IN SEARCH OF INTELLIGENT PEDAGOGICAL CONTENT KNOWLEDGE

CHING SING CHAI, 蔡敬新

PROFESSOR, ASSOCIATE DEAN HIGHER DEGREES

CUHK, FACULTY OF EDUCATION, CRI

CSCHAI@CUHK.EDU.HK

THE EVOLUTION TOWARDS ???

- Pedagogical content knowledge (PCK) (Shulman, 1986; 1987)
- Technological pedagogical content knowledge (Mishra & Koehler, 2006; Niess, 2005; Angeli & Valanides, 2006); ICT for knowledge creation (Bereiter & Scardamalia, 2006); ICT as mindtools/cognitive tools for 21st century learning (Jonassen, 2000; Chai et al., 2019)
- Currently, the breakthrough of artificial intelligence (AI) seems to demand Intelligent Pedagogical Content Knowledge (IPACK) (the need for pedagogical intelligence) (Diaz & Nussbaum, 2024)
- research on AI in education reflects a weak connection to pedagogical perspectives or instructional approaches, particularly in K-12 education (Chiu et al., 2024)
- The ideal IPACK: Epistemic coupling/collaboration/co-operation, humans plus machines coupling to optimize knowledge construction for common good and human development (human-centered AI to improve human condition, Yang et al; 2023)

CURRENT USE OF AI

	Customized intelligent system	**Generative AI**
AI education	Teachable machine	Machine generated codes
AI in education	ITS, ASR, AWE, AI as Socrates	genAI for all subject matters (pedagogical agents)

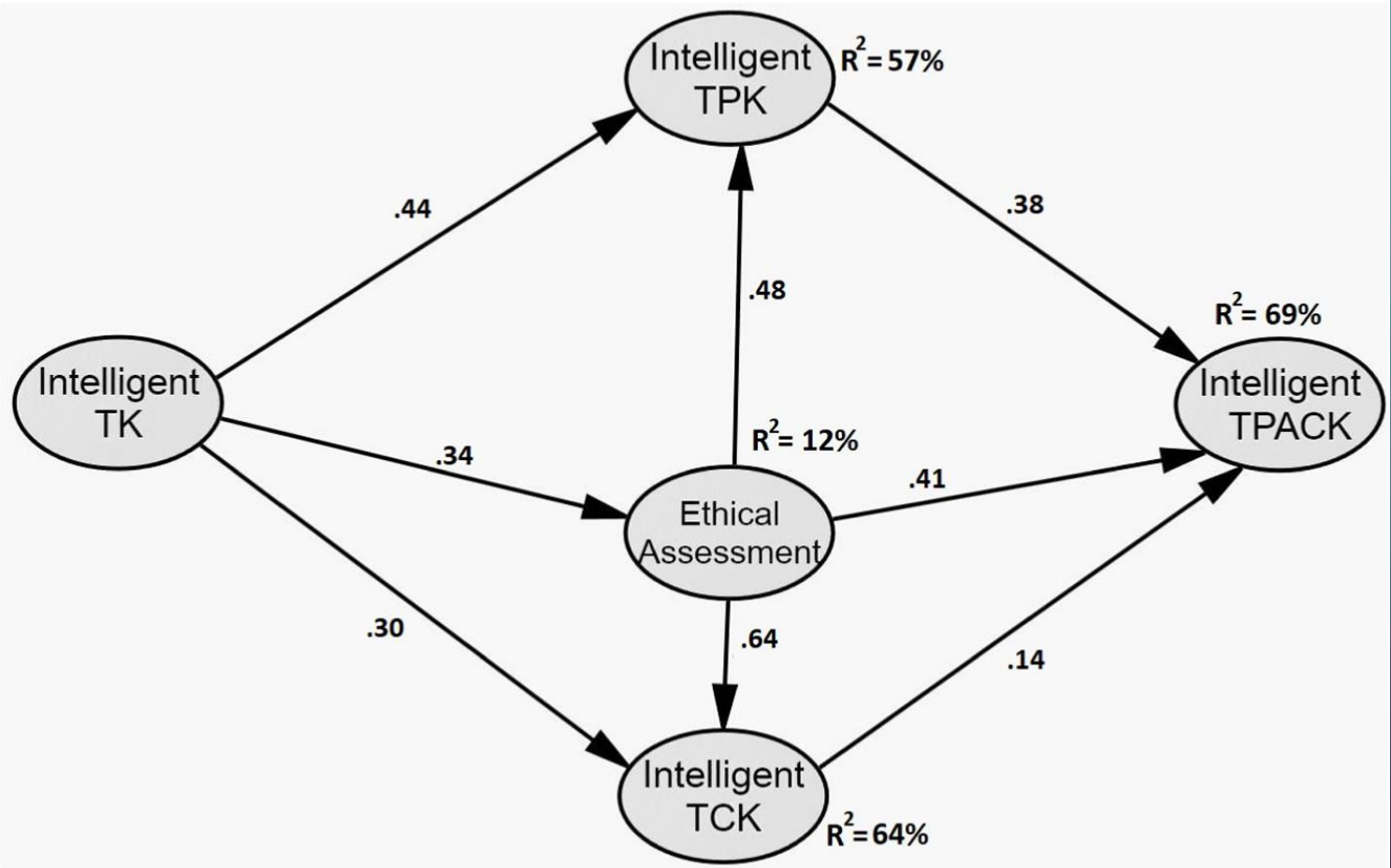
QUALITATIVE STUDIES: AFFORDANCES/ BENEFITS OF AI FROM TEACHER AND LEARNER PERSPECTIVE

