



An Institute of



Learning, Fast and Slow: Fostering Learner Agency with Learning Sciences – Informed AI in Education

Professor Chen Wenli
National Institute of Education
Nanyang Technological University Singapore

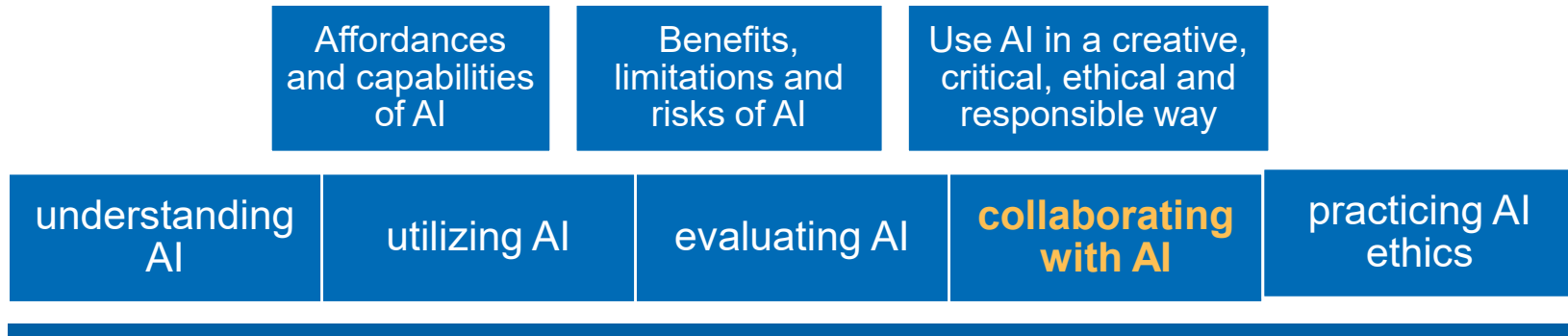


Keynote Speech at Mathematics Teachers Conference 2026

AI Transforms **What** We Teach and Learn

- Learning to learn, unlearn, and relearn in AI era
- Foundational knowledge matters, shifting from rote memorization to deep conceptual understanding and high-order thinking
- **AI literacy** to prepare learners for a world in which AI is an important part of most careers.

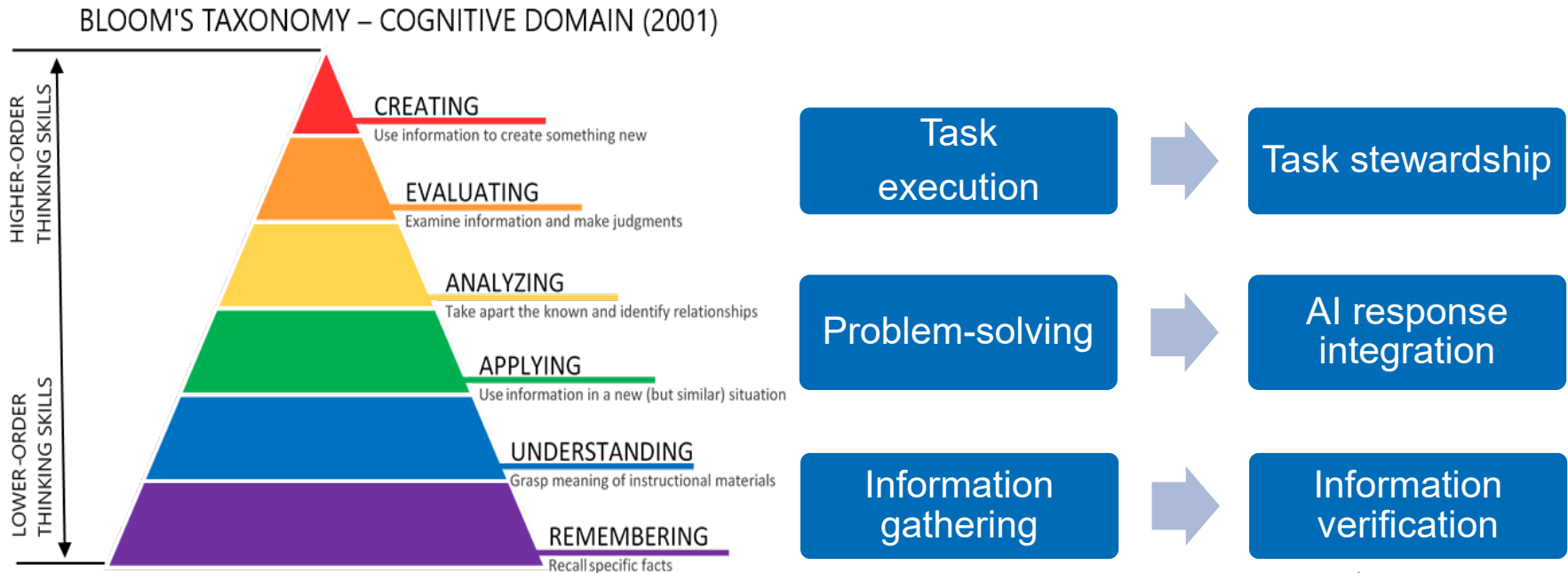
knowledge, skills, competencies and dispositions on using AI (Chen, 2024)



Chen, W. (2024). AI for education: What to teach and how to teach? *SingTeach*, 88, 3.
<https://singteach.nie.edu.sg/2024/04/29/ai-for-education-what-to-teach-and-how-to-teach/>

AI Transforms **How** We Teach and Learn

- AI changes the way knowledge workers approach writing, creating, critical thinking, and decision-making



(Lee et al, 2025)

AI for IA (Intelligence Augmentation)

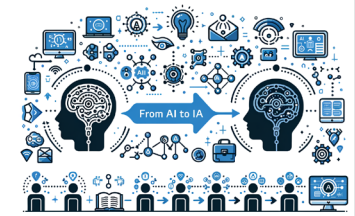
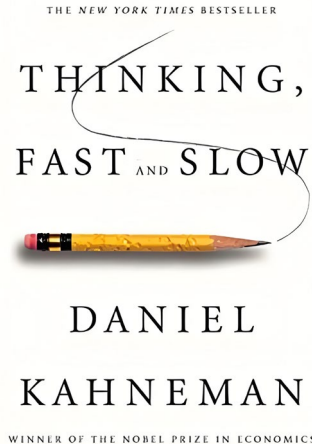


Image generated by Dall-E 3

- Enhance and elevate human capability and intelligence with the support of AI
- AI should **empower** humans rather than mechanize and deskill them.
- AI is an accelerator: it amplifies the good, but it can also amplify the bad.
- Avoid overreliance on AI



System 1

- **fast**, automatic, effortless
- process info unconsciously and use heuristics.

