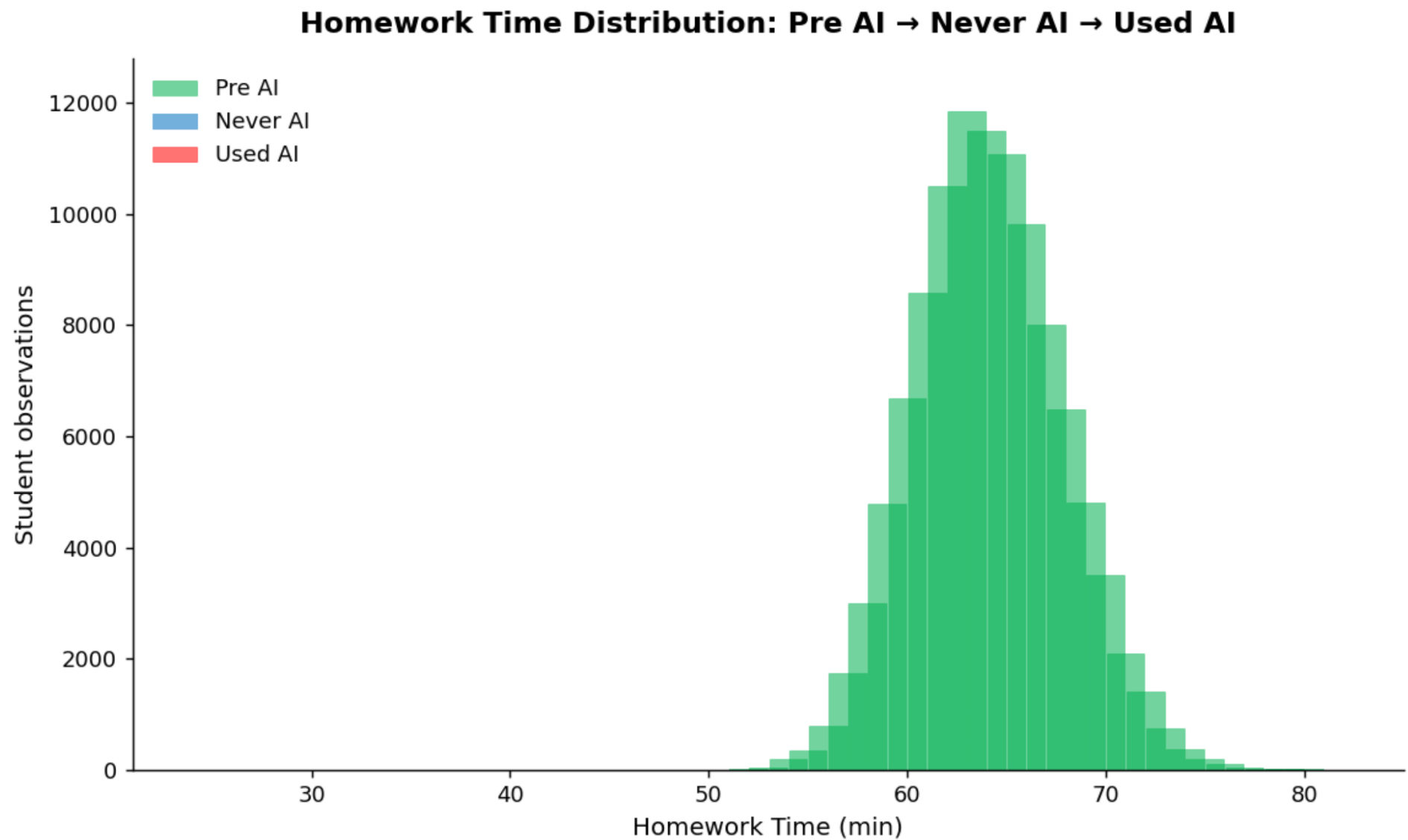
Abstract

Using 30 months of panel data on 26,811 Chinese students in grades 7–12, we study how generative AI affects homework productivity and learning. The data combine monthly closed-book exams, high-school and college entrance exams, and homework scores and completion time across nine subjects. We exploit staggered AI adoption in a difference-in-differences design. AI adoption raises homework scores by 18% and reduces completion time by 30%, but lowers monthly exam scores by 20% within six months. High-stakes entrance-exam scores fall by 18 and 24%, with the full penalty emerging only after about two

