Building Human Intelligence in a World of AI: Insights from the Learning Sciences

Barbara Means

Keynote presentation for eCOTS 2026
"Sparking Joy and Discovery In a World of AI"

June 17, 2026

Digital Promise®

AI in Headlines


THE SUNDAY GUARDIAN 20 | SUPPLEMENT TO THE SUNDAY GUARDIAN | 30 JUNE-06 JULY 2019 | NEW DELHI

Artificial intelligence can revolutionise education

The role of technology is becoming more and more central to our educational infrastructure, with AI-powered systems transforming the way we teach and learn. This is the age of the hi-tech classroom.


ET THE ECONOMIC TIMES

January 28th Sunday, 2024

What AI Means for the Future of Education


Don't Outsource Your Brain To AI.
It'll Kill Critical Thinking & Creativity


Reform educational system to incorporate AI

• Global initiative advises developing countries


Business Standard BENGALURU | WEDNESDAY, 7 JUNE 2023

Teachable moments for ChatGPT

Instead of an outright ban, schools in India's megacities are discussing how students and teachers can maximise the use of this generative AI tool


OCTOBER 26, 2023 | PRICE: $2.50

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WEATHER CLOUDY, HIGH 58°F

STUDENTS' FAVORITE TEACHER: CHAT GPT


AI-Ready Education: How Effective Technology Implementation Can Drive Better Learning Experiences


SEE PAGES 18-19

A.I. 'COULD WIPE OUT HUMANITY'

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AI Survey Data

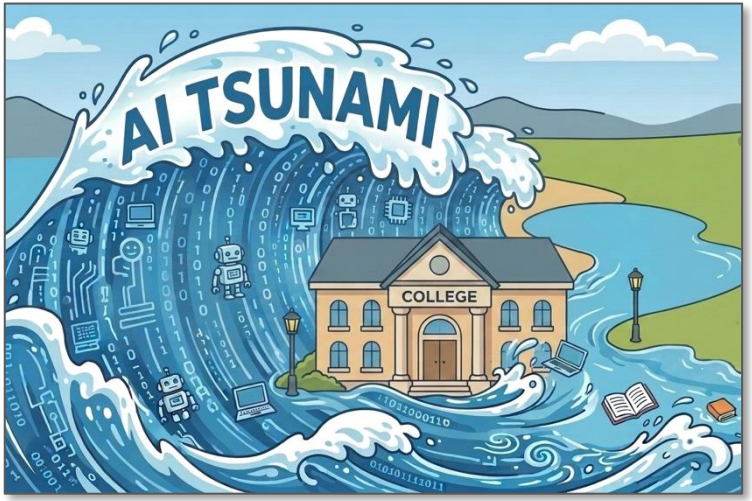


Image by Gemini

- In 2025 **92%** of undergrads reported using gen AI tools for course work, up from 66% the prior year. [a]
- **57%** of college students reported using AI for their schoolwork daily or weekly. [b]
- **64%** of students in a large higher ed system with universal AI access reported that it had positively affected their learning. [c]
- Yet only **34%** of students reported that it's easier to interact with gen AI than with their instructor. [d]

[a] Freeman (2025)
[b] Gallup & Lumina Foundation (2026)
[c] The California State University (2025)
[d] Ravsˇelj et al. (2025)

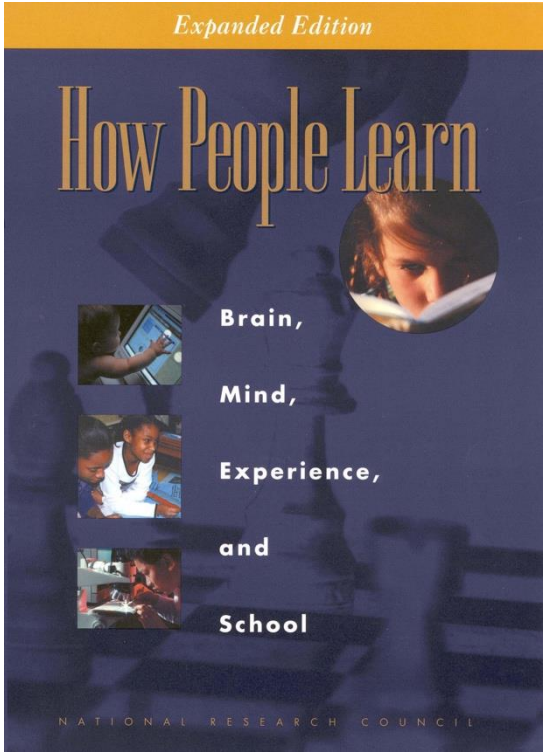
Common Student-Reported Uses of AI

Image by Gemini

- Generate answer
- Provide content summary
- Simplify (restate) complex information
- Personal tutor/study partner to answer questions about concepts or procedures
- Generate formative assessments for self-testing
- To locate sources, data sets
- Brainstorm ideas for writing assignment
- Generate written product
- Edit written product

What implications does student use of generative AI have for learning and instruction?