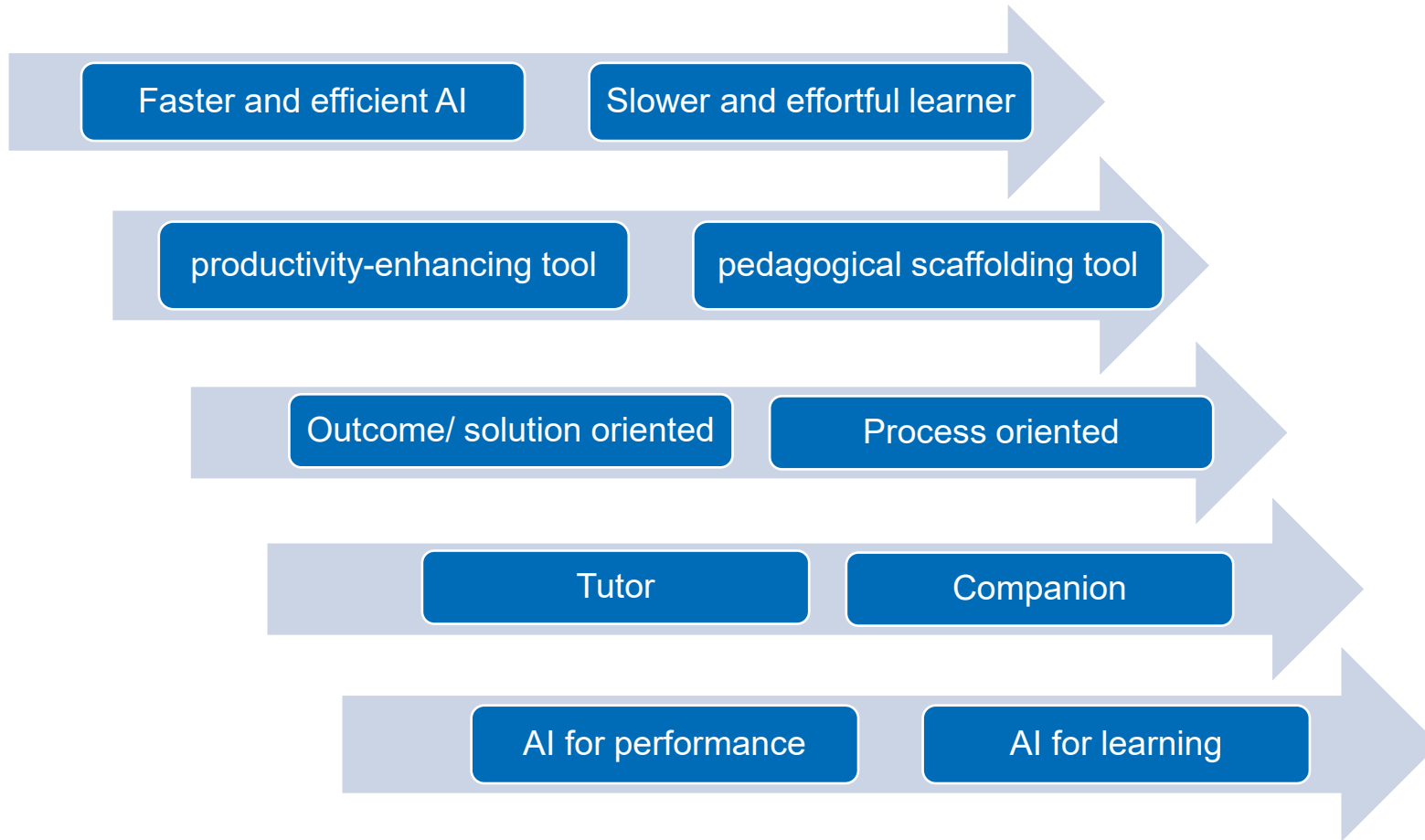
System 2

- **slow**, deliberate, analytical
- for complex reasoning but is cognitively costly.

when and how to sustain effort to protect learning, judgment, and agency?

*[A] masterpiece... This is one of the greatest and most engaging collections of insights into the human mind I have read."—WILLIAM EASTERLY, *Financial Times*

From Automation to Augmentation



Canva AI "Code for Me"

The image shows a screenshot of the Canva AI interface. At the top, there are tabs for 'Your designs', 'Templates', and 'Canva AI'. Below this is a text input field with the placeholder 'Describe your idea, and I'll bring it to life'. Below the input field are buttons for 'Design for me', 'Create an image', 'Draft a doc', 'Code for me', and 'Create a video clip'. A small warning message reads 'Canva AI can make mistakes. Please check for accuracy. See terms · Give feedback'.

The main chat area shows a conversation. The user has entered 'disappear'. The AI responds: 'Added to memory Manage', 'Here's your Math Drop game! 🎮', 'Questions fall from the top of the screen, and students type the correct answer to make them disappear with a star burst effect. If a question reaches the bottom, they lose a life.', 'Features:', and a list of features: 'Three modes: Addition, Subtraction, or Mixed', 'Difficulty increases as they score more points', 'Fun animations when they get answers right', and '3 lives before game over'. The AI also says 'Try it out — pick a mode and start typing answers! Want me to adjust the difficulty, add multiplication, or change the number ranges?' and 'Ask me anything'.

On the right, a preview of the 'Math Drop!' game design is shown. It features a dark blue background with a colorful abacus icon at the top. The title 'Math Drop!' is in large yellow font. Below the title, the text reads 'Answer the falling math questions before they reach the bottom!'. At the bottom, there are three buttons: 'Addition' (green), 'Subtraction' (orange), and 'Mixed' (purple).

AI for Learning (Augmentation)