- 24/7 access to act as language editor, content provider (80 plus percentile performances for most subject matter), content generator (e.g., making a rubric), feedback provider/evaluator, interlocutor/debater/ learning partner; and as companion (Tin et al., accepted)
- three teacher roles (orchestrating different resources with quality pedagogical decisions, making students active investigators, and raising AI ethical awareness) (Jeon & Lee, 2023)
- genAI unstandardized intelligent outputs

INHERENT DRAWBACKS (IT'S NOT A MIND, WOOLRIDGE, 2023)

- AI hallucination or false claims (Cheung et al., 2024; Hicks et al., 2024)
- Fluent plausibility that may be treated as epistemic authority
- GenAI lack awareness of contextual socio-scientific and human issues
- Unable to understand the intricacies of real world phenomenon, unable to deal with novel situation (Farrokhnia et al., 2024)
- Data Bias, toxicity, inaccuracy (Biswas, 2023; Labadze et al., 2023; Woolridge, Youtube, Dec 2023)
- The potential to weaken human agency, in particular epistemic agency (epistemic cognition: Aims, Ideal, Reliable process; apt epistemic performances)

INTELLIGENT TPACK (CELIK, 2023)



Intelligent TPACK

TPACK1: In teaching my field, I know how to use different AI-based tools for adaptive feedback.

TPACK2: In teaching my field, I know how to use different AI-based tools for personalized learning.