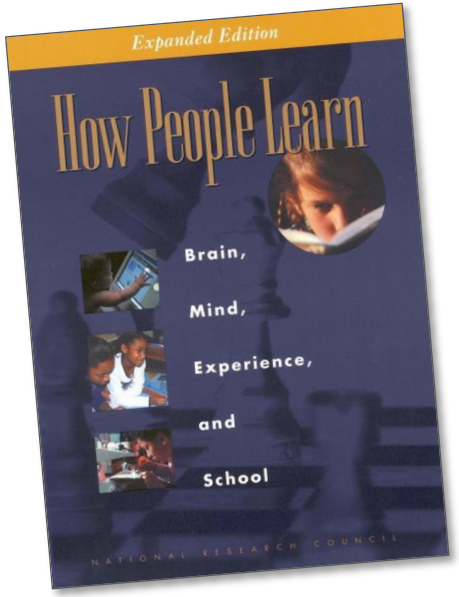
How People Learn I (2000)

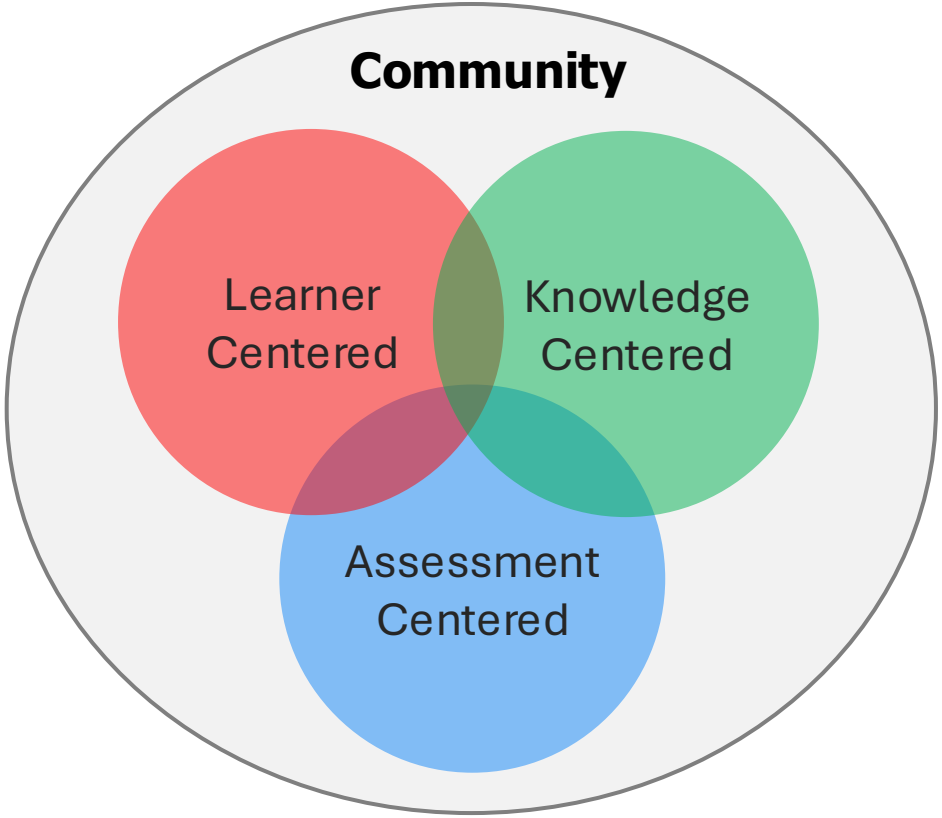


- Learning with understanding involves organizing information into conceptual frameworks that facilitate retrieval and support making inferences in new situations.
- Active learning involves using existing conceptual frameworks to make inferences, solve problems, assessing whether new information supports, connects, or clashes with what is already known.
- The organized conceptual frameworks of domain experts help them retrieve relevant information and apply it to new situations.

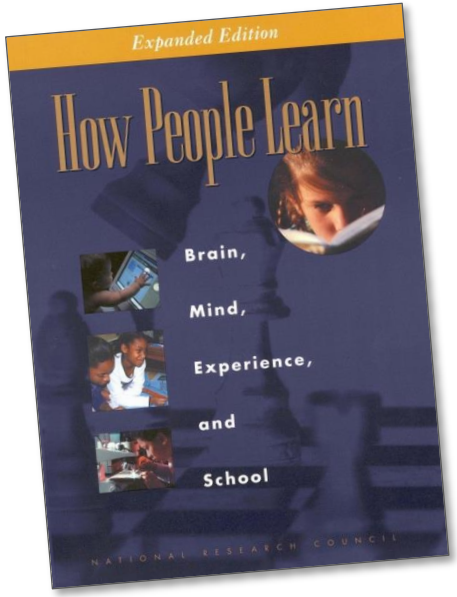
https://www.nationalacademies.org/publications/9853