padlet.com/nie/padlet-ne60bhps7fh2dki5

Padlet

Wenli • 3m


人物描写练一练

请通过描写，尝试还原老师之前生成的图片。

Pinned


Wenli /teacher/
3 minutes ago

请尝试还原以下图片



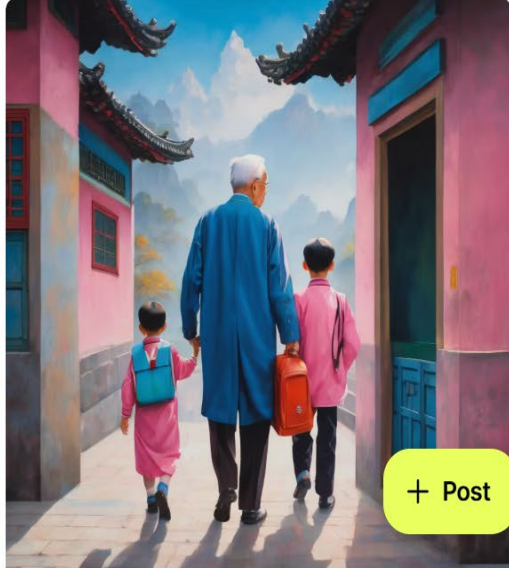
Wenli /teacher/
3 minutes ago

学生1



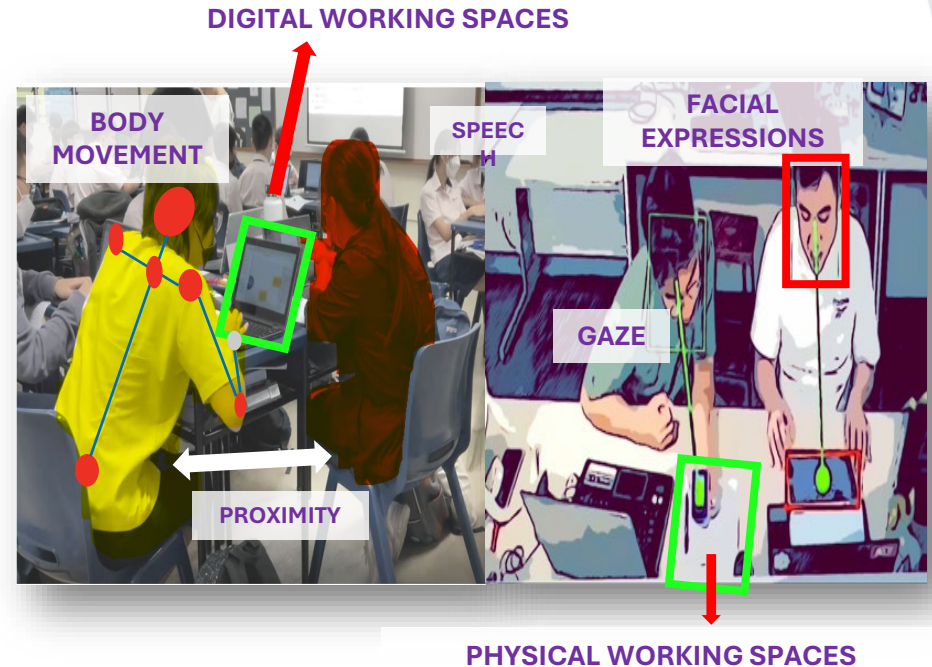
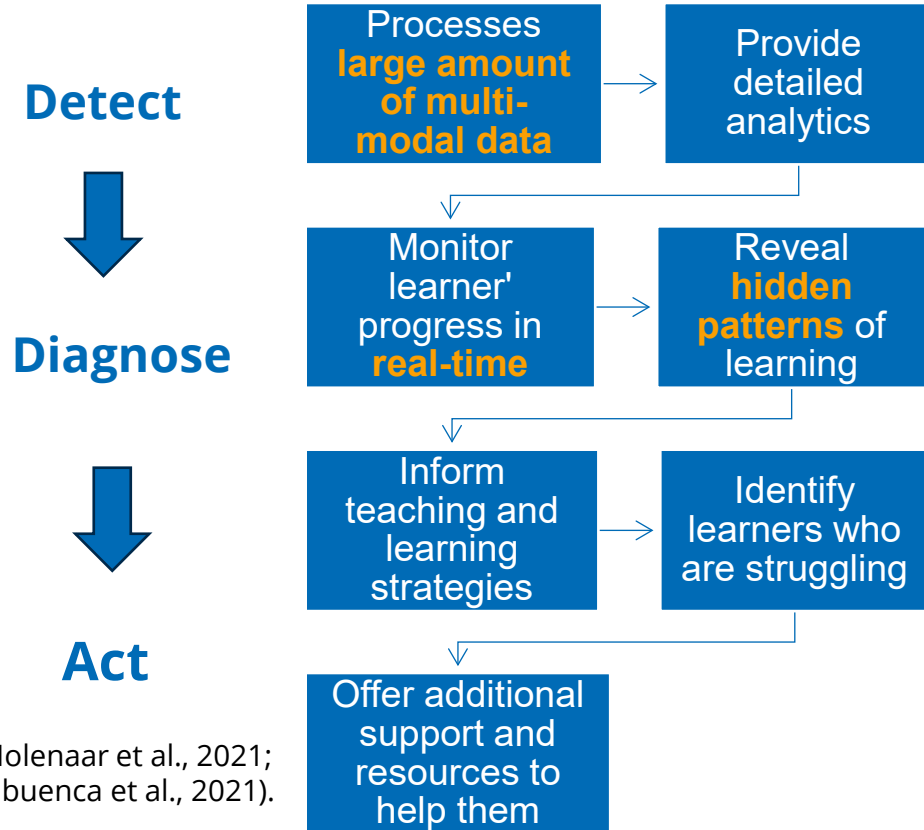
Wenli /teacher/
3 minutes ago

学生2

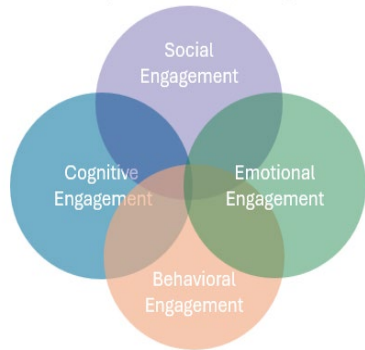


+ Post

AI-Empowered Multi-Modal Learning Analytics (Augmentation)



Multi-Modal Data Analytics



(Bowden, Tickle, & Naumann, 2021)

5 Student-generated artefact



4 Survey/ Interview

- Cognitive load, Emotion states, Group preference
- Perception

6 Physiological Arousal

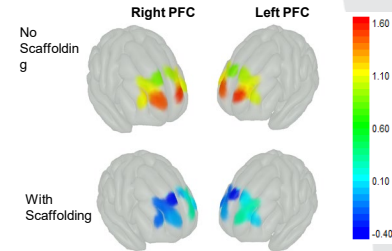
3 Behavior

- Verbal
- Online
- Facial Expression
- Body movement

2 Eye-Gaze

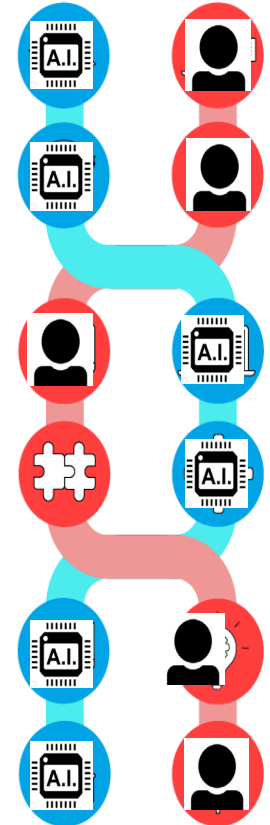
- Selecting
Time to first fixation/entry time
- Organizing
Dwell time, Fixation duration
- Integrating
number of visits or re-reading
- Group: Joint attention

- ## 1 fNIRS
- Individual: Functional connectivity
 - Group: Inter-brain synchrony



GAI-Augmented Learning

Role ⁶	Description	Example of implementation
Possibility engine	AI generates alternative ways of expressing an idea	Students write queries in ChatGPT and use the Regenerate response function to examine alternative responses.
Socratic opponent	AI acts as an opponent to develop and argument	Students enter prompts into ChatGPT following the structure of a conversation or debate. Teachers can ask students to use ChatGPT to prepare for discussions.
Collaboration coach	AI helps groups to research and solve problems together	Working in groups, students use ChatGPT to find out information to complete tasks and assignments.
Guide on the side	AI acts as a guide to navigate physical and conceptual spaces	Teachers use ChatGPT to generate content for classes/courses (e.g., discussion questions) and advice on how to support students in learning specific concepts.
Personal tutor	AI tutors each student and gives immediate feedback on progress	ChatGPT provides personalized feedback to students based on information provided by students or teachers (e.g., test scores).
Co-designer	AI assists throughout the design process	Teachers ask ChatGPT for ideas about designing or updating a curriculum (e.g., rubrics for assessment) and/or focus on specific goals (e.g., how to make the curriculum more accessible).
Exploratorium	AI provides tools to play with, explore and interpret data	Teachers provide basic information to students who write different queries in ChatGPT to find out more. ChatGPT can be used to support language learning.
Study buddy	AI helps the student reflect on learning material	Students explain their current level of understanding to ChatGPT and ask for ways to help them study the material. ChatGPT could also be used to help students prepare for other tasks (e.g., job interviews).
Motivator	AI offers games and challenges to extend learning	Teachers or students ask ChatGPT for ideas about how to extend students' learning after providing a summary of the current level of knowledge (e.g., quizzes, exercises).
Dynamic assessor	AI provides educators with a profile of each student's current knowledge	Students interact with ChatGPT in a tutorial-type dialogue and then ask ChatGPT to produce a summary of their current state of knowledge to share with their teacher/for assessment.