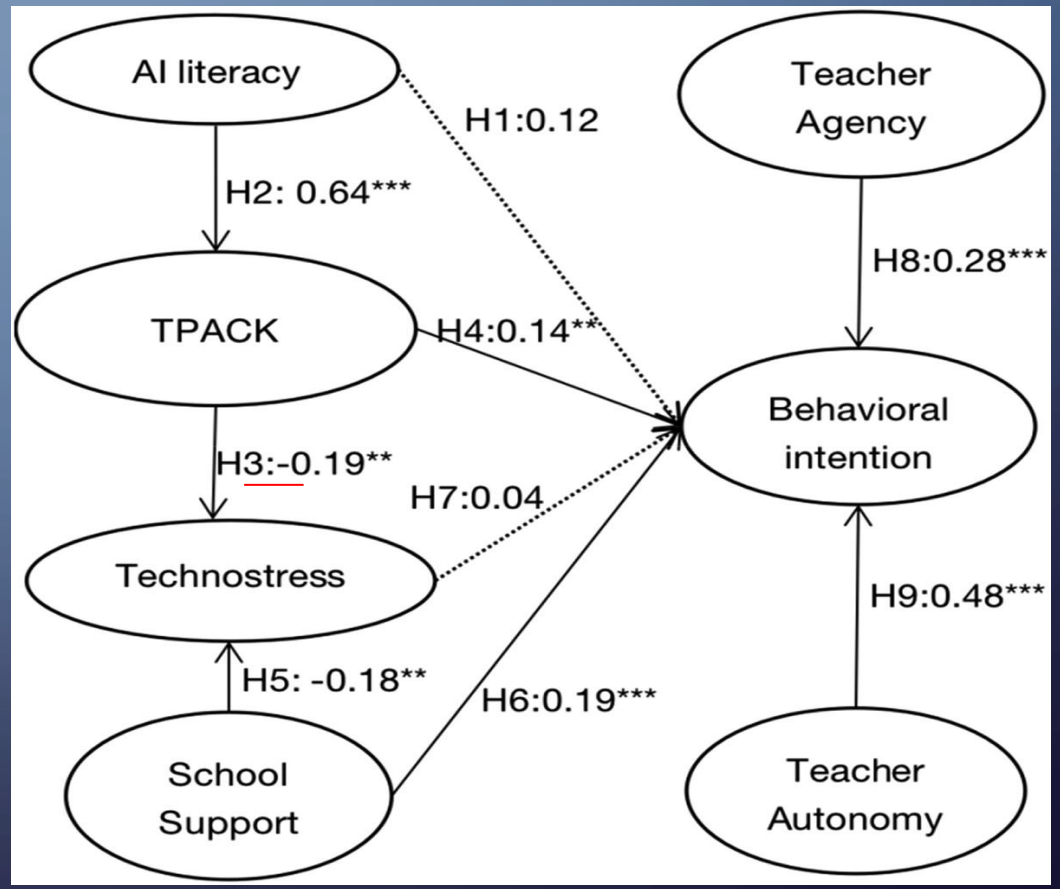
TPACK3: In teaching my field, I know how to use different AI-based tools for real-time feedback.

TPACK4: I can teach a subject using AI-based tools with diverse teaching strategies.

TO TEACH SUBJECT MATTER WITH AI, THE KNOWLEDGE WE NEED

- AI literacy
- GenAI-related issues such as bias, discrimination, and hallucinations
- TPACK for AI (e.g., Supporting 5E with AI for photosynthesis)
- Prompt Engineering (from teachers to students and vice-versa)

(Wang et al., 2024; Feldman-Maggor et al., 2024)



THE CORE: CONTENT KNOWLEDGE (SCIENCE)

What is knowing science?

- Given a natural phenomenon, being able to make sense of how variables/agents interact employing scientific methods
- In face of a knowledge claim about natural world, being able to assess if the claim is warranted

THE MATERIALITY OF SCIENCE

- "natural science is unique because the ontological and epistemological understanding of nature is fundamentally rooted in our interaction with material objects in the physical world. GenAI, powered by statistical probability arising from a massive corpus of text, is devoid of any connection to the physical world. The use of GenAI thus raises concerns about our connection to reality and its effect on science education." (Tang & Cooper, 2024, p.)
- IPACK involves managing epistemological trade-offs (Billingsley, 2024), preserving disciplinary ways of knowing

THE KEY QUESTION

- When my students learn with AI/GenAI, will they become more able and better developed individuals epistemically/educationally or other wise? Can we know for certain? How?
- After the information (ICT) revolution, have anyone become an expert of any kind with cut-and-paste? Can anyone become an expert of any kind with prompt engineering?
- What actually make someone an adequately informed and useful person, if not an expert?

