Beyond Tools: Transitioning and Repairing Epistemic Infrastructure in Education

Bodong Chen

cbd@upenn.edu • bchen.net

Associate Professor, University of Pennsylvania

Penn GSE
GRADUATE SCHOOL OF EDUCATION
UNIVERSITY of PENNSYLVANIA

About Bodong

Interests

- Knowledge Building
- Learning analytics
- Digital transformation

Penn Wonder Lab

Graduate Students

Basel Hussein
PhD Candidate

Jiayu Cheng
PhD student

Yuwei Liang
PhD student

Vivian Leung
MSEd

Amanda Tran
MSEd student

Emily Yan
MSEd student

Chen Wang
Instructional Technologist

Kexin Chen
MSEd student

Developers

Benji Encalada Mora
Lead Software Engineer

Wenxi Chen
Developer

Visiting Scholars

Lee, Vwen Yen Alwyn
Research Scientist at National Institute of Education, Singapore

Simone Luchini
PhD student at PSU

Sorry I know nothing about **Computational Thinking**...

At the **Center for Learning Computational Thinking**

At CLCT, we define CT as the cognitive processes involved in developing IT artifacts and programs to live in the world today.

We understand this in a broad sense, so that critical reflection on the design and use of IT artifacts is an integral part of their development. …

In its broadest sense, we view CT as **a problem-solving process aimed at finding creative solutions to the significant societal problems facing the world today**.

Consider CT broadly

1. **Computational Thinking** (Wing, 2006)
2. **Computational Participation** (Kafai & Burke, 2014)
3. **Computational Empowerment** (Dindler et al., 2020)

> Contemporary views on CT … should focus on articulating how humans can design for, partake in, and critically appraise human–machine collaborations (Nina Bonderup Dohn, 2024, p. 850).

Knowledge Building

A theory and pedagogy, developed by **Marlene Scardamalia** and **Carl Bereiter**, that treats the production of knowledge as the central focus of education.

It represents a fundamental shift from traditional approaches to learning:

- Students: consumers → **active creators**
- Knowledge: **objects** to be improved
- Learning: advancing knowledge in a **community**

Unpack Knowledge Building

1. **Knowledge transformation by experts** (Bereiter & Scardamalia, 1987)
    - Knowledge telling → knowledge transformation
2. **Knowledge-building communities** (Scardamalia & Bereiter, 1994)
    - Collective responsibility for knowledge advancement
3. **Epistemic agency, knowledge for public good**
    - Students taking high-level responsibility
    - Critical awareness of knowledge creation processes
    - Knowledge work contributing to public knowledge

Parallels between CT and KB

Parallel Aspect	Computational Thinking	Knowledge Building
Individual to Collective	Individual programming skills → computational participation	Individual knowledge work → collective knowledge advancement

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Human Agency	Emphasizes computational agency	Emphasizes epistemic agency