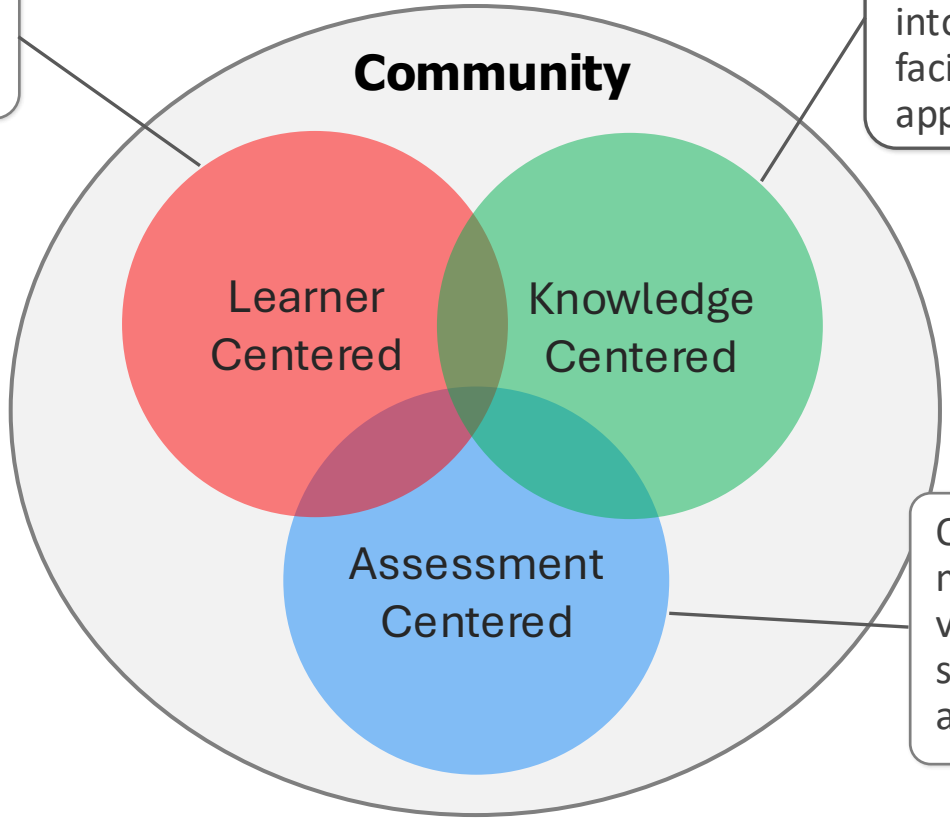
How People Learn implications for instruction





Draw out & work with pre-existing understandings

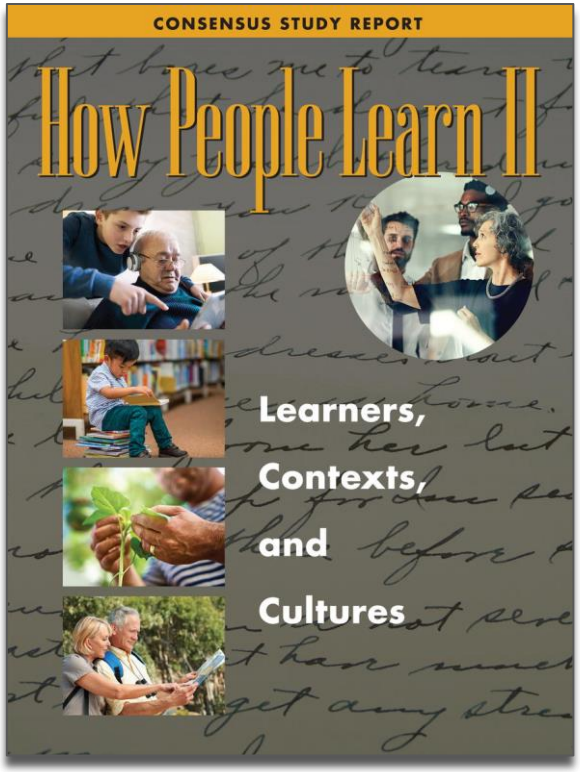




Disciplinary knowledge needs to be organized into concepts that can facilitate retrieval and application

Ongoing assessments make student thinking visible & facilitate both self-directed learning and teaching

How People Learn II (2018)



- An HPL I supplement, not a replacement.
- Updated with more recent research and expanded coverage:
  - Social, emotional and motivational aspects of learning
  - Influence of culture on learning
  - Learning across the lifespan, including young, middle and older adulthood
  - Assessment practices
  - Cognitive neuroscience
  - Learning technologies

https://www.nationalacademies.org/projects/DBASSE-BBCSS-13-06/publication/24783

Some Learning Sciences Fundamentals

- Meaningful learning involves integrating new information/ ideas with what you already know.
- Working memory is limited, a constraint that can be exacerbated by distractions or anxiety, or that can be ameliorated by scaffolding some parts of a task.
- Organizing what you know into schemas, models, or “big ideas” supports flexible application to future situations and problems.
- Practicing with many examples and counterexamples facilitates learning.