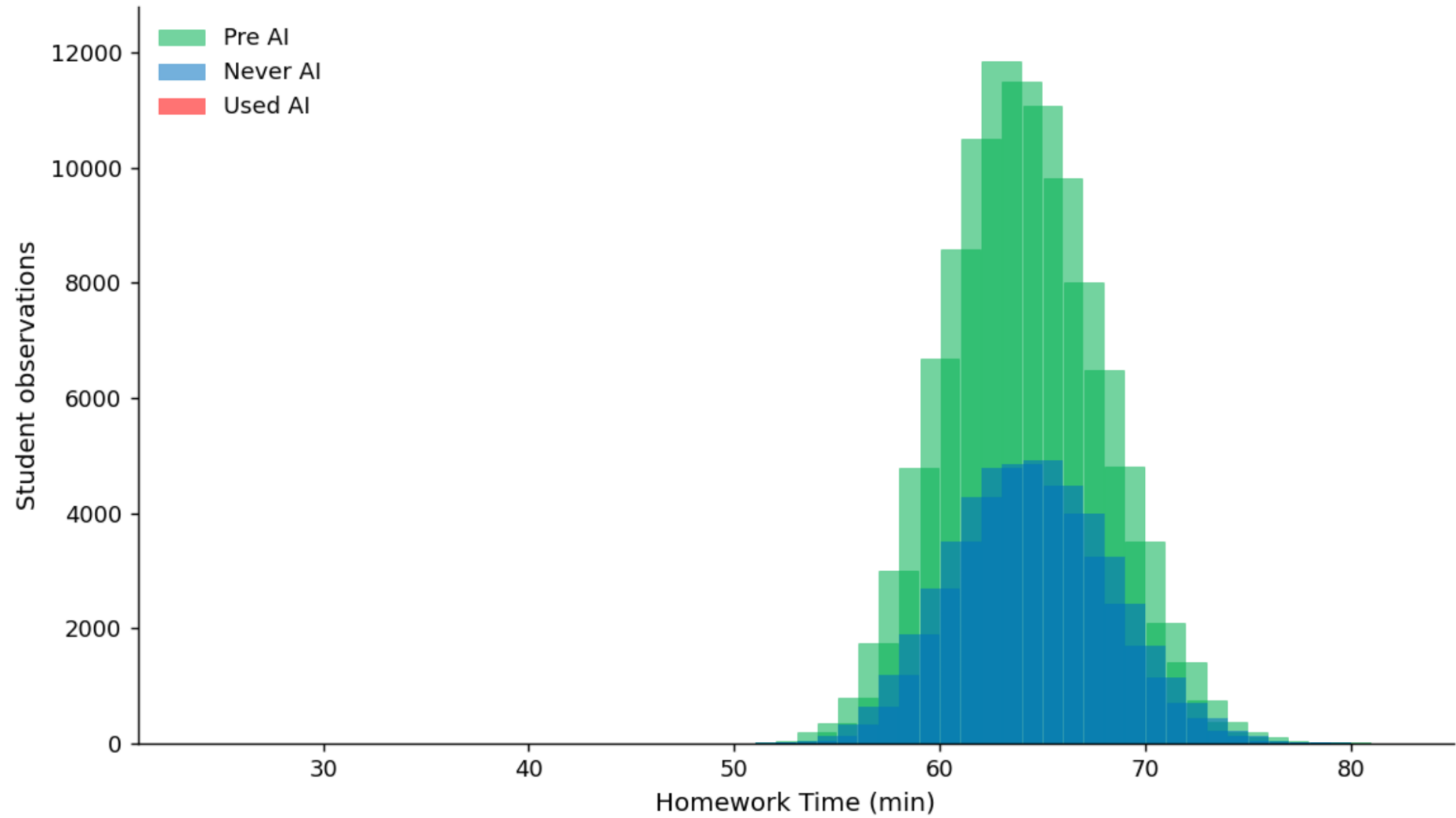
The researchers state plainly that ...

“... our findings show that generative AI, which is likely to become a prevalent technology for education, ***has