Both KB and CT care about enhancing **human epistemic agency**[1] in the world

1. Every time we act in an effort to attain our epistemic goals, we express our epistemic agency (Ahlstrom, 2010).

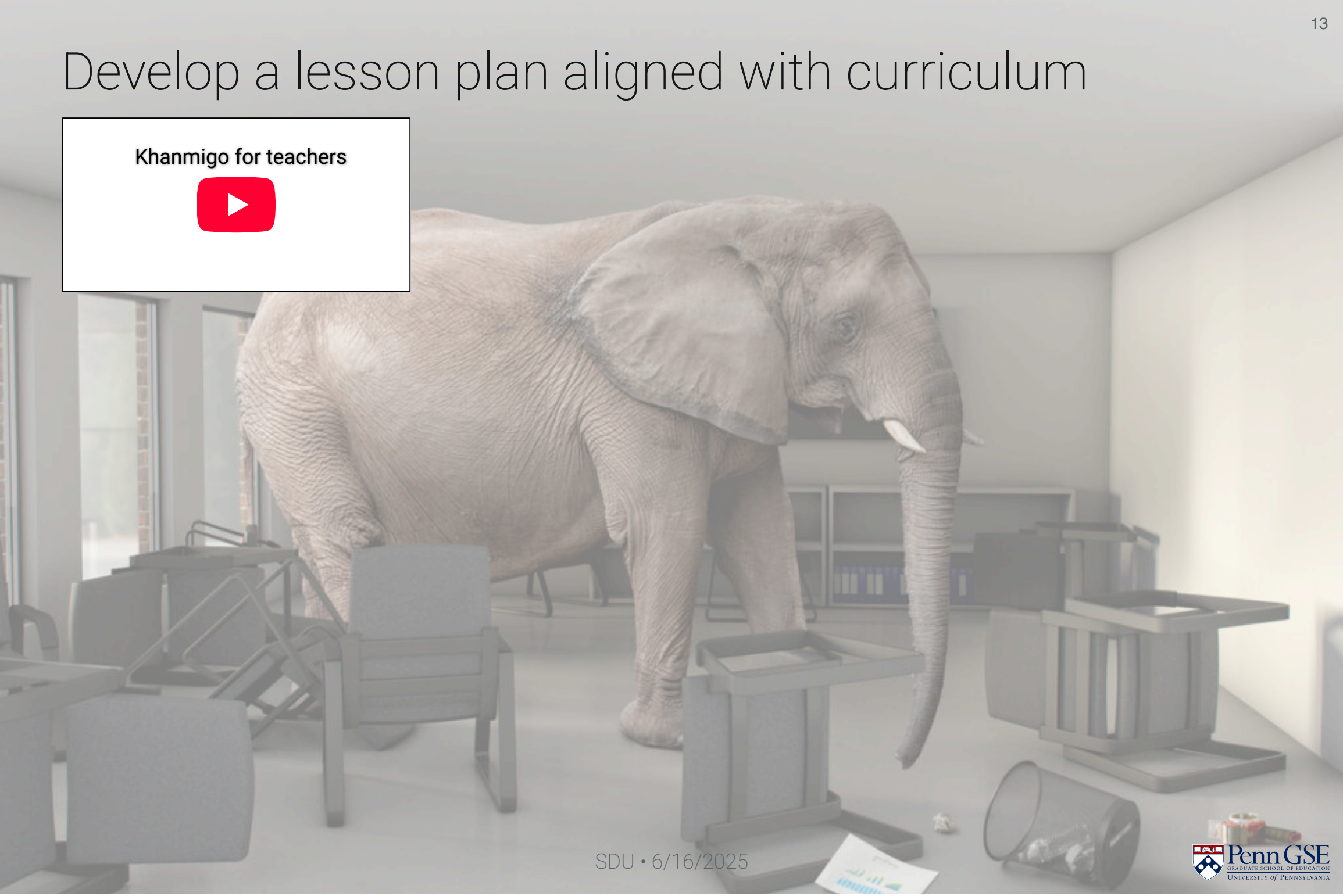
However,

human epistemic agency

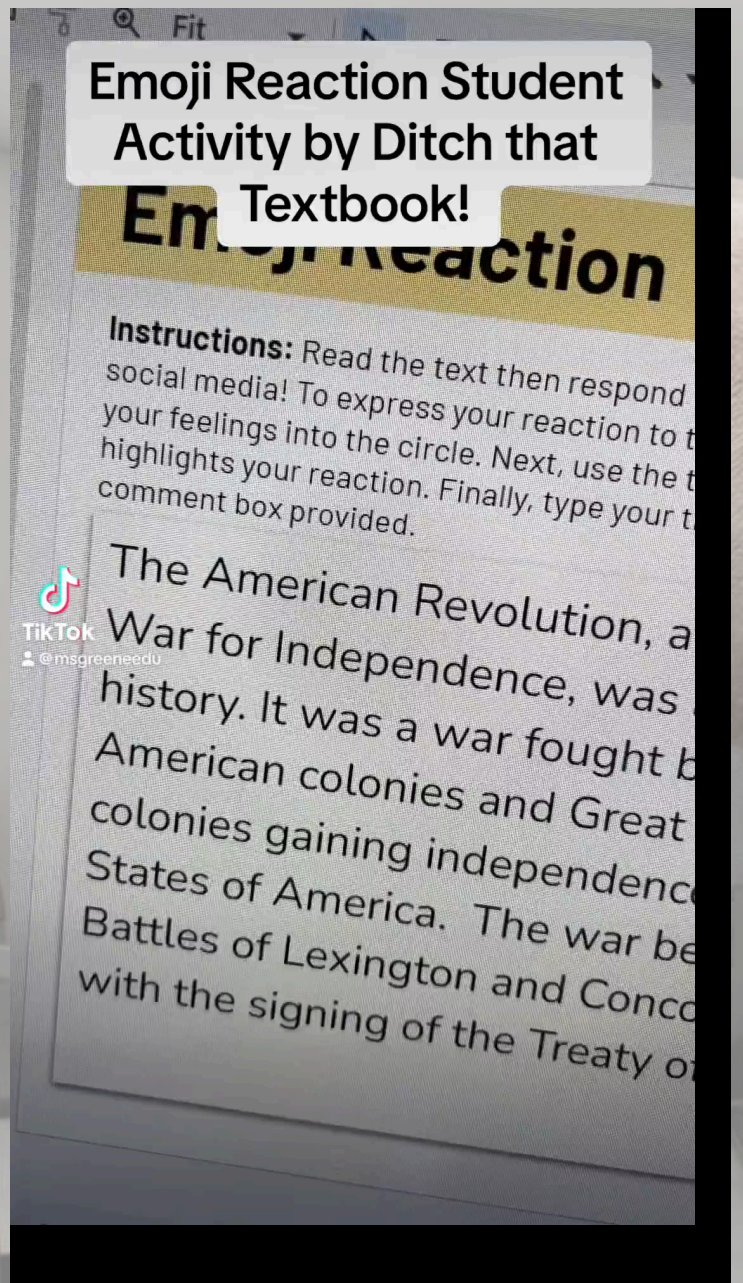
is challenged by generative AI

Develop a lesson plan aligned with curriculum

Khanmigo for teachers