Image by Gemini

- Human learning is fundamentally social and cultural in nature and is powered by emotional engagement.
- Mature learners reflect on what they do and do not understand and use that information to guide their future behavior (metacognition).

Eight learning sciences-based strategies

Strategy	*Definition*
Active Learning	Practices that ask the learner to construct and/or apply knowledge
Collaborative Active Learning	Practices that call on students to construct/apply knowledge collaboratively with peers
Building on Prior Knowledge	Cues that activate students' background knowledge and experiences with relevance to course content
Formative Assessment	Opportunities to practice skills and receive timely, targeted feedback to be used for learning
Supporting Metacognition	Practices that help students take control of the learning process and learn how to be a better learner
Transparency	Providing students with a clear description of course content, learning objectives, and criteria to be used in assessing their work
Fostering Belonging & Inclusion	Practices that enable all students to feel that they and their unique background are welcomed in the course
Data-informed Instruction	Use of near real-time student learning data to inform teaching

The 10 Recommendations in the 2025 GAISE College Rep dy f these strategies

#8. Employ pedagogies that actively engage students in learning

#6. Incorporate software/ apps to explore concepts & work with data

#4. Integrate real data that are meaningful & engaging to students

#3. Focus on conceptual understanding rather than algebraic manipulation and formulas

#9. Use a variety of formative and summative assessments to improve teaching & learning

#10. Implement inclusive strategies creating learning environments where all students are valued

Strategy	
Active Learning	Practic apply knowledge
Collaborative Active Learning	owledge
Building on Prior Knowledge	nts' bac owledge and experiences
Formative Assessment	Opportunities timely targeted feedback
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Transparency	Provi cription of course content, learning d in assessing their work
Fostering Belonging & Inclusion	to feel that they and their unique course
Data-informed instruction	Use of near real-time student learning data to inform teaching

See https://amstat.quarto.pub/college-gaise/

Digital Promise Research on Statistics Teaching and Learning

- **Gates Foundation goal for Postsecondary Digital Learning**

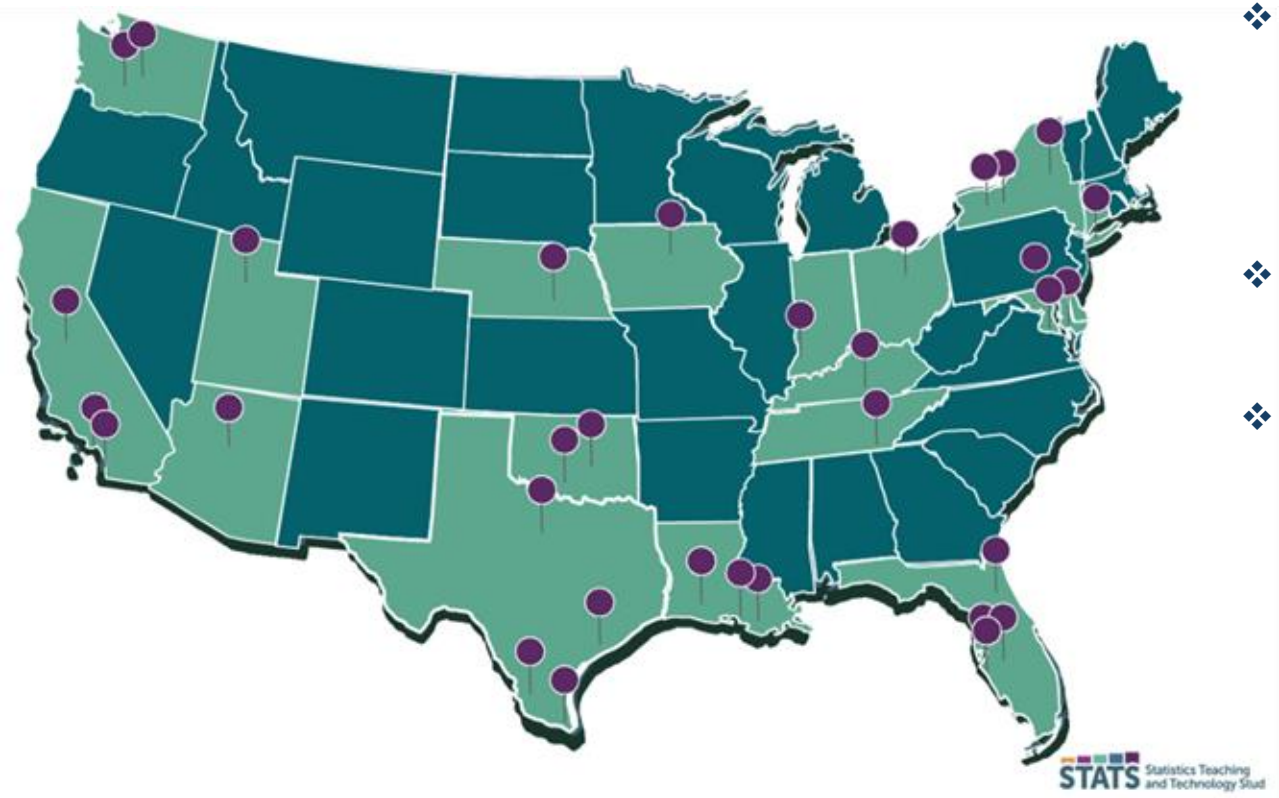
  Leverage learning technology to increase the proportion of students succeeding in key gateway college courses in broad-access institutions