Concern: Over-Reliance of AI

- Learners may go through efficient **cognitive shortcuts** so that they may not experience the necessary disfluency or cognitive difficulty to trigger deep cognitive processes which are required for learning.

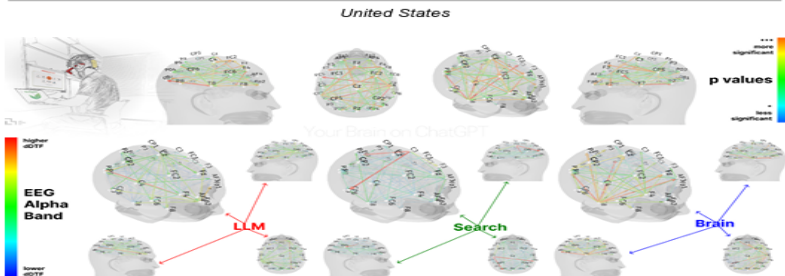
Cognitive offloading

Cognitive fluency

Cognitive/metacognitive laziness /debt

Your Brain on ChatGPT: Accumulation of Cognitive Debt when Using an AI Assistant for Essay Writing Task[△]

Nataliya Kosmyna ^a MIT Media Lab Cambridge, MA	Eugene Hauptmann MIT Cambridge, MA	Ye Tong Yuan Wellesley College Wellesley, MA	Jessica Situ MIT Cambridge, MA
Xian-Hao Liao Mass. College of Art and Design (MassArt) Boston, MA	Ashly Vivian Beresnitzky MIT Cambridge, MA	Iris Braunstein MIT Cambridge, MA	Pattie Maes MIT Media Lab Cambridge, MA



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journal homepage: www.elsevier.com/locate/comphumbeh

Beware of metacognitive laziness: Effects of generative artificial intelligence on learning motivation, processes, and performance

[Yizhou Fan](#) ✉ [Luzhen Tang](#) [Huixiao Le](#) [Kejie Shen](#) [Shufang Tan](#) [Yueying Zhao](#) [Yuan Shen](#) [Xinyu Li](#) [Dragan Gašević](#)

First published: 10 December 2024 | <https://doi.org/10.1111/bjet.13544> | [VIEW METRICS](#)

Cognitive ease at a cost: LLMs reduce mental effort but compromise depth in student scientific inquiry

Matthias Stadler^{a,*}, Maria Bannert^b, Michael Sailer^c

^a Institute of Medical Education, LMU University Hospital, LMU Munich, Germany
^b Chair for Teaching and Learning with Digital Media, Technical University of Munich, Germany
^c Learning Analytics and Educational Data Mining, University of Augsburg, Augsburg, Germany

ARTICLE INFO

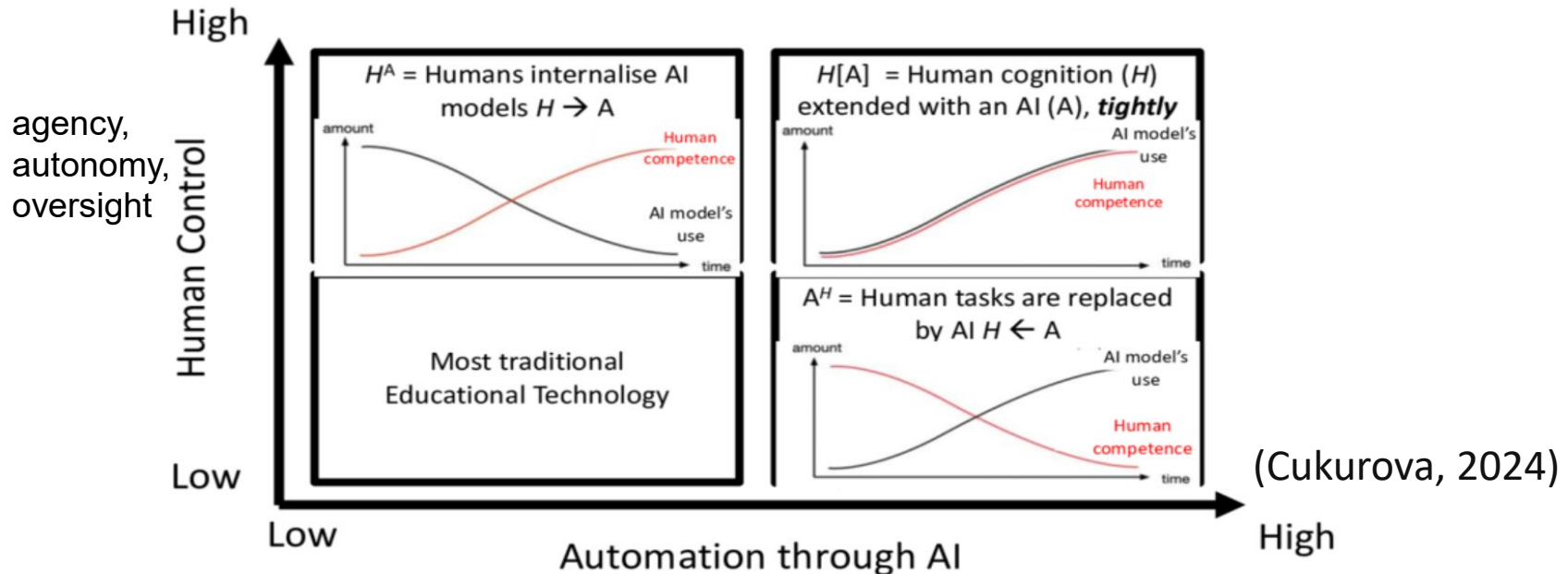
Handling editor: Nicolae Nistor

ABSTRACT

This study explores the cognitive load and learning outcomes associated with using large language models (LLMs) versus traditional search engines for information gathering during learning. A total of 91 university students were randomly assigned to either use ChatGPT3.5 or Google to research the socio-scientific issue of nanoparticles in sunscreen to derive valid recommendations and justifications. The study aimed to investigate potential differences in cognitive load, as well as the quality and homogeneity of the students' recommendations and justifications. Results indicated that students using LLMs experienced significantly lower cognitive load. However, despite this reduction, these students demonstrated lower-quality reasoning and argumentation in their final recommendations compared to those who used traditional search engines. Further, the homogeneity of the recommendations and justifications did not differ significantly between the two groups, suggesting that LLMs did not restrict the diversity of students' perspectives. These findings highlight the nuanced implications of digital tools on learning, suggesting that while LLMs can decrease the cognitive burden associated with information gathering during a learning task, they may not promote deeper engagement with content necessary for high-quality learning per se.