a substantial negative impact on student learning.***”

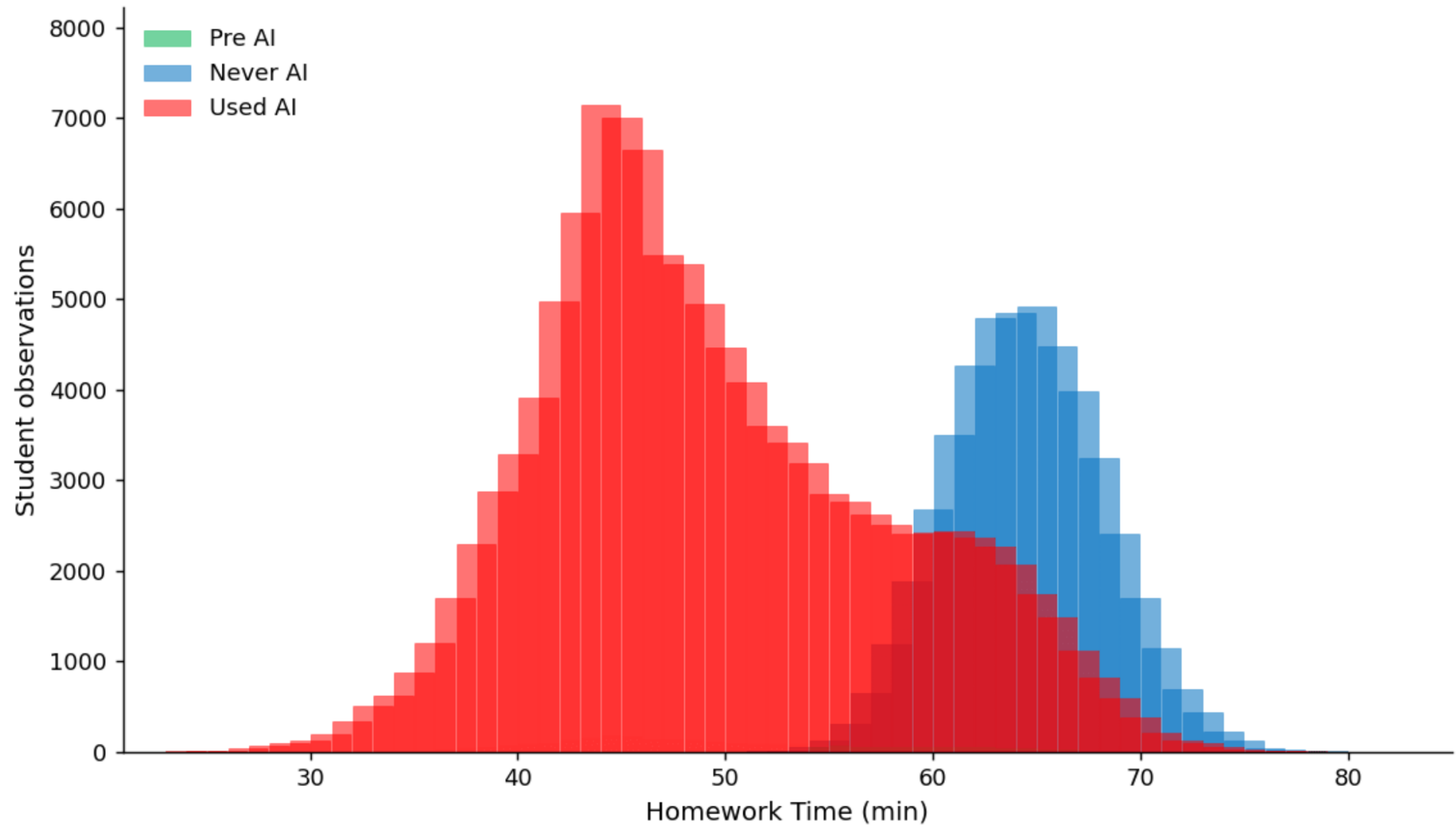
1) What is the impact of AI on the amount of *time* that students spend on their homework?