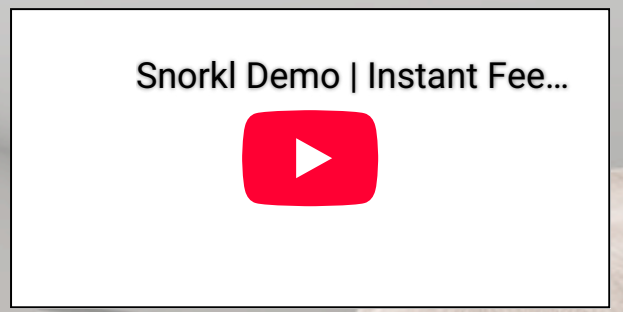


Generate instructional materials



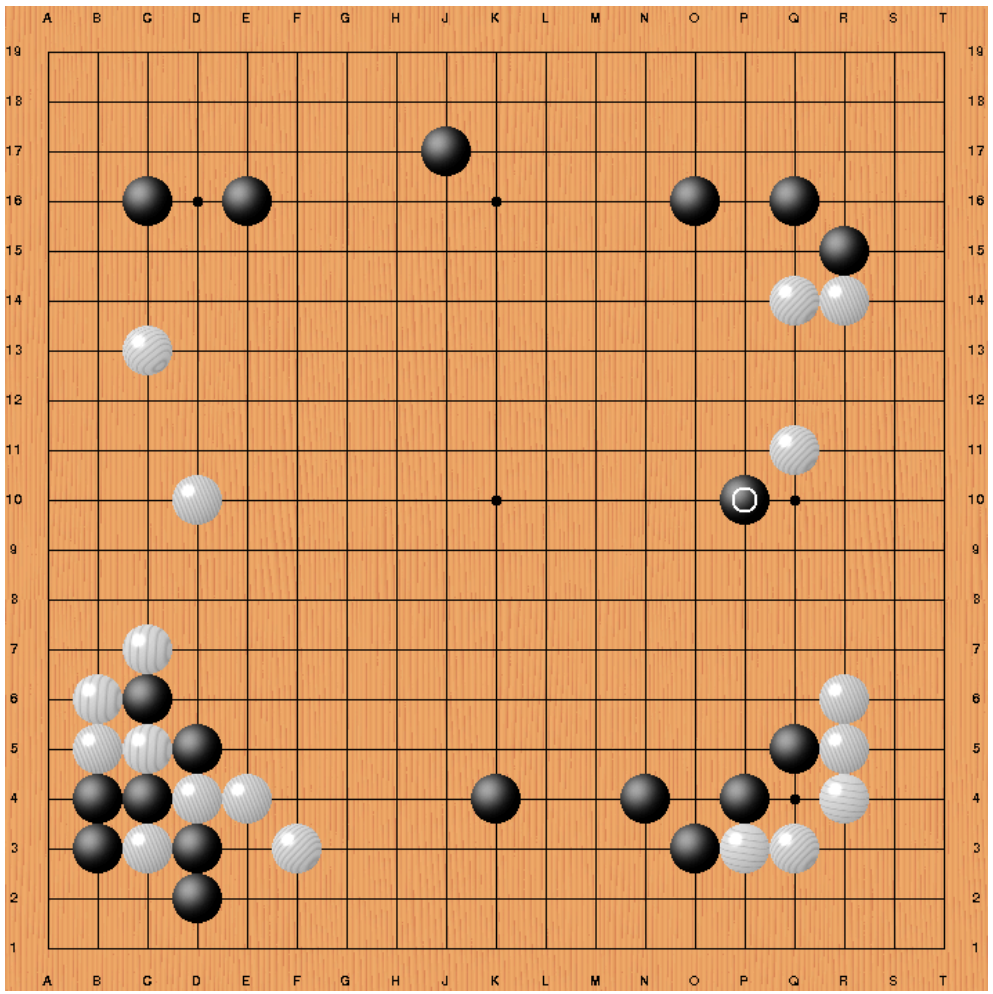
Students chatting with AI characters

“Instant feedback” on student thinking



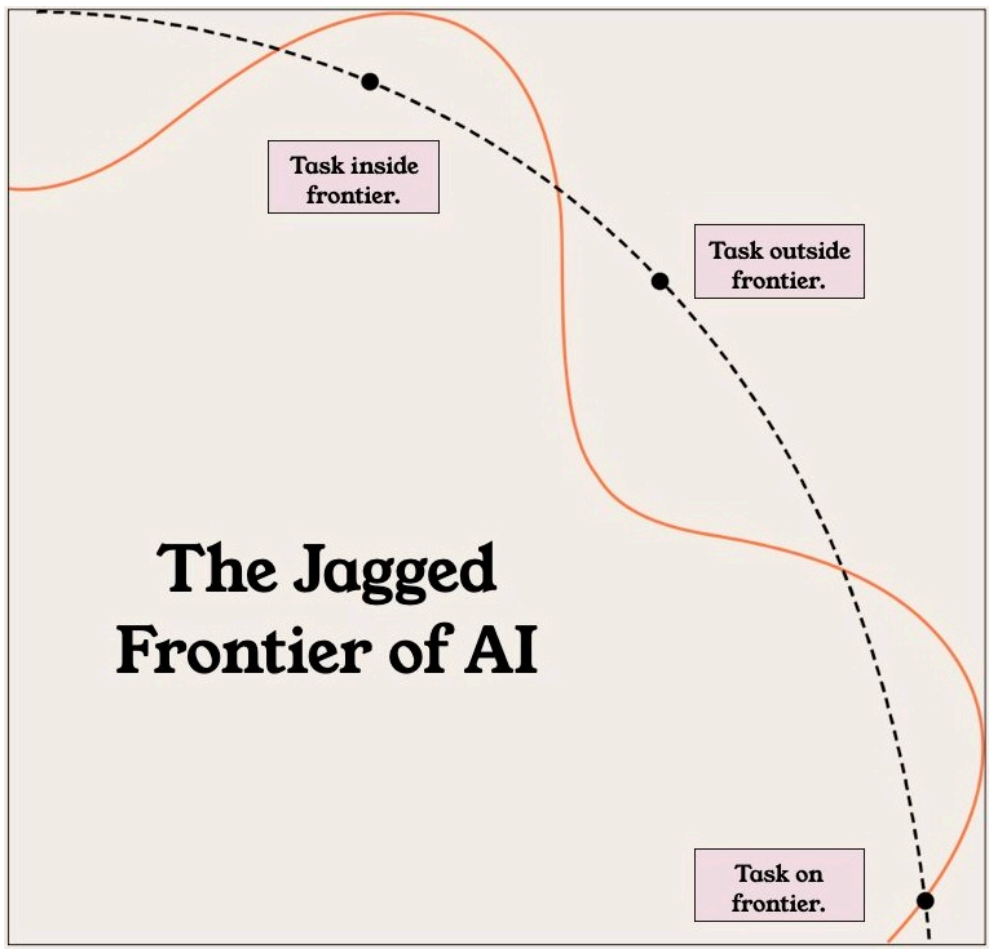
An ongoing **societal transformation** involving the **redistribution** of **labor**, **agency**, and **creativity** between **human** and **non-human** entities