- **Courseware developed by Lumen Learning**

- **Key Implementation Research Question**

  To what extent does an instructor's use of evidence-based teaching (EBT) practices influence student outcomes?

Our Study Sites



- Mostly “broad- access” institutions accepting 80% or more of applicants
- Roughly half 2-year and half 4-year
- More than half with an MSI designation

How we measured use of learning sciences instructional strategies

- We know that terms like metacognition, formative assessment, and active learning are not understood in the same way by everybody
- Moreover, instructors are likely to feel uncomfortable saying they do not provide transparency around learning goals, active learning, etc., so we ask students about course practices.
- We developed behavioral descriptions of two or more specific practices associated with each evidence-based teaching strategy.
- We asked students to describe the frequency/ consistency of use of each of the resulting EBT practices in their course.

Learning sciences-based strategies

Strategy	*No. Practices*	
Fostering Belonging & Inclusion	6	
Individual Active Learning	3	
Collaborative Active Learning	2	
Building on Prior Knowledge	2	Cues that activate students' background knowledge and experiences with relevance to course content
Data-informed Instruction	2	Use of near real-time student learning data to inform teaching
Formative Assessment	4	Opportunities to practice skills and receive timely, targeted feedback to be used for learning
Supporting Metacognition	4	Practices that help students take control of the learning process and learn how to be a better learner
Transparency	4	Providing students with a clear description of course content, learning objectives, and criteria to be used in assessing their work

- Assigning long-term collaborative learning activities in which small groups of students work together
- Asking students to work together in pairs or small groups where they explain or justify their ideas or their thinking

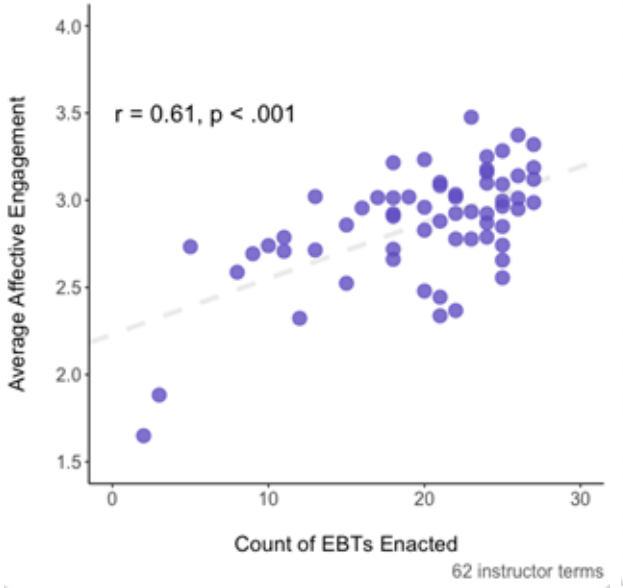
Student Outcome Measures

Affective Engagement	Higher Grades	Better Learning
• Average of 9 items on the student survey assessing liking, value, and success expectations for the course • 4-point scale from “Strongly Disagree” to “Strongly Agree”	• Measured by end-of-course grades provided by the institutions • A-F range converted to 0-4 point scale	• Measured by scores on a standardized exam (BASIC) designed to measure statistical knowledge • Potential student scores range from 0 - 32

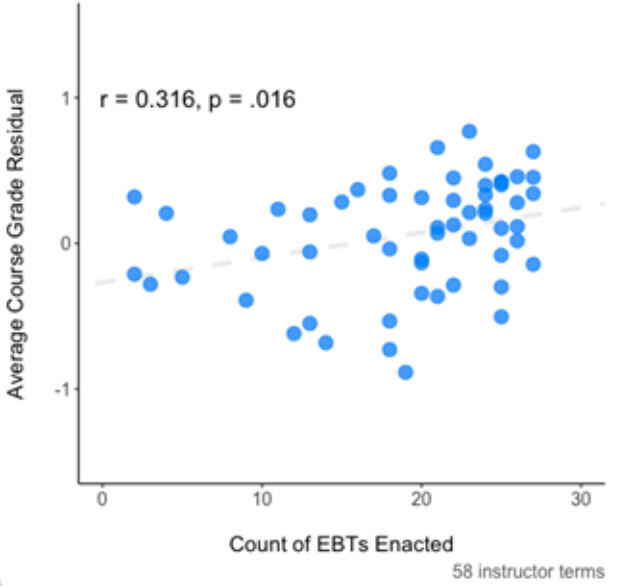
Student scores on each outcome were averaged for the class and then compared with mean student reports of learning sciences-based practices for that class.