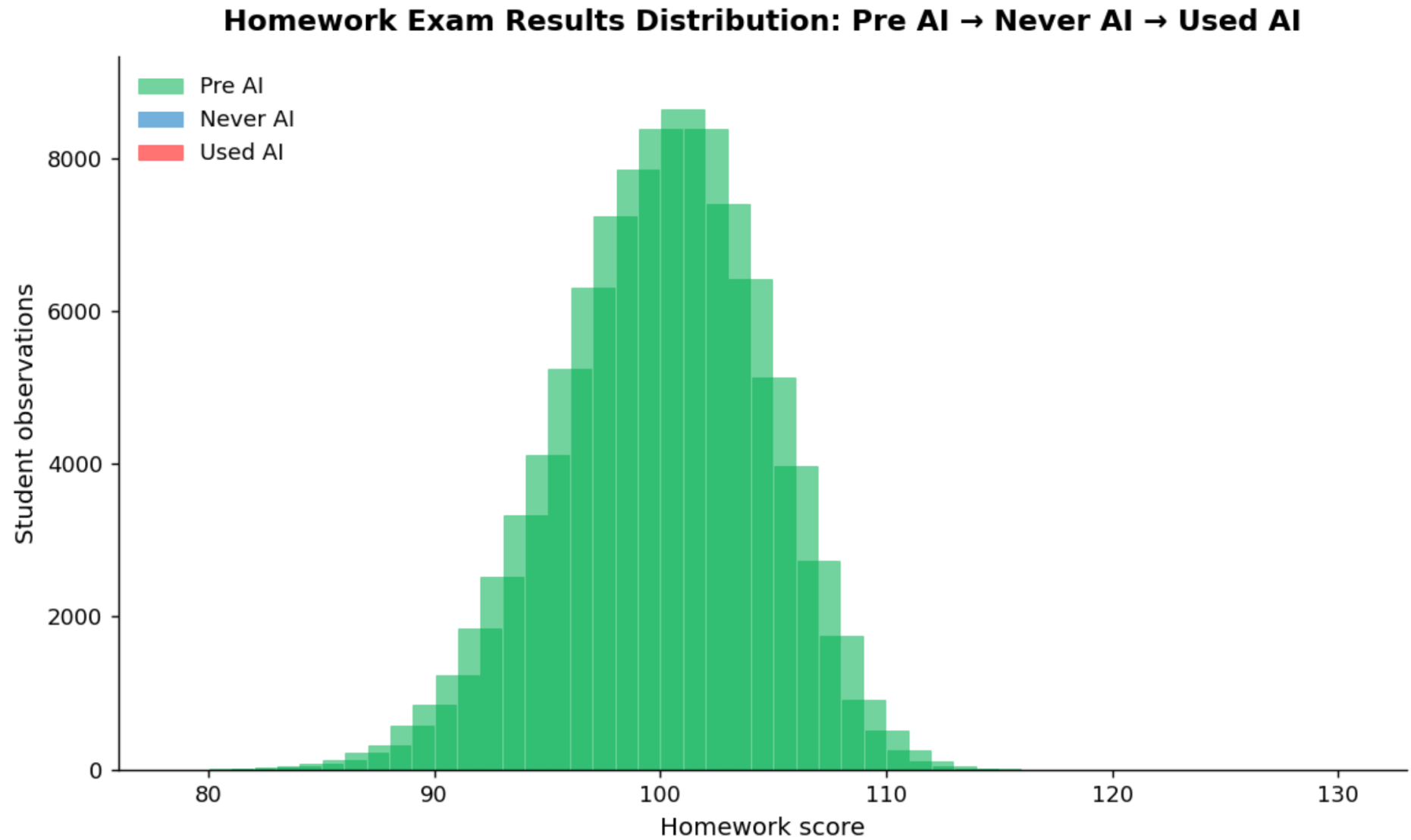
Homework Time Distribution: Pre AI → Never AI → Used AI