“Superhuman performance”



(Move 37)

“Jagged frontier”



(Dell’Acqua et al., 2023)

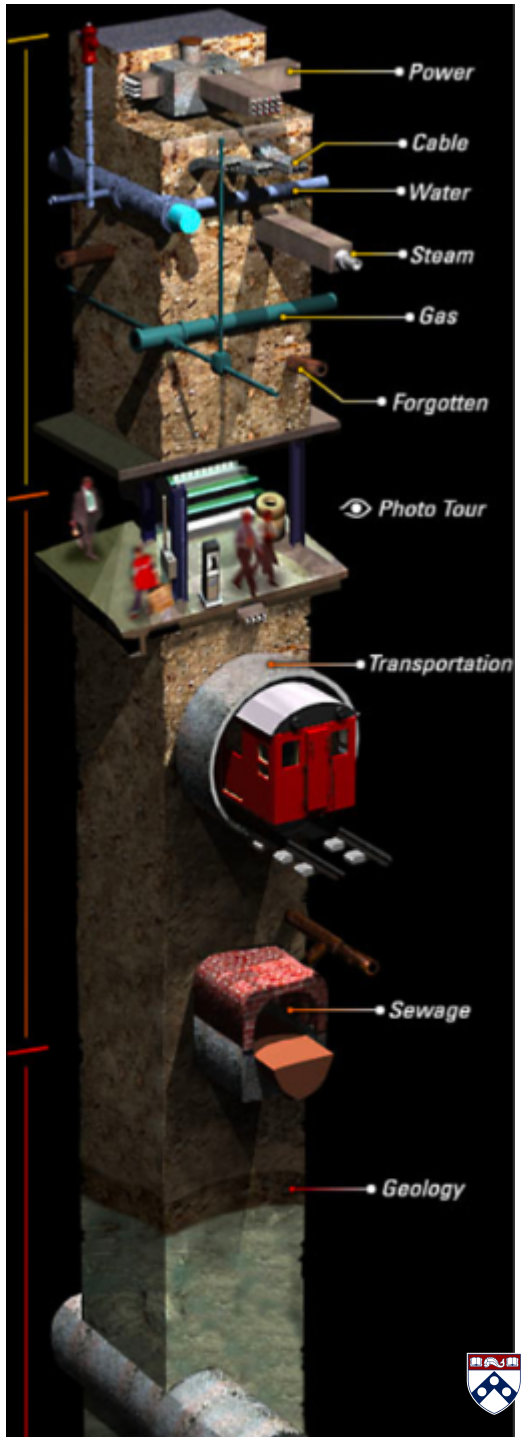
How to navigate the transformation with care?

Two Perspectives

1. Infrastructure

“the basic physical and organizational structures and facilities (e.g. buildings, roads, power supplies) needed for the operation of a society or enterprise.”

- Embedded, hidden
- Relational, socio-political
  (Bowker, 1994; Star, 1999; Read, 2019)



Infrastructure – as *verb*

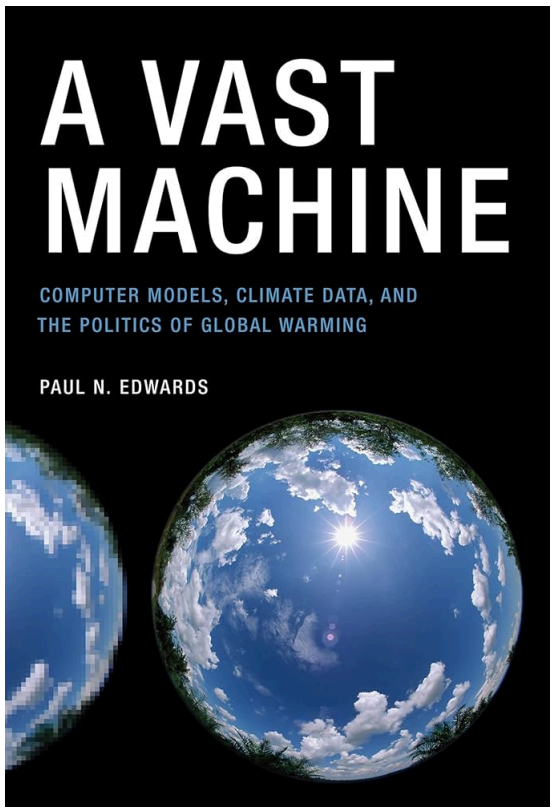
the ongoing process of design and redesign when an infrastructure is created in a setting (Karasti & Syrjänen, 2004)

- Blurs the boundary between users and designers
- Recognizes ongoing design work
- Constant “repair” (Mikalsen et al., 2018)

Epistemic Infrastructure

- Structures and systems that “enable individuals and societies to know what they know and to do what they do” (Hedstrom & King, 2006)
- Related terms: knowledge infrastructures (Edwards, 2010); thinking infrastructures (Kornberger et al. 2019)