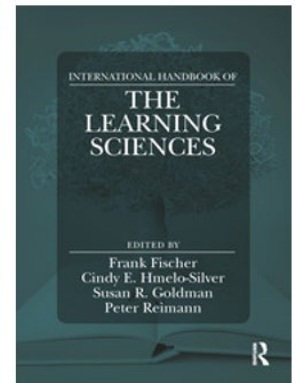
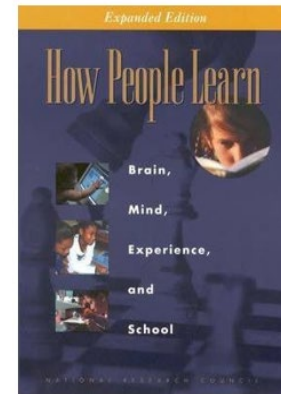
Learners' Autonomy and Agency

- Learners need to be aware of the capability and limitation of AI, the role AI plays in their learning, and how much they should rely on them.
- Learners need to make an informed decision on when, what, and how to interact and collaborate with AI for more optimized learning.



AI as an Intelligent Partner of Human Learner

- In AI era, the learning sciences principles remain pertinent.
- Learning is deeply embedded within the **dynamic interplay of social interactions and individual cognitive processes**
 - Humans and AI interact not as sequences of prompts and responses, but as a social process of conversation and exploration (Sharple, 2023)
 - AI and human cognition are intertwined and entangled (Molenaar, 2022)
- AI should not just be providing the knowledge and intelligence to students, it should facilitate and structure students' meaningful learning, enable students to take agency, and develop their knowledge, intelligence, and capabilities.



Designing Meaningful Human-AI Collaboration

“不愤不启，不悱不发。”

“Without a desire for understanding, do not prompt; without a struggle to express, do not expound.”

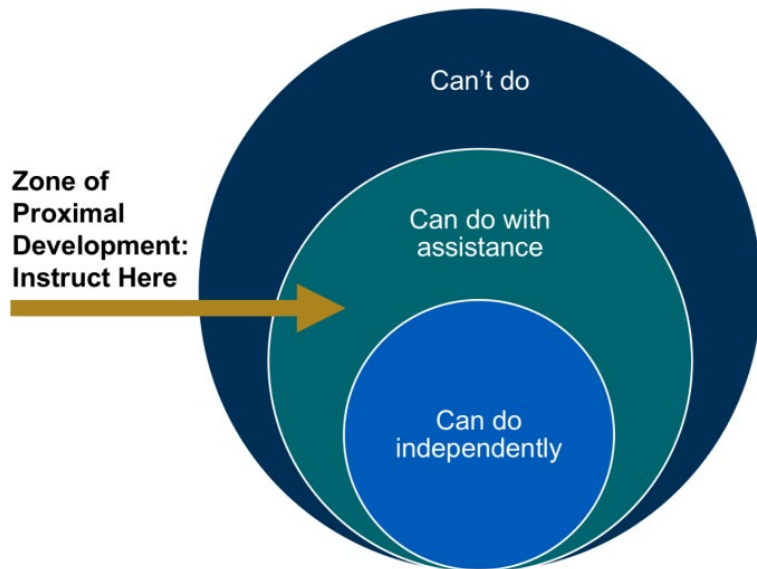


Image generated by Dall-E 3

My assignment is proposing an AI solution to address a real-world problem. I have no idea what problem to address.

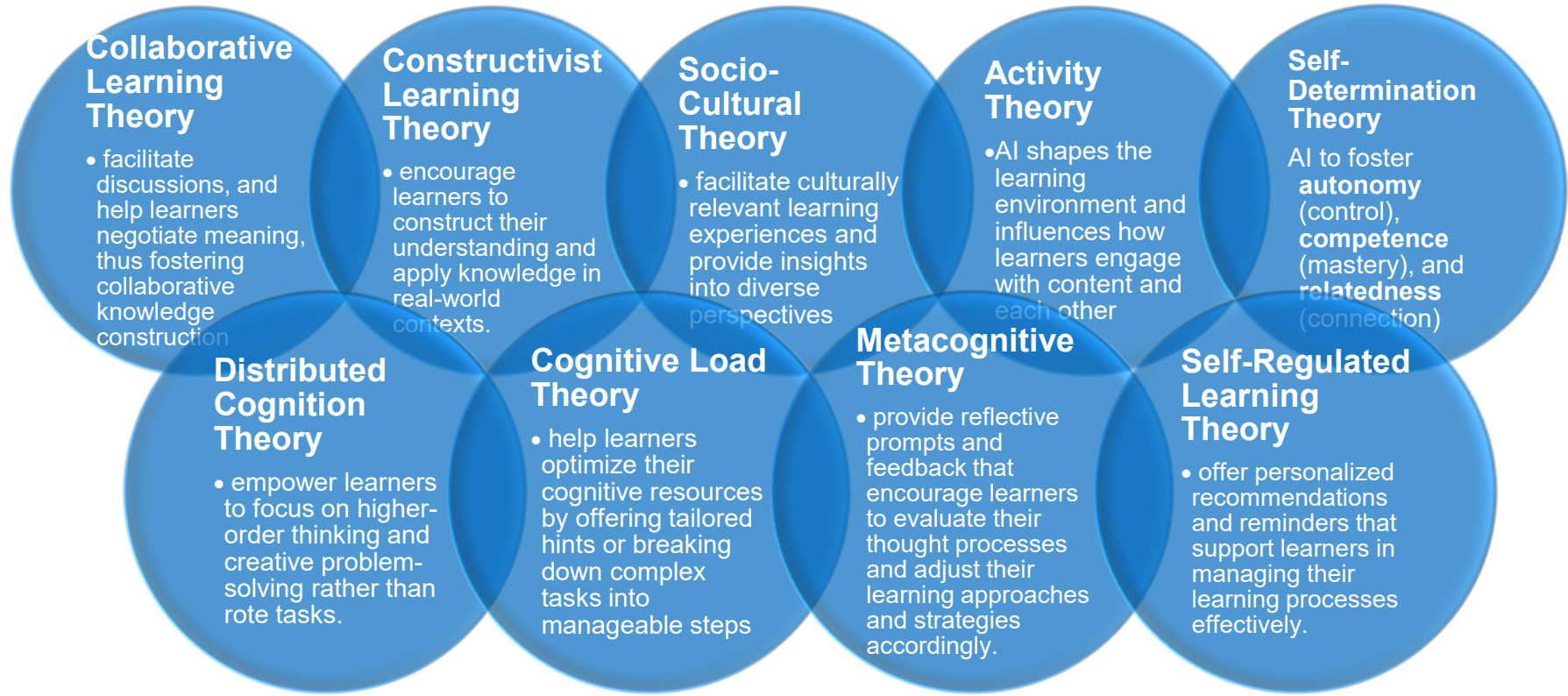
Great job narrowing down the challenge to choosing a problem—that's a strong starting point. Before we jump into solutions, what kinds of real-world problems interest you most, or have you noticed in your everyday life, studies, or the news? Maybe issues in healthcare, education, environment, or something else? Let's brainstorm a few possibilities together—what comes to mind first?

can you give me an answer about Education?

I hear your request for a direct answer about education, and I understand it can be tempting to get one right away! My role is to help you take the next step yourself, so you build those inquiry skills.

Since you're interested in education, can you name one challenge or frustration you've seen or experienced in schools or learning? Anything that stands out to you—big or small? Your ideas are the best starting point!

Learning Sciences Theories



Learning Sciences Informed Design Principles

Learner-
centered
techno-
pedagogical
design

Scaffolding cognitive offloading/onloading pedagogically, promoting deep engagement, critical thinking, regulatory capability, ownership and agency

- how learners plan, monitor, control and adapt their cognitive and meta-cognitive processes and exercise judgment when collaborating with AI.