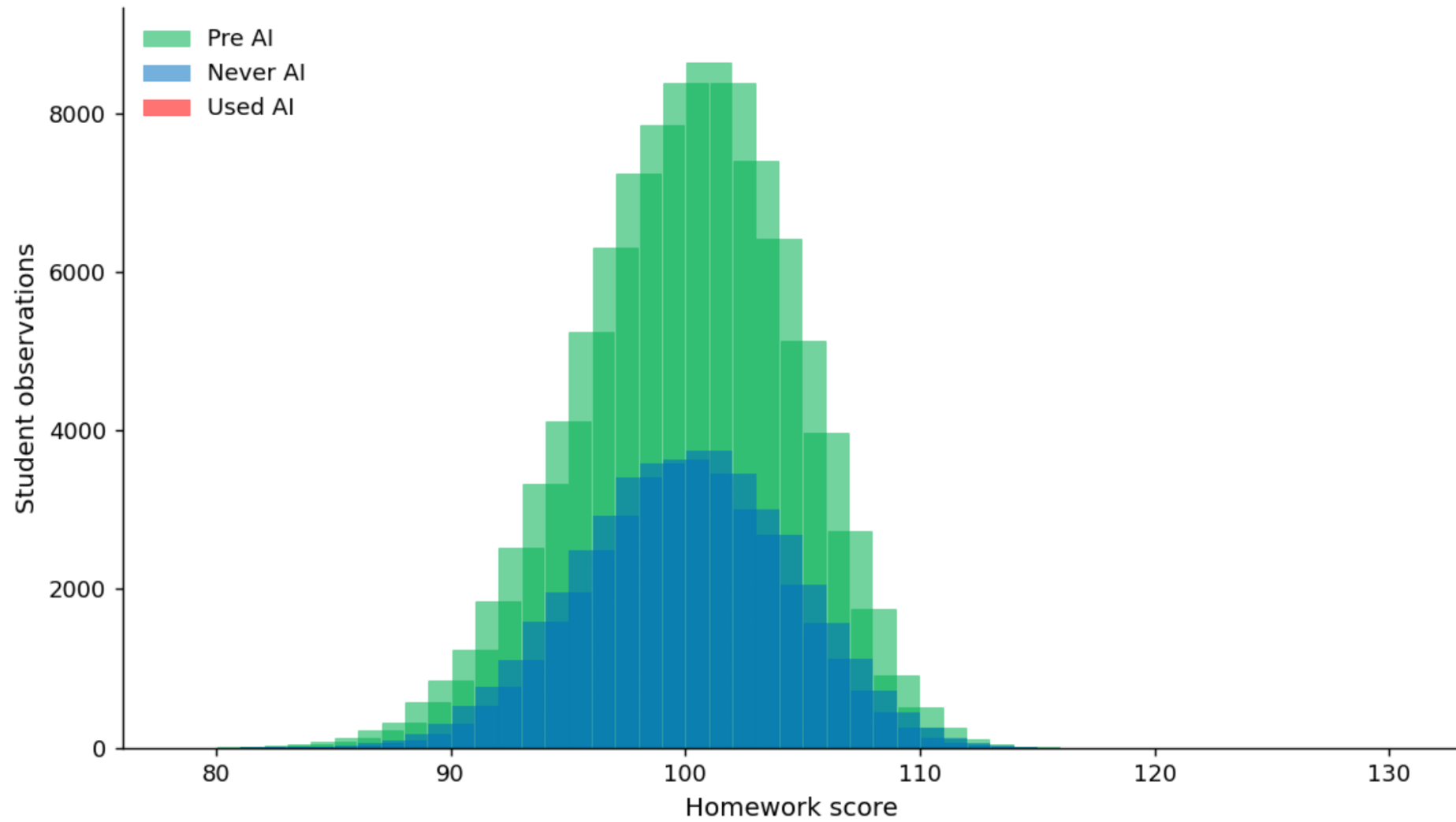
Homework Time Distribution: Pre AI → Never AI → Used AI



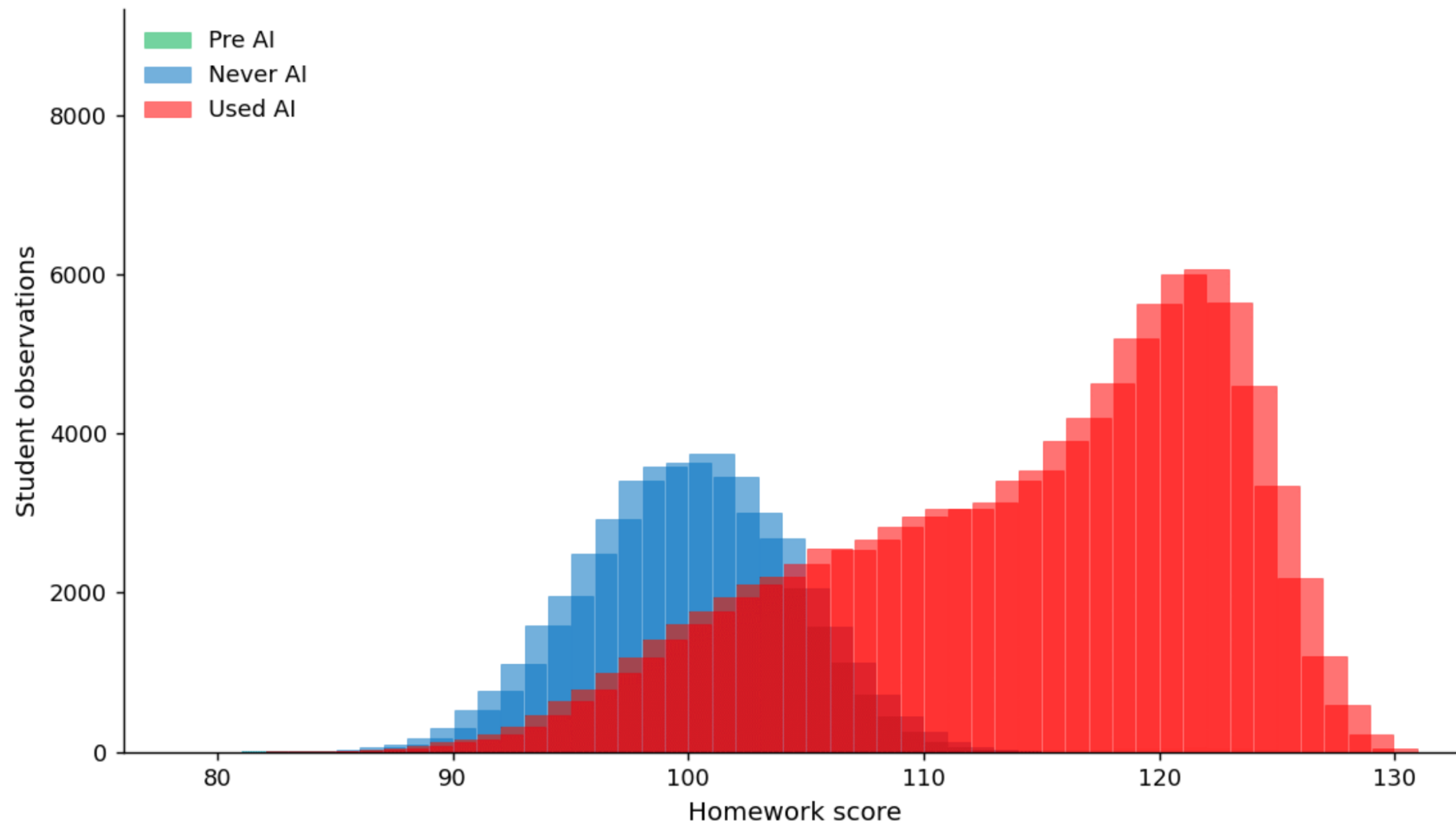
2) What is the impact of AI on how students score on their homework?