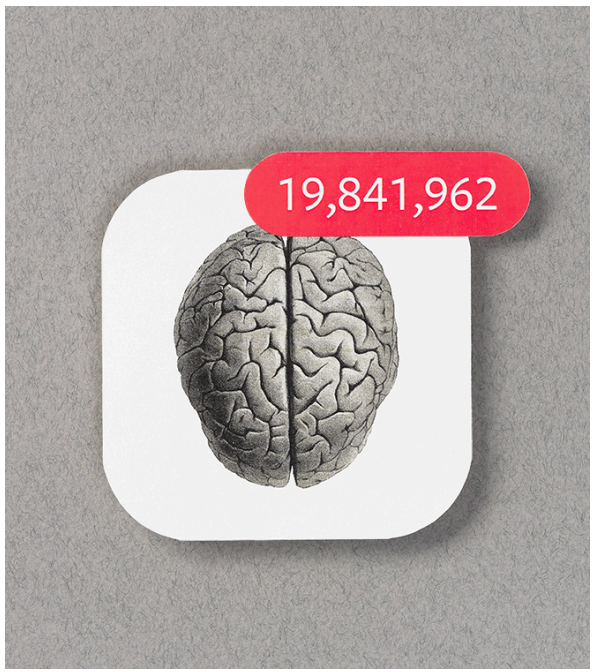
Epistemic Infrastructure



For climate science: “Robust networks of people, artifacts, and institutions that generate, share, and maintain specific knowledge about the human and natural worlds” (Edwards, 2010)

- Climate scientists, the public, etc.
- Satellites, sensors, computer models, etc.
- Truthfulness, evidence, consistency
- Emergency responses, polices, personal actions

Epistemic Infrastructure

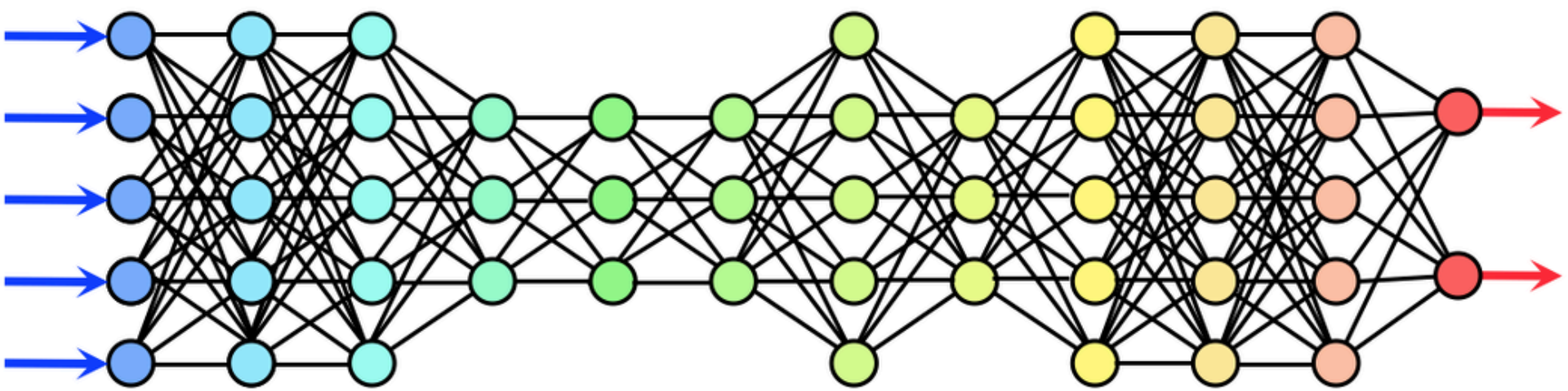


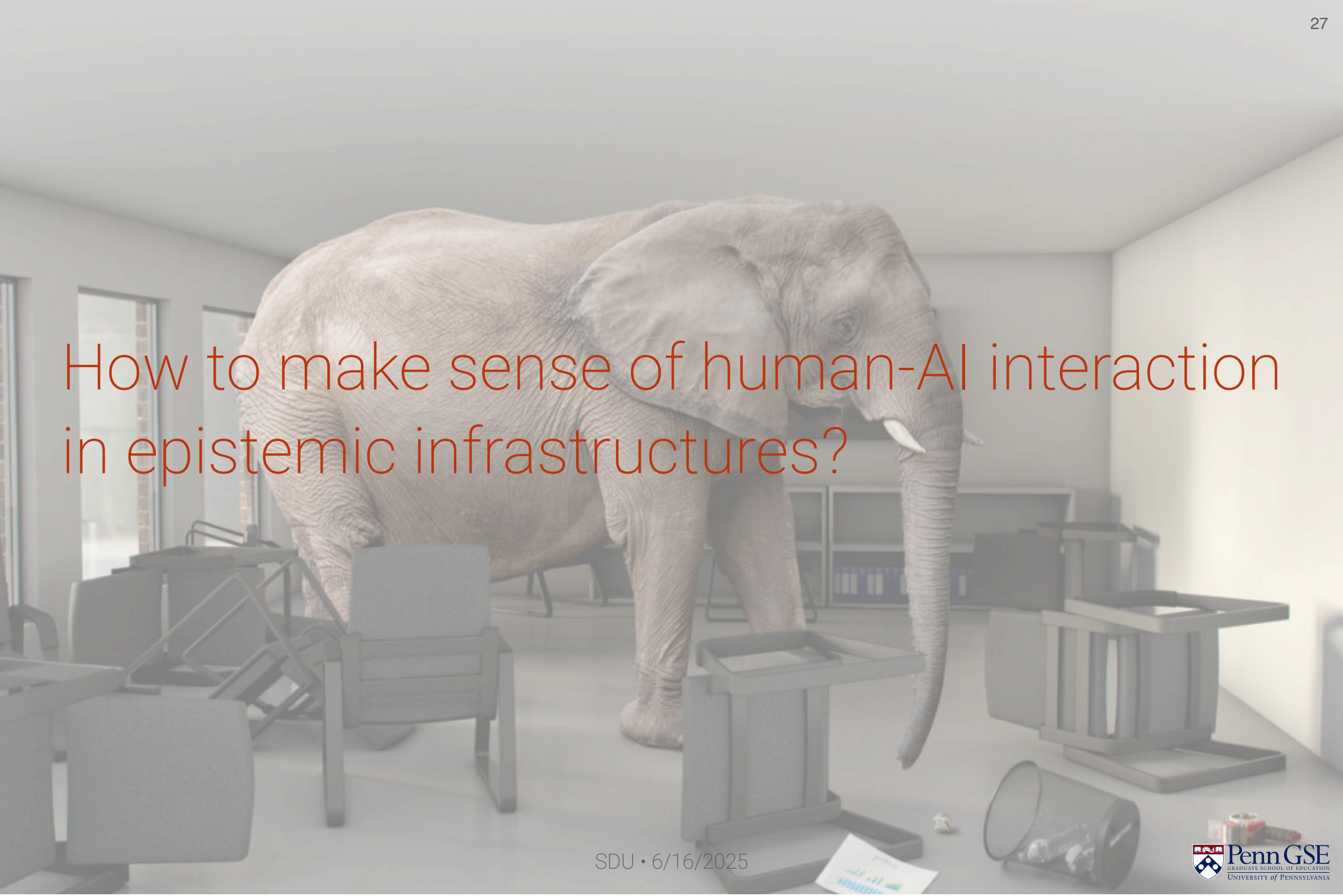
Social media for climate discussions: Bad faith communication fueled by political polarization and attention economy