PEDAGOGICAL PRINCIPLE 1: REAL WORLD KNOWING

- All subject matter knowledge has a ontological reference, a world they are dealing with
- The learning of subject matter should be real world focus as far as possible (Google Lens for object recognition, GenAI for support)
- Understand and use AI as powerful but not error free epistemic tools, it is not authoritative source of information (good but not ultimate) though it appears so (Cooper, 2024)
- the vetted textbook is more authoritative, and so is the teacher (teachers as epistemic guide)

PEDAGOGICAL PRINCIPLE 2: FOSTER EPISTEMIC AGENCY FOR PRODUCTIVE EPISTEMIC WORK

- The student is the epistemic agent who needs and wants to know the world, and constructing epistemic artefacts mediate productive learning (minds-on driving hands-on)
- In practice, it means assuming authorship and the most important subject we author is ourselves represented by our epistemic artefacts (scientific theories, investigations, reports, representations etc.)
- ICT as mindtool/genAI for knowledge construction, customized AI for knowledge reproduction

RESULTS (TIN ET AL., ACCEPTED; SEE ALSO BREHAN ET AL., 2024)

Trigger and Exploration

- Triggers: teachers, peers, and media
- Probing affordances: exploring the functionalities of ChatGPT

Positive experiences and problems identified

- Satisfying Experiences: fast response time, availability, and powerful classification features of ChatGPT
- Problems: provide incorrect information, fail to correct its own mistakes, provide false or unauthoritative information, fail to satisfy students in writing and programming tasks

Spontaneous adjustment strategies

- Structuring questioning prompts: using repeated question prompts
- Changing questioning prompts: using more specific and clearer commands, English rather than Chinese, direct imperative instructions

Multiple roles of ChatGPT

- Useful functions: an information provider, an inspiration source, and an analyzer
- Interactive partner: a collaborator, a team player, a stimulator, a debater, and even a friend

Contradictions and negotiations

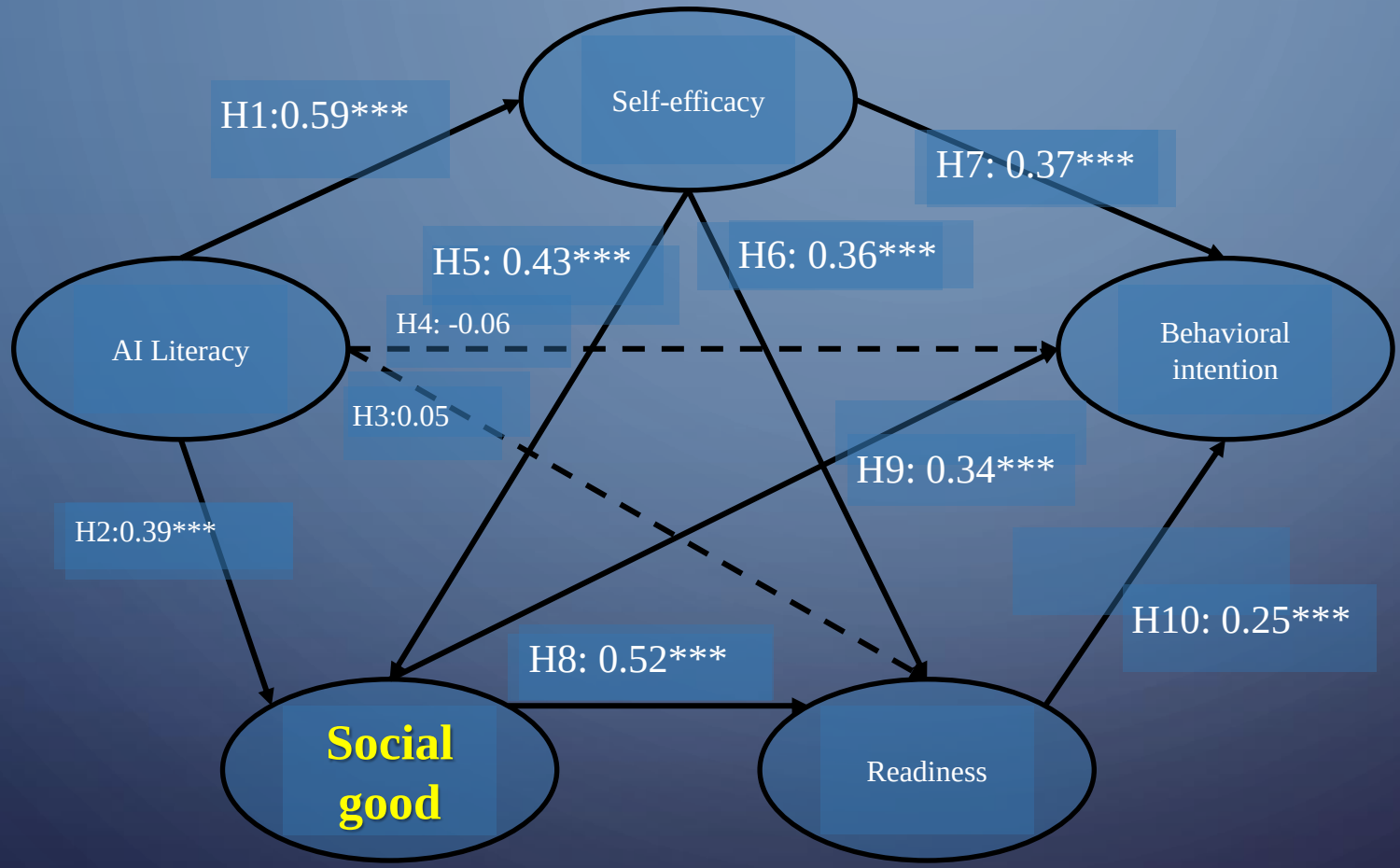
- Struggles: hope ChatGPT is intelligent enough to provide more help & worry about ChatGPT surpasses humans
- Preservation of agency: frequently judge and select the information provided by ChatGPT