Use of learning sciences-based instructional practices and course outcomes

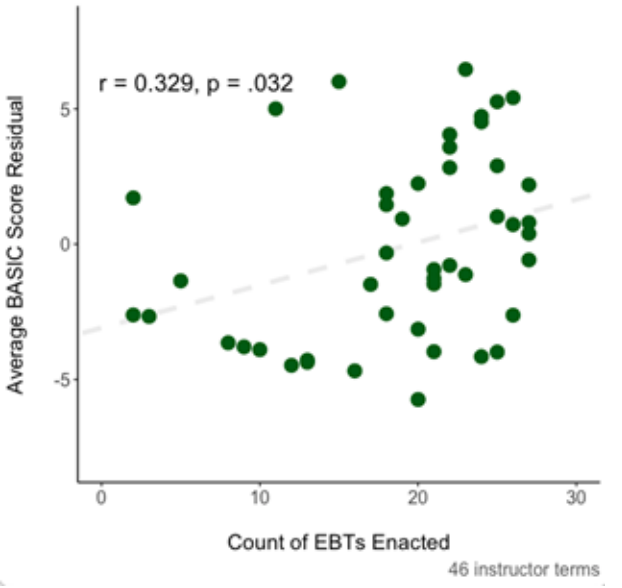
Affective Engagement



Course Grade*



Concept Test Score*



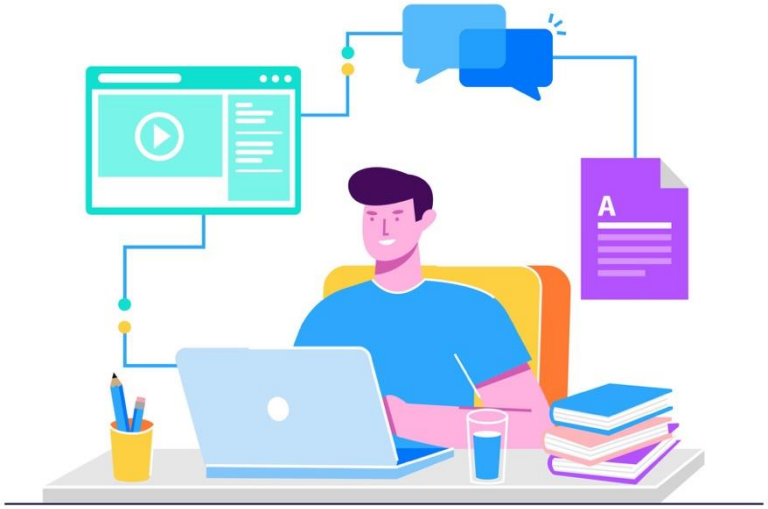
* Controlling for class-average prior academic achievement

Key Finding: Instructional Practices Matter

- Students are more engaged in classes that employ more learning sciences-based practices.
- Both students overall and those from low-income backgrounds or racially minoritized groups get better-than-expected grades in classes that employ more of them.
- Students taught by instructors who employ more learning sciences-based practices achieve better conceptual understanding than would be predicted by their prior achievement.

Photo credit: Ambika Silva

How does student AI use affect learning?