- Users who consume and react to content
- Personalization, sorting algorithms, notifications
- Contested epistemic norms
- Little consequence

Hampers Epistemic Agency

- If supporting apt epistemic performance is not the goal
- If one dominant way of knowing edges out other ways of knowing, e.g., “fast knowledge” pushes out “slow knowledge” (Orr, 1996)
- In the AI case, if “parametric knowledge” of AI models pushes out humane ways of knowing





How to make sense of human-AI interaction in epistemic infrastructures?

2. Situated Cognition

Cognitive processes extend beyond the brain to include the body and environment

- views the brain, body, and surrounding environment as an integrated cognitive system in continuous interaction (Carney, 2020)
- the mind as a “dynamic coupling” of brain–body–world (Newen et al., 2018; Robbins & Aydede, 2008).

A Situated Approach to Analyzing Epistemic Agency and Infrastructure

Consider the agent–infrastructure interaction

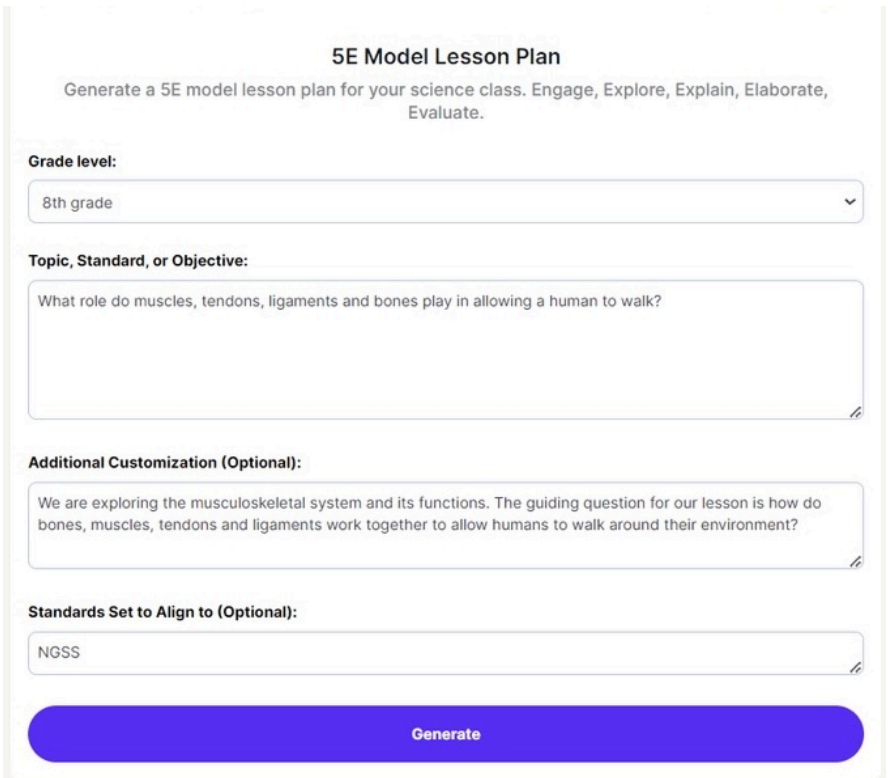
Dimensions	**Description**
Skilled actions	A range of actions users can carry on
Epistemic sensitivity	Conditions for activating these skilled actions to meet epistemic goals
Habit building	Repeated actions and interactions that build epistemic habits

AI—when *carelessly* deployed—threatens:

1. Epistemic infrastructure in education
2. Situated cognition and action by humans

Case 1: Generate lesson plans

Magic School AI



Skilled actions: Teachers design lessons based on pedagogical principles and student backgrounds

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Epistemic sensitivity: Steering prompts, but AI generation remains opaque