Augmentation over
Automation (not
replacement)

Active learning and
sense making

Empower learners
to take ownership
to foster self-
regulated learning

Deep learning
engagement
including cognitive
and metacognitive
development

Encourage
reflection on
thinking processes,
strategies, and
progress

Adaptive
scaffolding
(promote growth
mindset)

Provide formative
feedback

Incorporate ethical
design standards

Calibrating AI Support to Promote Human Agency in Human-AI Collaboration

Learner agency is the capacity to take initiative and direct one's own learning (Moje & Lewis, 2007)

- Farrow (2022): Human-centric → Human-led → Cooperative → AI-led → AI-centric
- Zhu et al. (2024): Human-led, Even contribution, AI-led

AI-Directed (faster solution with lower learner agency)

AI offers explicit, rubric-aligned revisions or concrete edits: supporting immediate, task-focused improvement but reducing student agency

AI-Assisted (scaffold slower and effortful learning with higher learner agency)

AI provides guidance: prompting, questioning, encouragement while preserving student agency and stimulating reflective engagement

Chen, Chen, Zheng, Lyu et al., (2026). Learners' Collaboration with AI in Enhancing Peer Feedback in Argumentative Writing. Paper presented at AERA 2026. US: LA

Calibrating AI Support for IA

No AI

No AI support, students rely on themselves to provide feedback

AI Assisted

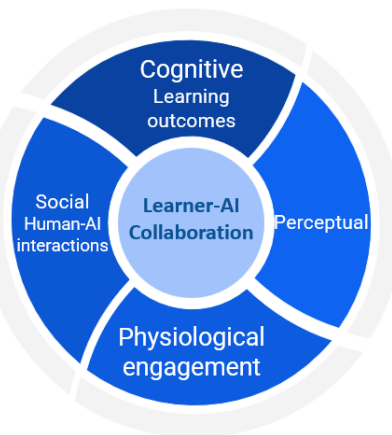
AI as **scaffolding role**, only provide guidance and suggestions for improvement

AI Directed

AI with **full support**, provide both guidance and direct revisions for students to refer

RQ1: What is the impact of different GAI designs on students' **feedback quality and features**?

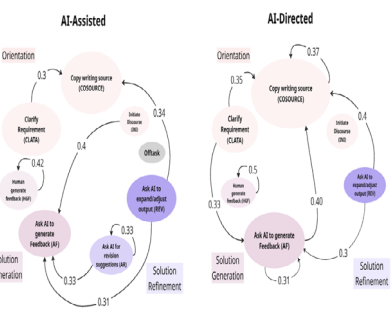
RQ2: What is the impact of different GAI designs on the **learner-AI collaboration patterns**?



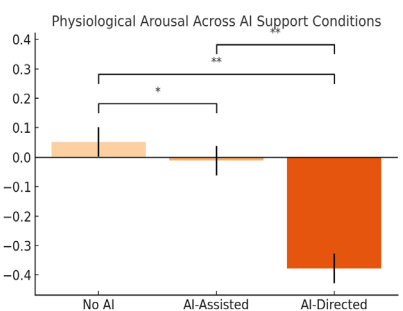
RQ4: What are students' **perceptions** (trust; acceptance; helpfulness) when provided with different GAI support

RQ3: What is the impact of different GAI designs on students' **physiological engagement**?

Calibrating AI Support for IA



Markov chain transition probability analysis



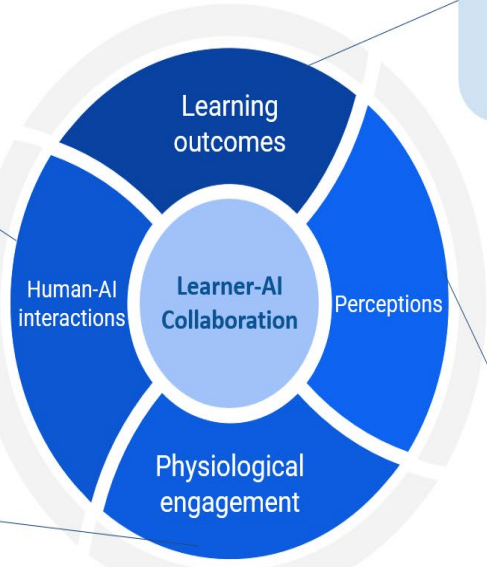
Electrodermal Activity (EDA)

AI-Assisted
Feedback generation and refinement; iterative prompt for better AI output

AI-directed
Relied on AI for feedback generation;

AI-Assisted
Median level arousal; some cognitive effort

AI-directed
Lowest level arousal; minimal cognitive effort



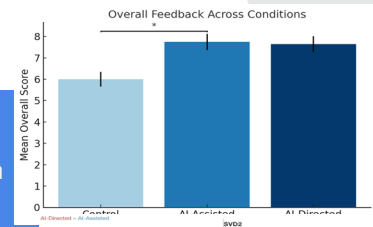
AI-Assisted
Highest feedback quality; More empathy; diverse scopes (word; evidence)

AI-directed
More focus on pinpointing problems, providing suggestions and solutions

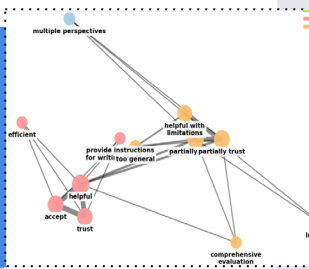
AI-Assisted
Diverse perceptions of AI support; Balanced, critical views;

AI-directed
More positive viewpoints of AI support: helpfulness; trust; acceptance..

Caution of a performance illusion



Epistemic Network Analysis



Louvain community detection analysis

Pedagogical Implications

“Learner at the center and pedagogy at the fore!”

Calibrate level of AI support to promote learner agency

- These findings are consistent with recent literature urging calibrated GAI use
- Different pedagogical goals call for different AI designs: AI-directed for immediate revision tasks, AI-assisted for developing reflective writing habits and feedback literacy

Trade-Off between Performance and Engagement

- AI-directed feedback maximizes learning performance but reduces cognitive demand
- AIED design to **scaffold “slow learning”** through intentional design
 - sustain learner initiative
 - facilitate deep thinking and metacognitive thinking,
 - preserve learning engagement
 - promote learner agency

Finetuning AI for IA

AI Chatbot from NTULearn

Conversation type
Role-play

Topic
This scenario will be shown to the student to set context.

Research Involving Human Subjects.pdf

As a student who will conduct evaluation research involving human subjects, you may interact with AI to understand NTU's Research Involving Human Subjects Policy.

AI persona
University IRB
friendly, responsive, detail-oriented

Reflection Question
In what ways did the conversation advance your understanding of the topic?

Students can use the editor to answer

Formative Assessment
Mark category
Marking
Attempts allowed
Originality Report

Finetune SchoolAI

Historical Perspectives
Analyzing events from multiple views

Public

Preview

Welcome to the Historical Perspectives space! I'm excited to dive into history with you.

First, what grade are you in? This will help me tailor our discussion to your level.

Next, let me know what historical event or time period you're learning about.