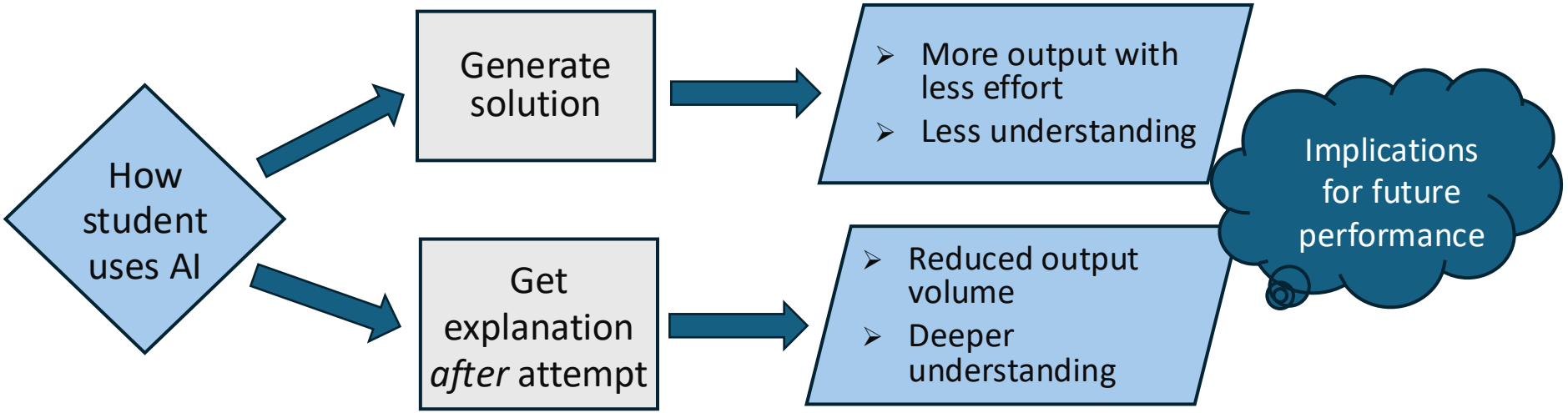


- Forero & Herrera-Suárez (2023)
- Jin et al. (2025)
- Kestin et al. (2025)
- Kumar et al. (2023)
- Maiti & Goel (2025)
- Yan et al. (2025)

- Abbas et al. (2024)
- Bastani et al. (2024)
- Kosmyna et al. (2025)
- Lehmann et al. (2025)
- Melumad & Yun (2025)
- Stadler et al. (2024)

Learning sciences principles help us understand disparate effects of AI tools on teaching and learning

Series of studies by Lehmann, Cornelius, & Sting (2025) found no effect of LLM use on post-test scores, but important implications for differences in how students used LLMs.



Likely Learning Consequences of Various Uses of AI

Student-initiated AI Use	Likely Consequences for Learning
Generate answer	Lowered likelihood of recall, understanding, transfer
Provide content summary	Likely reduction in new content assimilation; may help with time management
Simplify (restate) complex information	May help with comprehension and assimilation; risk of learning inaccurate or biased content fr…
Generate formative assess… as study aide	…nt understands course learning goals …ompt
Personal tutor/study guide … questions about concepts o…	…student with sufficient AI savvy focused on increasing understanding
Research assistant	Increased efficiency in locating information, resources, data; risk of surfacing and learning irrelevant, inaccurate, or biased content
Brainstorm ideas for writing assignment	Likely reduction of sense of ownership and memory for ideas writing about
Generate written product	Likely reduction of sense of ownership and memory for ideas writing about
Edit written product	Reduced anxiety about quality of the writing; possible reduction of sense of ownership of the writing; possible atrophy of writing mechanics skills

Disclaimer: These are my extrapolations; not empirical findings.

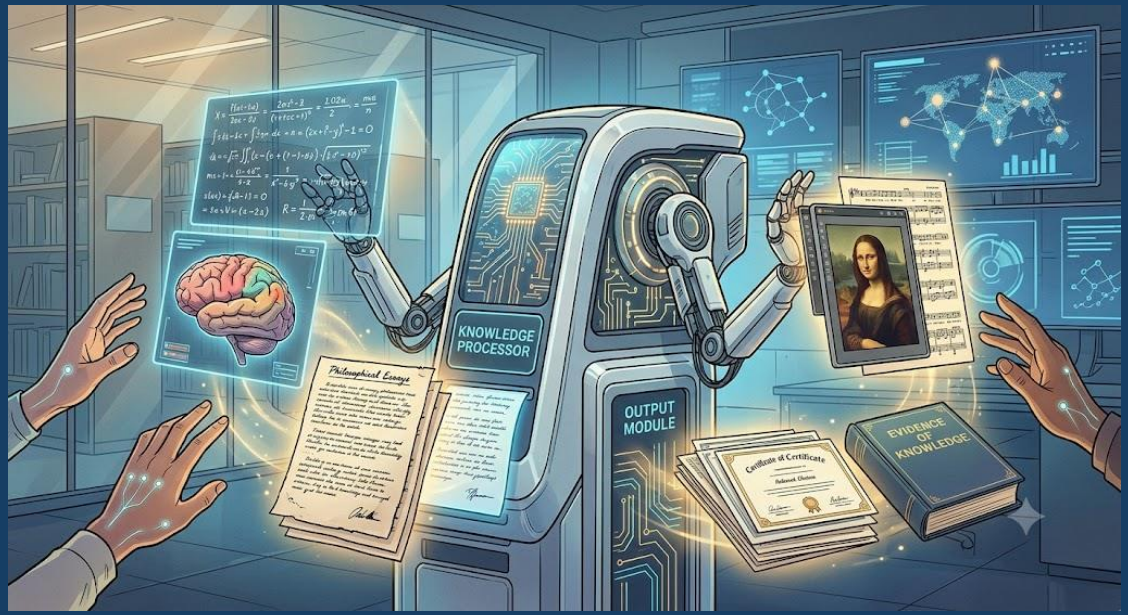


Image by Gemini

"... if a machine can now flawlessly mimic the outputs we've long treated as evidence of learning, then ***the value of higher education can no longer rest on product.*** *It must rest on the formation of actual* ***human capability***—*judgment, originality, ethical reasoning, collaborative intelligence, and the ability to think in public under pressure."*

-- Prof. Steven Mintz, UT Austin

What can instructors do now?