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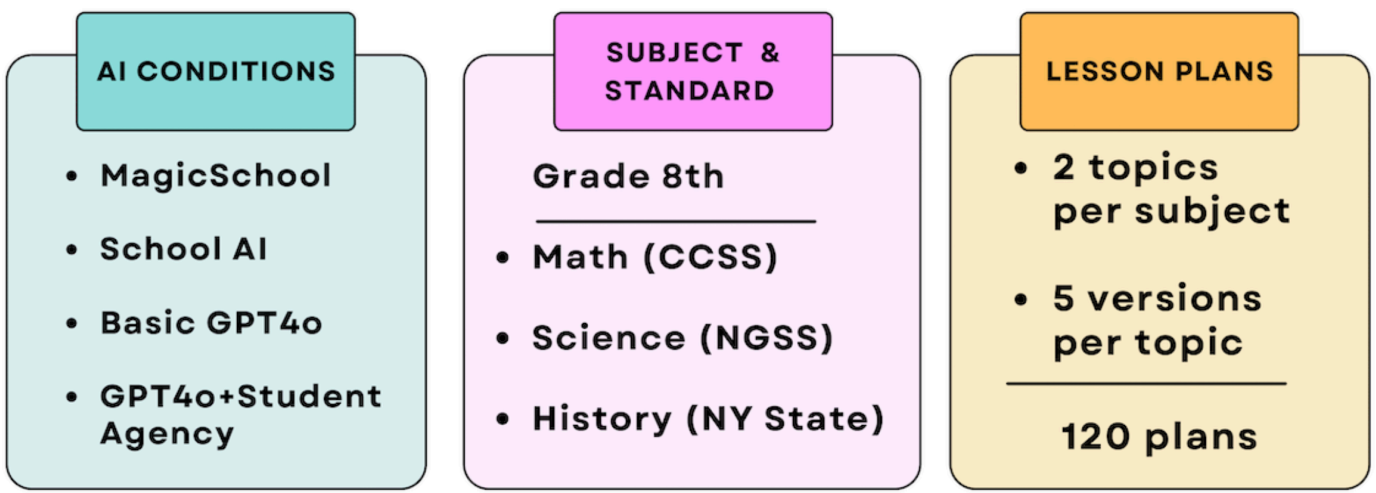
Habit building: Speed, reliance, and no native support for iteration

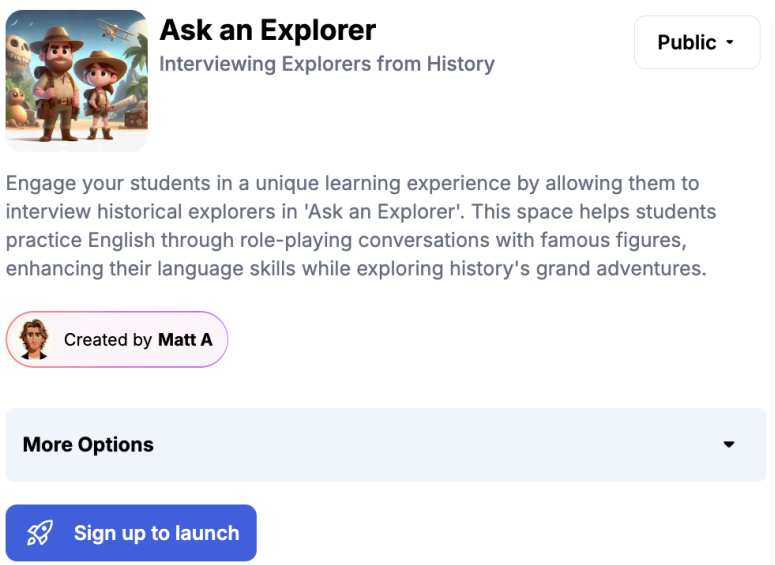
Problem with current lesson plan generators

- Position teachers as *end-users* rather than *designers*
- Pedagogical biases (Cheng et al., 2025)
  - → Limited student agency (teacher centered)
  - → Uninspiring classroom dialogue (rote, teacher-class)



Case 2: Build AI characters for students

School AI



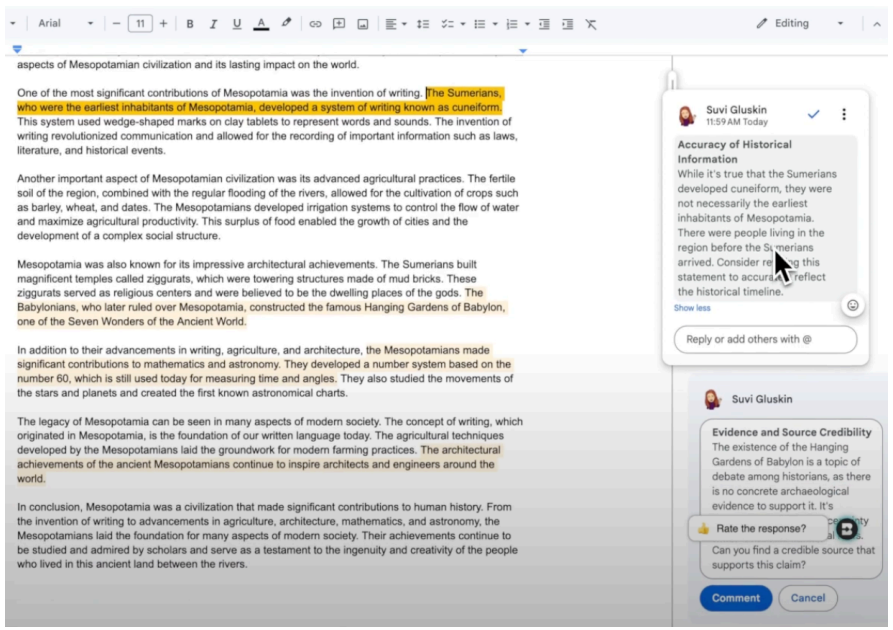
Skilled actions: Teachers nurture diverse perspectives and facilitate dialogues. Students consider multiple perspectives.

Epistemic sensitivity: Teachers can design interesting chat experiences. Students converse with artificial figures, but may not have time to fact check.