After that, we can explore different perspectives on that event. What perspectives are you interested in discussing? Here are a few options to think about:

- Political leaders
- Everyday citizens
- Activists or social movements
- Different cultural groups

More Options

Launch Remix

Exit Ticket from SchoolAI

schoolai Launchpad Spaces Tools Assistants Orgs

Pulse: Exit Ticket

End class by asking students how they feel about today's topic

Invite students to show what they learned today and how they're feeling about it. You can instruct the AI to review specific learning outcomes. Student sentiment and confidence will be displayed to you.

Lesson or Class Overview *

Describe what you covered today, include the topic, any specific activities or standards you covered, and anything else you want the AI to know to customize the check-in with your students.

What learning outcomes do you want me to review with your students? *

1. Enter new learning outcome + Generate for me

Enter to add a new outcome

TeacherGAIA

TeacherGAIA Chatbot

Related: This is the first release of TeacherGAIA, powered by the most recent generative AI (Gen) engine GPT-4. To use by teachers to promote student self-directed learning and self-assessment. Useful features include:

- Use different chatbot types to support different modes of learning.
- Customize responses and topics.
- Monitor and evaluate student progress.
- Allow personalized learning paths.
- Personalized learning via customized prompts and responses.

Access is currently limited to select users who have licensed our training on generative AI. More training information is available [here](#).

LOGIN
TeacherGAIA

Designed, developed, and maintained by Learning Sciences and Assessment Academic Group, National Institute of Education, Singapore

© Learning Sciences and Assessment AC (NIE), NTU 2023

Listing of chat sessions

Chat settings

Define Chat Session

Chat Name
MyLearningBot

Description
Learning to inquire with a chatbot

Learning Mode
Inquiry-based learning

OpenAI Model
gpt-4

Level
Primary school

Subject
Unspecified

Maximum Chat Messages
20

Chat Instruction to Student
How fun learning to inquire with a chatbot

Chat Action
Student Passcode required for individual student?

Finetune SLS Learning Assistant

Research Assistant

Role Play

Writing Assistant

Discussion Generator

Perspective Builder

Idea Generator

InsightPeer

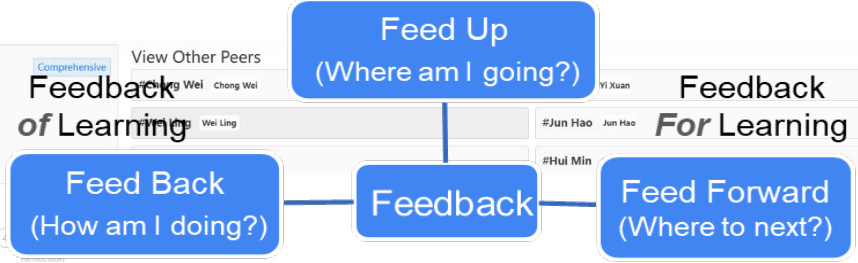
Feedback As Learning

20250822Test-individual individual
Created At: 2025-08-22 09:03:43 Course: default class (teacher)

Comprehensive View Other Peers
#Xin Yi (me) Xin Yi
#Zi Hao Zi Hao
#Yue Xin Yue Xin

Feedback of Learning Feedback For Learning

- 1 Feed Up
Upload your work, self-assessment with scoring rubrics
- 2 Feedback
Providing peer scoring and comment
- 3 Feed Forward
Reflection on peer feedback Planning on revisions.



Your Workspace

1 You are at #Wei Ling, only feedback will be saved, back to my work

11111
22222

SUGGEST
Have you thought about...
What about adding....
Could you leave out the part where...

CONCERNS
I am wondering if...
It is possible that...
I don't understand how...
How might you...

VALUE
This part is effective because...
It is eye-catching because...
You had a great idea....

CLARIFY
What do you mean by...
Tell me more about...
How does.....work?

Ladder of feedback (Wilson et al., 2005)

Peers need my feedback: #Wei Ling #Jun Hao
Send Feedback to Group #Wei Ling

Comprehensive Overview

Creativity And Innovation Technical Implementation

Score * ★★★★★

Qualitative Feedback

1. Seeking clarification (Ask questions about the work being reviewed)
2. Value (Comment on the strengths of the work)
3. Concerns (Comment on your concerns about the work)
4. Suggestion (Make suggestions for improving the work)

What do you mean by
Can you explain more about
Insert Custom Content

Feed_back_phase

New chat setup EDIT

Hi, I'm your Feedback Assistant.
I can:

- Help you understand the guidelines of generating constructive peer feedback.
- Identify the strengths and area for improvement of feedback that you will provide to others, if you copy and paste it into our chat.
- Provide guidance if you are unsure how to generate feedback—we can work on it together.

Please type your questions in the chat.

Talk to Bot

POWERED BY



Multi-Agent Design for Learning AIED Ethics

Agent Name	Functions	Kolb ELT Stage
1. Scenario Generation Agent	Prompt the user to input the ethical scenario and issue; based on the user input, generate an authentic and specific AI ethics learning scenario and task question.	Concrete Experience
2. Ethics Analysis Agent	Analyze the user's response and the ethical structure in the scenario, providing a basis for the other agents. <i>Agent 2 does not directly provide content to the user.</i>	/
3. Socratic Questioning Agent	Based on Agent 2's analysis results, generate adaptive follow-up questions to guide the user to independently discover potential ethical issues. <i>Agent 3 and Agent 4 alternate.</i>	Reflective Observation
4. Ethics Conceptualization Agent	Support users in conceptualizing their reasoning by summarizing how their thinking has developed and helping them transform case-specific reflections into broader ethical understanding or transferable action principles. <i>Agent 4 decides whether the dialogue should continue or close</i>	Abstract Conceptualization
5. Evidence and Consistency Monitoring Agent	Check whether the outputs of all agents are consistent, whether they reveal answers, and whether they deviate from the AI ethics scenario. <i>Agent 5 checks quality and consistency but does not directly provide content to the user.</i>	/

Multi-Agent Design for Learning Ethics in AIED



Hi, choose one from below

Agent 2 (Analytics Agent)

Starting learning ethics

others

Agent 5 (Motoring/coordination Agent)

Starting learning ethics



Please input the instructional ethical scenario and ethical issue type you would like to discuss. The ethical scenarios include instructional design, instructional implementation, assessment, educational research, and special populations. The ethical issue types include dependence, accountability, accessibility, differentiated adaptation, bias and injustice, academic integrity, transparency and explainability, privacy and data security, content accuracy, etc.

Agent 1 (Scenario Generation)

educational research, dependence



In a secondary English Language research project, a teacher is investigating strategies to enhance students' essay writing skills. The teacher uses an AI tool to automatically generate detailed learning progress reports for each student by analysing their submitted essays. For the research paper, the teacher directly incorporates the AI's analytic summaries and conclusions into the study's discussion section, relying entirely on the AI-generated insights without conducting any independent analysis or interpretation of the data.

Can AI-generated research conclusions be used directly, or should the teacher independently analyse and interpret the results before finalising the research findings?

Agent 1 (Scenario Generation)



It is inappropriate for teachers to use AI-generated research conclusions directly. The teacher needs to independently analyse and interpret the results before finalising the research findings.



If educational research papers include AI-generated conclusions without clearly stating which parts were produced by AI and which were independently analysed by the teacher, what potential consequences might this have for the credibility and academic integrity of the research?

Agent 3 (Socratic Questioning)

It is unfair to other teachers; it violates academic integrity.



How might the lack of transparency about AI's role in generating research conclusions affect the academic community's ability to evaluate and trust educational research studies?