Homework Exam Results Distribution: Pre AI → Never AI → Used AI

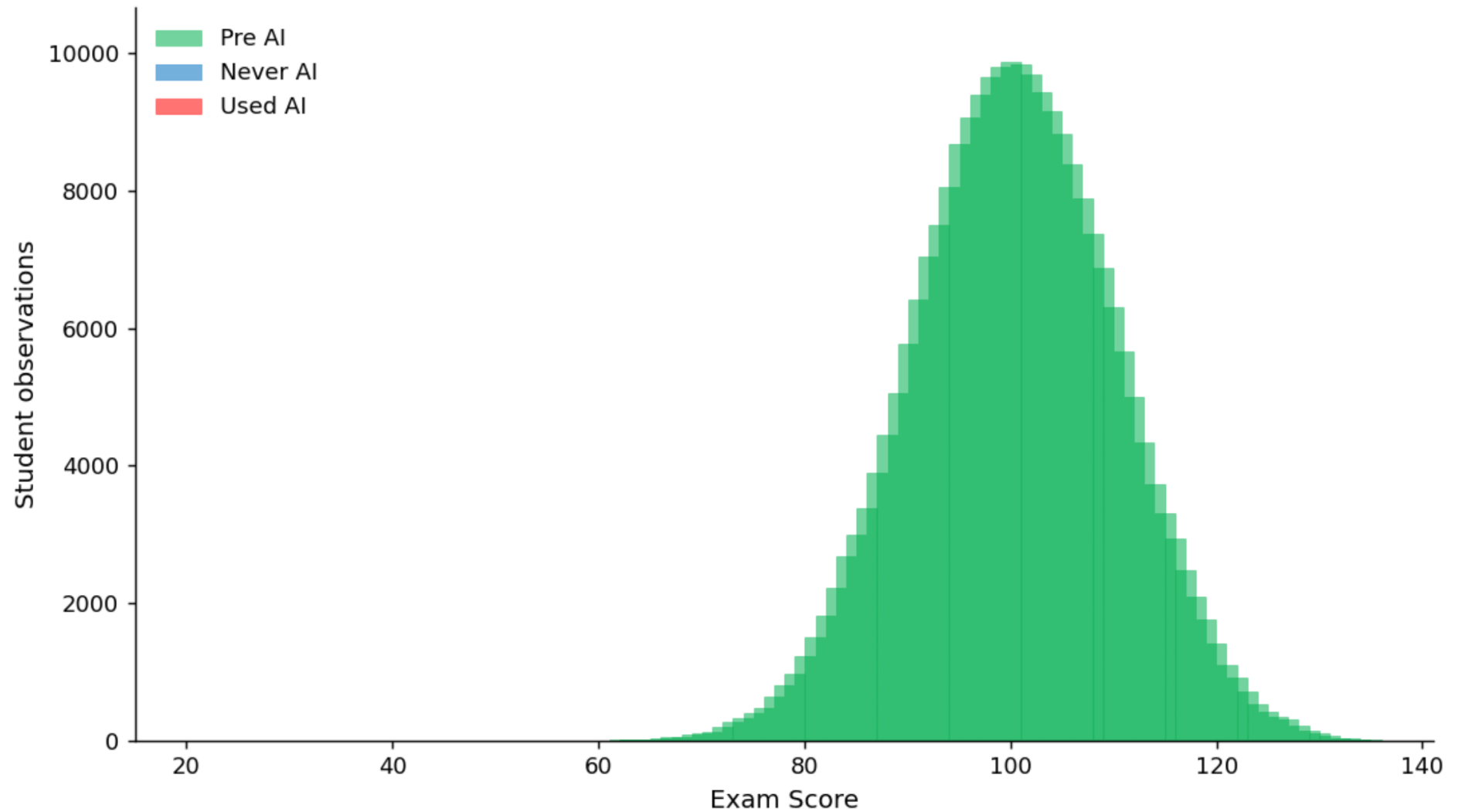


Homework Exam Results Distribution: Pre AI → Never AI → Used AI

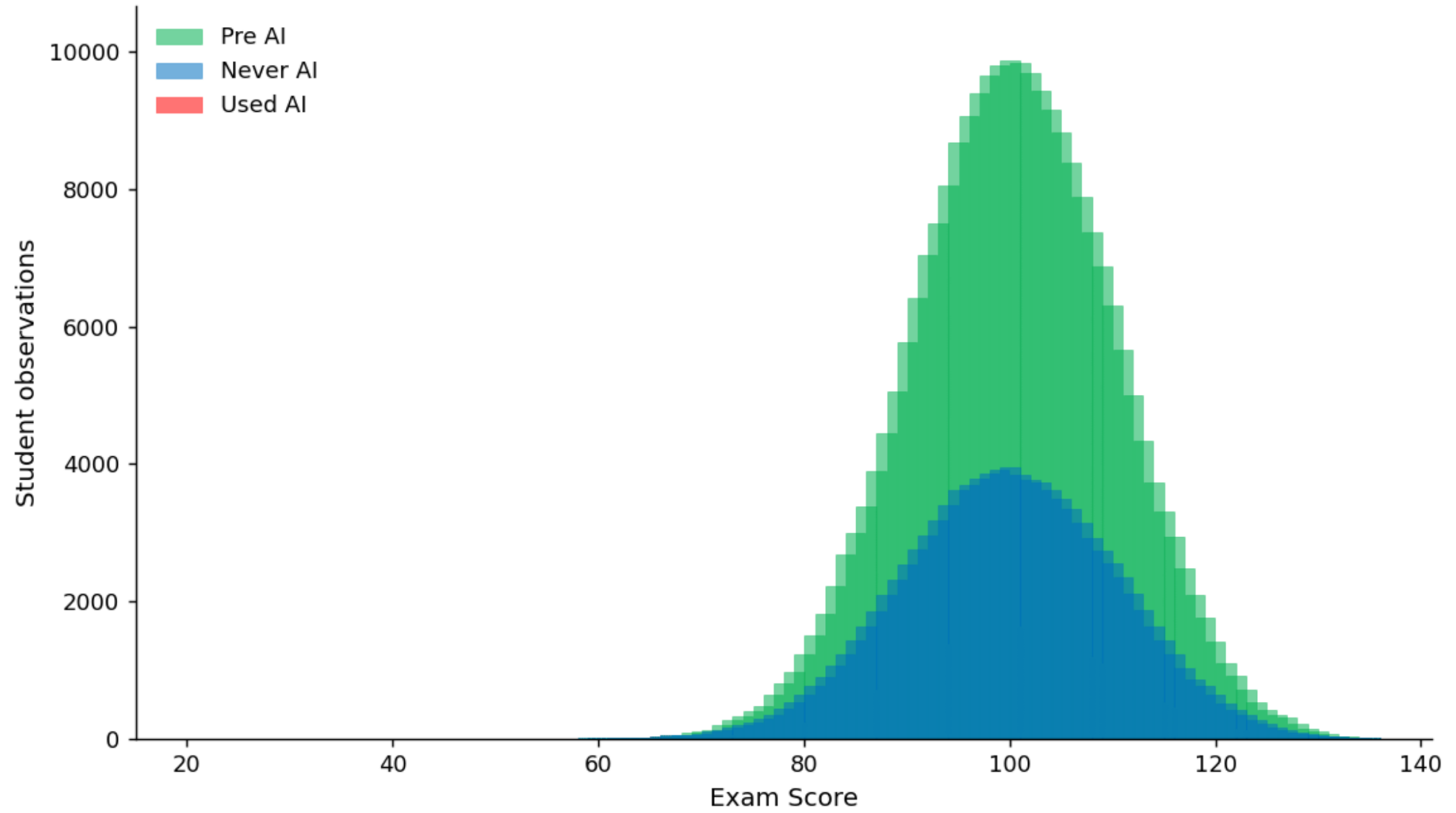


3) What is the impact of AI on how students perform on closed-book exams?