Habit building: Isolated dialogues with chatbots, lack of communal discourse and epistemic responsibility

Case 3: Provide feedback on essays

Diffit



Skilled actions: Teachers provide personal feedback to students

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Epistemic sensitivity: Teachers can review before submitting each comment, but AI decides where to provide feedback

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Habit building: Speed, reliance, and over time less knowledge about students

Agent–Infrastructure Interactions

- Skilled epistemic actions of teachers and students are not sufficiently considered and are in tension with speed and efficiency
- While some AI tools leave space for humans to exercise their skilled actions, they are in general designed or advertised in ways that reduce epistemic sensitivity
- AI tools provide opportunity for quality checks. But interactions typically favor instaneous generation over iteration. Reduced epistemic operations by humans create habits that would lead to reduced human knowledge of practice, and of other humans.

Potential Responses?

Proj 1: CraftPad: Teachers as Designers

Design Goals

- Support teachers to iteratively design KB lessons

Approach: Meta-Design

- Position teachers as designers, not merely users
- Center teacher expertise and epistemic agency
- Support complex, nuanced work of knowledge building design

CraftPad: Demo

Proj 2: Mixed-initiative design patterns

Design Goals

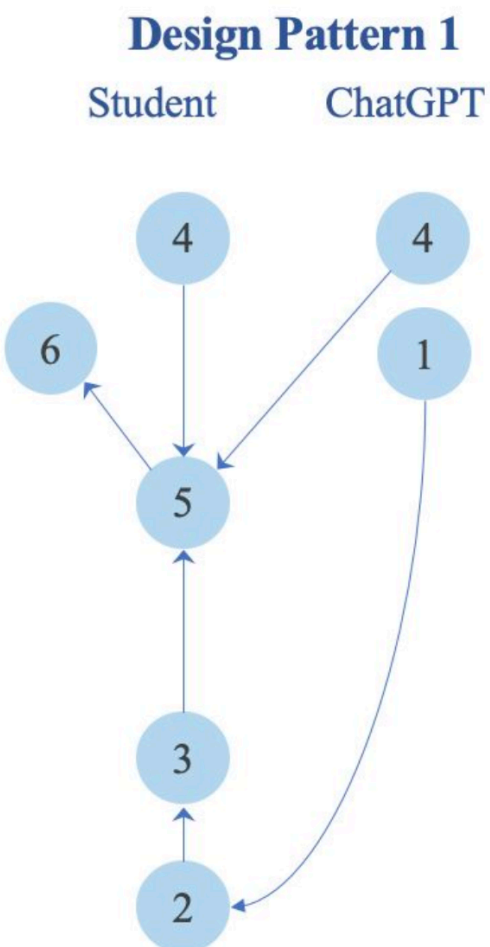
1. Augment students' creative work
2. Promote students' AI competency

Approach:

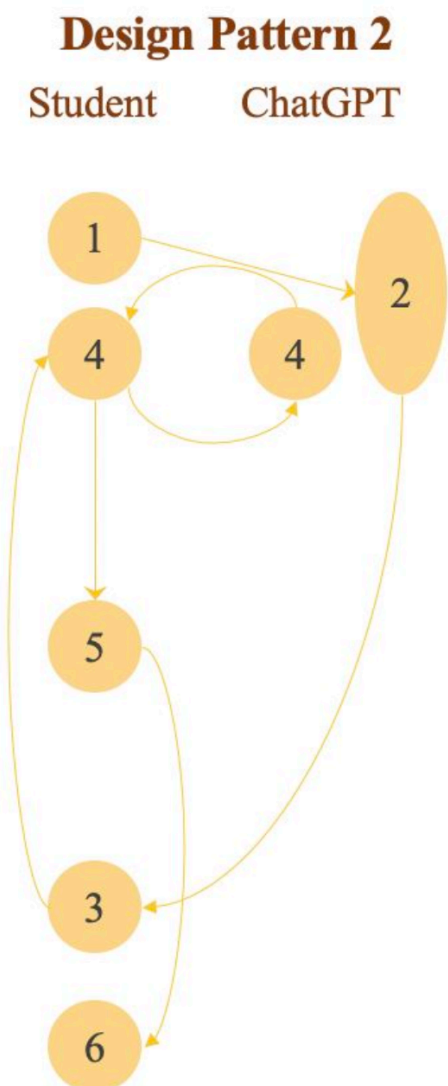
- Mixed-Initiative Creative Interfaces

Chen, B., Zhu, X., & Díaz del Castillo H., F. (2023). Integrating generative AI in knowledge building. *Computers and Education: Artificial Intelligence, 5*, 100184. https://doi.org/10.1016/j.caeai.2023.100184

Design Patterns



Knowledge-Creating Dialogue Moves
Problem definition
New ideas
Promisingness evaluation
Meta-dialogue
Comparison
Critical discourse
Higher-level ideas



Key Insights

- The use of AI made learning harder—rather than easier—when mindful engagement is needed

- Students took high-level agency in the process
- Cope with ‘Stochastic parrot’ 🦜 and ‘Concentrated owl’ 🦉
- We need more design patterns to purposefully integrate AI in collaborative learning

Departing Thoughts

1. Beyond tools

AI systems in education are **more than tools**. They are often epistemic infrastructures that shape our actions, habits, relations for years or decades to come.

2. Infrastructures need repair

Due to mis-alignment with societal values,
but also pedagogical values.
Therefore, they are **broken by default**
and need constant care and repair.

3. A vast design space

is presented in front of us if
we adopt a situated perspective.
We need more designs that
center relationship and human experience.
We need more diverse voices to
explore the space.

What roles should CT play?

I look forward to learning from you all!

Thank You!

cbd@upenn.edu