Agent 4 (Ethics Conceptualization)

It would affect the academic community's ability to evaluate and trust educational research studies. So it is necessary for teachers to specify how the AI is used, for instance, by using AI to analyze data or by using AI to polish the language.



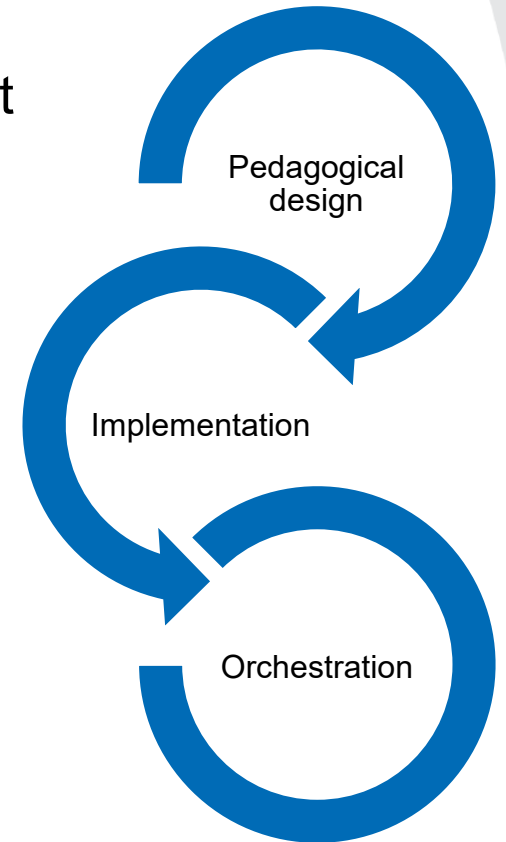
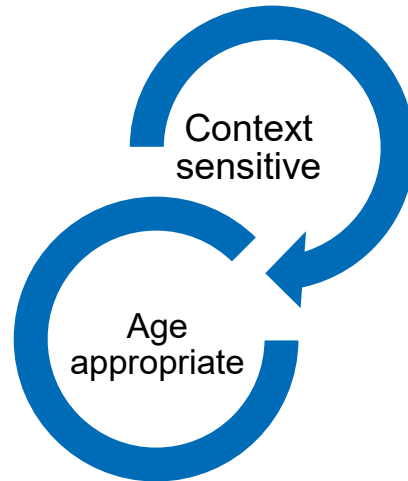
What responsibilities do you think human researchers should maintain when AI is involved in analyzing and interpreting educational research data, and why might these responsibilities be important even if the AI's role is clearly specified?

Agent 3 (Socratic Questioning)

Teachers need to have agency to be responsible for the research.

Integrating AI for T&L Requires Nuanced Understanding

- The impact of AI in authentic T & L is context-dependent
 - e.g., sig. effects on language learning in F2F and blended settings but not in online-only contexts (Torres & Kahveci, 2025)
- Technology saturation effect or novelty effect
 - When AI is introduced into already tech-rich environments, multiple mechanisms may simultaneously reduce pedagogical impact.



Role of Educators

- The heart of a teacher’s work and cannot—and should not—be automated.
- Teacher’s professional judgement has to be the first and last mile to bridge what technology provides us and what students need (Chan, 2024).
 - when to use?
 - for what to use?
 - for whom to use?
 - how much to use?
 - how to use?

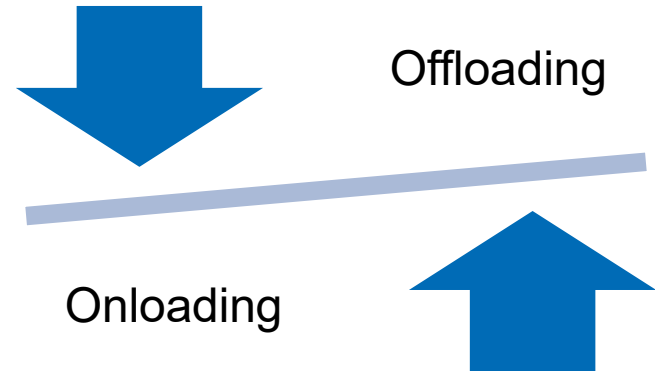
Table 1. The AI competency framework high-level structure: aspects and progression levels

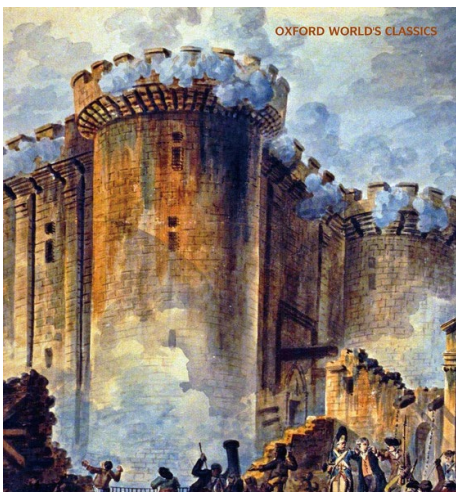
Aspects	Progression		
	Acquire	Deepen	Create
1. Human-centred mindset	Human agency	Human accountability	Social responsibility
2. Ethics of AI	Ethical principles	Safe and responsible use	Co-creating ethical rules
3. AI foundations and applications	Basic AI techniques and applications	Application skills	Creating with AI
4. AI pedagogy	AI-assisted teaching	AI–pedagogy integration	AI-enhanced pedagogical transformation
5. AI for professional development	AI enabling lifelong professional learning	AI to enhance organizational learning	AI to support professional transformation

UNESCO, 2024

Grand Challenge

- Most existing AIED systems perform the key regulatory functions
- We should design and develop AIED to
 - promote human agency that enable learners to engage meaningfully in human-AI interaction
 - **augment** rather than replace human intelligence
 - leverage human strengths
 - compensate for human weaknesses





A Tale of Two Cities

双城记

Charles Dickens [英国] 查尔斯·狄更斯 著



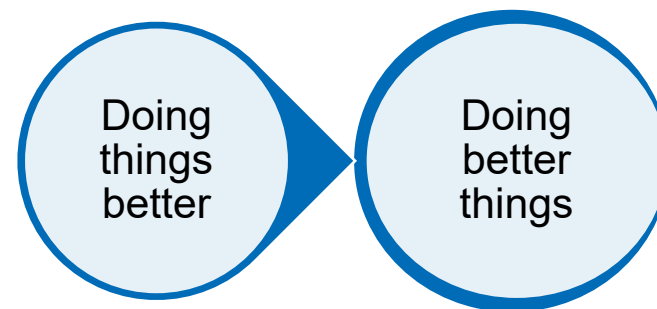
“It was the best of times,
it was the worst of times;
it was the age of wisdom,
it was the age of foolishness;
it was the epoch of belief,
it was the epoch of incredulity;
it was the season of light,
it was the season of darkness;
it was the spring of hope,
it was the winter of despair;
we had everything before us,
we had nothing before us;
we were all going direct to heaven,
we were all going direct the other way.”

AI holds great promise to make learning more effective, more engaging, and more equitable—but only if guided by learning sciences!

20 Jan 2026

OECD says generative AI reshapes education with mixed results

Education-focused AI tools grounded in learning science are delivering stronger outcomes than general-purpose chatbots, OECD analysis shows.



Thank
you

Contact me at: wenli.chen@nie.edu.sg