Efforts to ban use of AI are unlikely to be successful. Instead, we need to

Photo credit: Ambika Silva

- Distinguish between student *products* and *student learning*
- Rethink evaluation and grading practices to focus on evidence of student thinking that demonstrates preparation for future learning
- Double-down on supporting metacognition and self-directed learning skills in light of the temptation to relegate one's thinking to AI
- Discuss, demonstrate, and scaffold metacognitive processes as essential to statistical investigation, including but not limited to reflecting on how use of AI tools affects deeper understanding and retention of statistical concepts
- Encourage students to use and examine formative assessments, testing their preparation for future demonstrations and applications of their learning

You Can Influence Your Students' Learning Behaviors

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> Teacher: And then I highly recommend you do draw these pictures even if it's kinda sloppy like I'm doing it, just because it kinda gives you a sanity check of what you expect the answer to be. (S24_Inst15_HCCSS1_03.01, Pos. 589-591)

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You Can Influence Your Students' Learning Behaviors

Two future assessment shifts potentially supported by AI

- From assessing *answers* to assessing *thinking* with disciplinary concepts

- From a few, high-pressure summative tests to assessment data collection occurring in the background as students learn

Making thinking visible

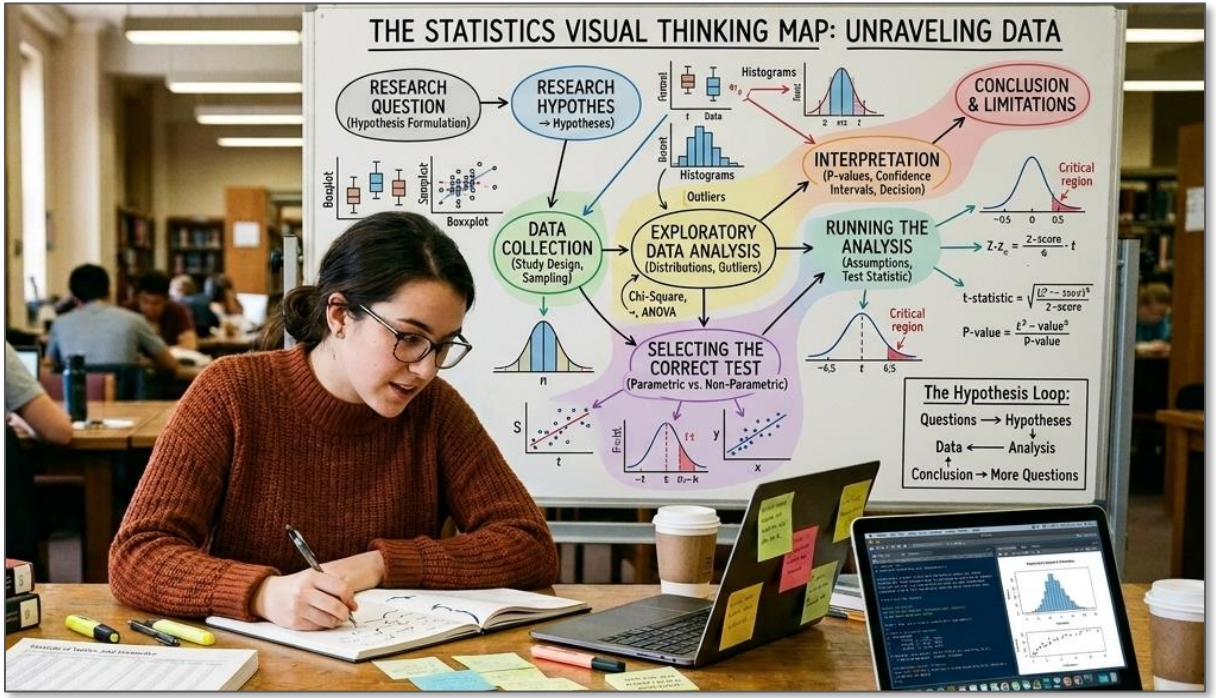

Image by Google Gemini

Assessing reasoning over time as students learn

Image by Gemini

Takeaways from this talk

- Students are using gen AI extensively and in many different ways.
- While gen AI is influencing student course behaviors, the basic principles of how people learn remain applicable and have implications for effective instruction.
- Digital Promise research shows that use of learning sciences-based teaching practices in statistics course matters for affective engagement, conceptual learning, and grade outcomes.
- As gen AI use continues to grow and proliferate, uses that complement or enable active learning and metacognition are likely to improve learning while those that support efficiency at getting right answers may undermine meaningful learning.
- Course assessment and grading practices need to change in light of the availability of AI.
- We should be assessing reasoning and inquiry processes rather than number of correct answers.
- In the near future, gen AI tools may support more efficient assessment of student reasoning on an ongoing basis.

Citations – 1 of 2

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Citations – 2 of 2

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