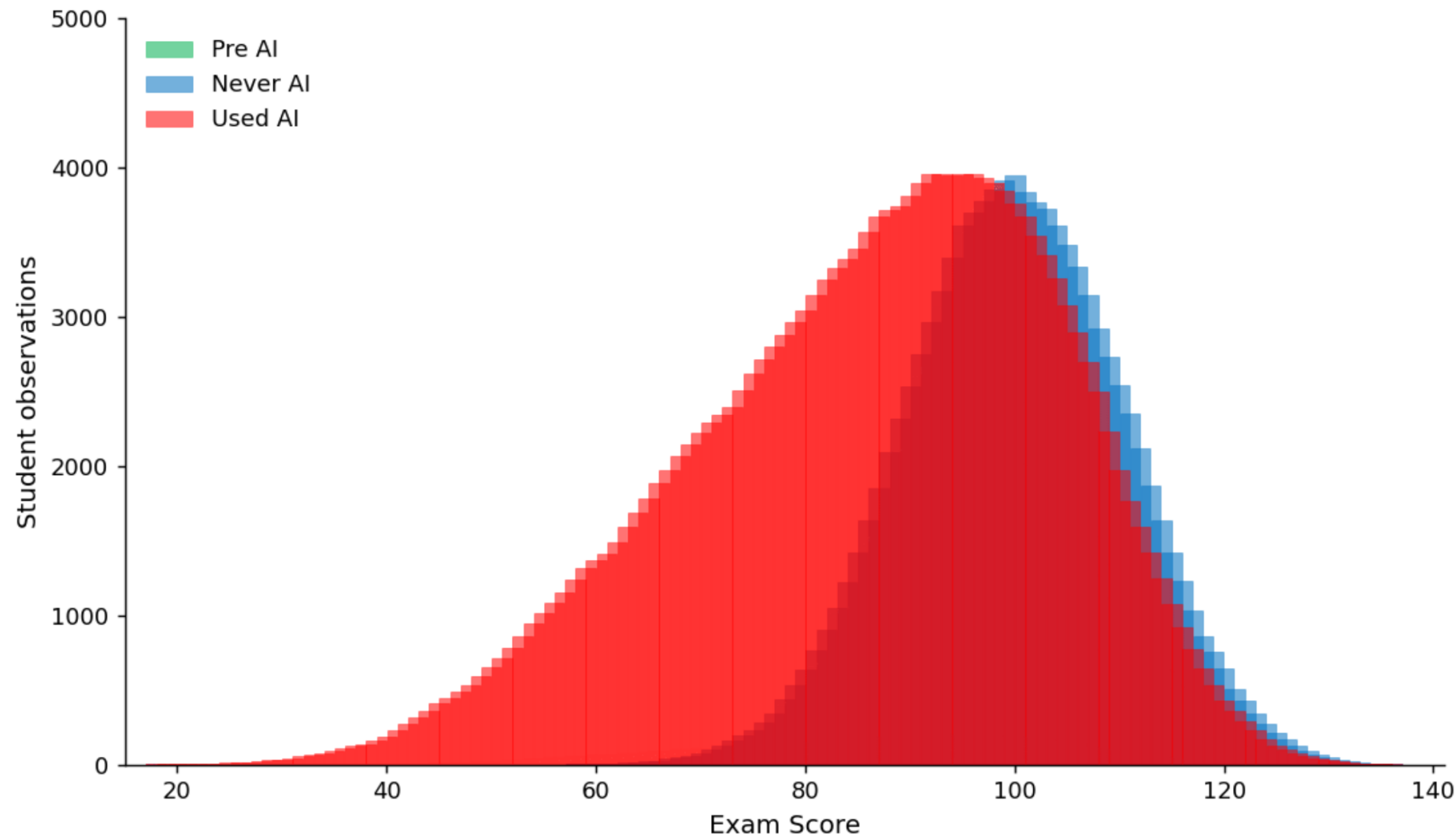
Exam Results Distribution: Pre AI → Never AI → Used AI



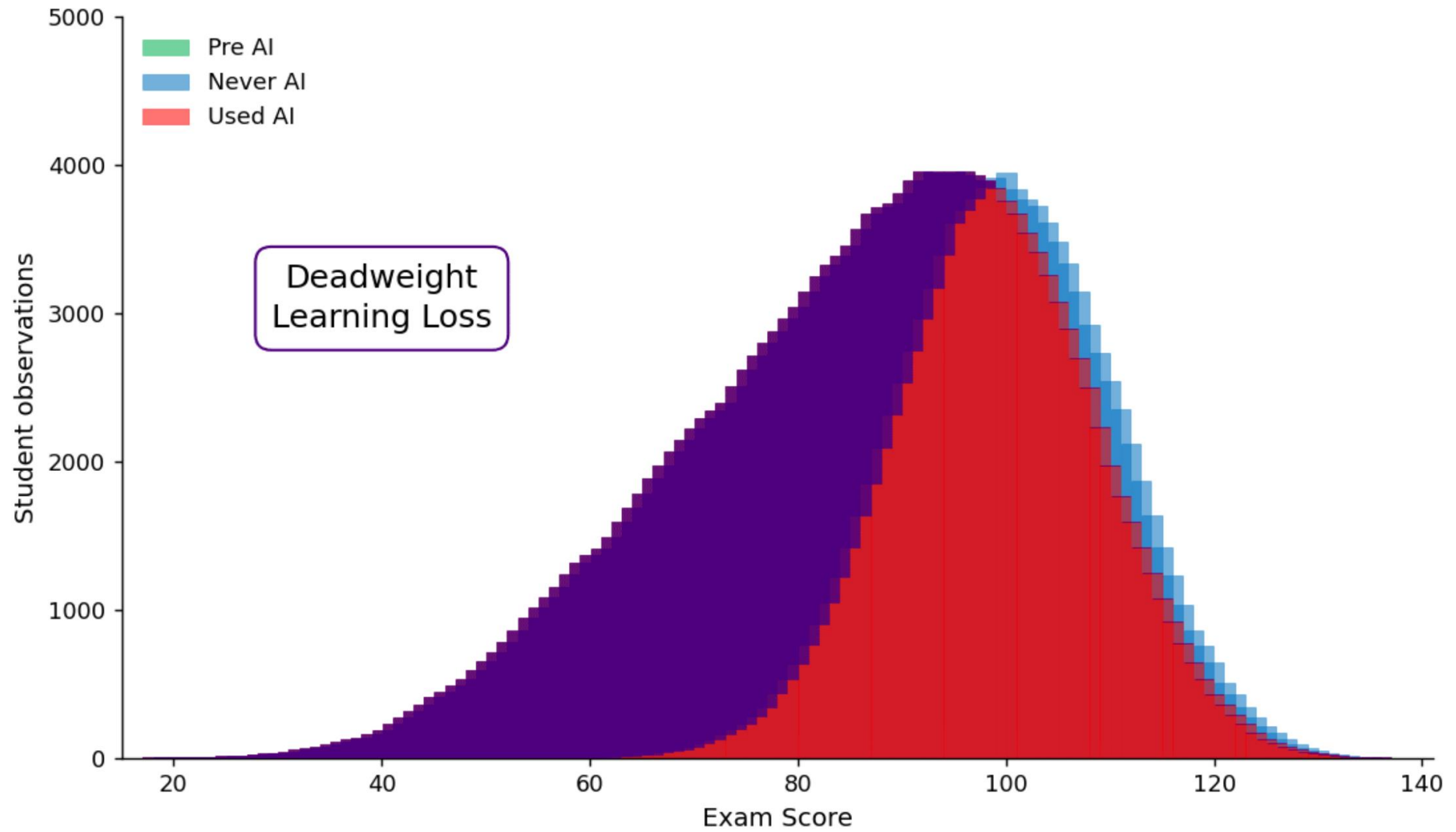
Exam Results Distribution: Pre AI → Never AI → Used AI



Exam Results Distribution: Pre AI → Never AI → Used AI



Exam Results Distribution: Pre AI → Never AI → Used AI



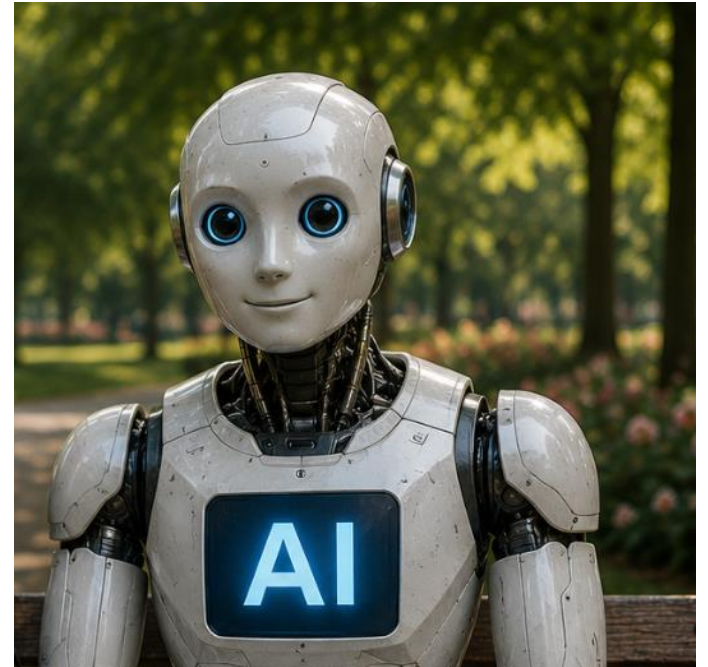


So, this is the story of
a generation of kids
who are told that **AI is**
“inevitable” and
“their future”!

That exchange
didn't exactly
look like a
dialogue, did it?



So I'll give the
talk myself.



ChatGPT



 New chat

 Library

What can I help with?

What are the benefits of using generative AI in education?



Instant ▾



What are the benefits of using generative AI in education?



I got a nice list with 10 bullet points—so let's go through it:



Okay. Let's go through
your list.

I will use the following
simple color-coding:

Red: dangerous

Orange: maybe

Green: Give it a try!

Major potential benefits

1. Individualized explanations and tutoring

AI can explain the same concept in different ways, adjust the level of difficulty, provide additional examples, or respond to a student's particular misunderstanding. This approximates some aspects of one-to-one tutoring, although it does not replicate the diagnostic expertise of a skilled teacher.

Social interaction among students is important.

2. Immediate feedback

Students do not necessarily have to wait for a teacher to respond. AI can comment on an explanation, identify weaknesses in an argument, suggest where reasoning is incomplete, or generate questions that help the learner reconsider an answer.

Robert Bjork: **Desirable Difficulties – “Reduced Feedback”**

3. Opportunities for deliberate practice

Generative AI can produce almost unlimited practice material: problems, worked examples, quizzes, retrieval questions, variations of a problem, or increasingly difficult tasks. This can be especially useful when the teacher specifies exactly what students should practise.

Yes! Further reading: **K. Anders Ericsson & Deliberate Practice**

4. Dialogue and active thinking

Used appropriately, AI can become a *thinking partner* rather than an answer machine. For example, students can be asked to defend a claim while the AI challenges their reasoning, presents counterarguments, or takes the role of a skeptical opponent.

Social interaction ...

5. Support for metacognition

AI can prompt students to explain *why* they gave an answer, compare alternative solutions, assess their confidence, identify what they do not yet understand, or reflect on how they solved a problem.

Most of our students lack the necessary maturity for this.

6. Accessibility and differentiation

AI can simplify difficult language, provide vocabulary support, translate material, generate examples at different levels, or help students with particular linguistic or educational needs gain access to material that might otherwise be difficult for them.

Probably ...

7. Support for teachers

This may be one of the strongest applications. Teachers can use generative AI to generate examples, alternative explanations, diagnostic questions, lesson ideas, assessment items, rubrics, differentiated tasks, sample misconceptions, or draft feedback. The teacher retains professional judgment while AI reduces some of the preparation workload.

YES! YES! YES!

8. Rapid creation and adaptation of educational materials

A teacher can quickly turn one task into five variants, adapt a text for different reading levels, create a new context for the same physics problem, or generate distractors based on common misconceptions.

YES! YES! YES!

9. Creative and exploratory learning

Students can use AI to simulate dialogues, explore hypothetical situations, brainstorm possible explanations, compare perspectives, or rapidly test ideas. This can broaden the space of possibilities available for investigation.

Exploratory learning ...

Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching

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10. AI literacy itself

Students will encounter generative AI outside school and in future workplaces. Education therefore provides an opportunity to teach them how to question AI outputs, verify claims, recognize hallucinations and bias, and decide **when AI should—and should not—be used.**

Not during school hours! But as (ungraded!) homework.

The teacher will check during the next classroom session to see if the students have understood the material.

Thank you.

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