AI dependence may be over-rated

PEDAGOGICAL PRINCIPLE 3: ADVANCING COMMON GOOD (RELATEDNESS)

- It seems that socio-scientific issues (e.g., pollution, global warming, helping the less advantaged people etc.) are good pedagogical anchors that motivate students to learn
- Teachers need to find relevant authentic problems for students to work on (GenAI can help)

- **Confirmatory factor analysis and SEM for hypotheses testing**
- Both the CFA and SEM models had good fit.



Qualitative findings:
Kids are overwhelmingly positive about AI

Chai et al., 2021
Chai et al., 2022 a, b;
Chai et al., 2024

EMERGING PEDAGOGICAL RESEARCH

- Online monitoring
- Teachable agent
- Assessment (students' sketches; argumentation)
- Teacher education
  - Support for STEM (primary teachers, Chen et al., submitted)

DESIGN CONSIDERATIONS (SDT PERSPECTIVE)

- Is the use of AI tool or how it is used developing students' competency?
- Is the use of AI tool or how it is used fostering students' autonomy (subjectification; epistemic agency); s/he is more able to be a person capable of productive reasoning about the subject matter?
- Is the use of AI tool or how it is used helping students to contribute to common good (purpose in learning)?

EMERGING THEMES

- Designing and testing IPACK through design-based research, action research or lesson study; enhancing educators and learners' productive/wise ethical reasoning on educational use of AI; instructional and managerial leaderships for intelligent reform; and creating equitable educational practices to serve students with special education needs with AI.
- Creating multiagent workflow (submitted); pedagogical agent (Lan & Chen; 2024)→ specific IPACK

TEAM TEACHING WITH AI (LAN & CHEN, 2024)

- "The human teacher brings expertise in pedagogy, subject knowledge, and emotional intelligence, while the GAI teacher offers versatile information processing capabilities, personalized learning suggestions, and data-driven feedback. The human teacher could focus on creating engaging, interactive learning activities, and providing personalized support strategy and mentoring approach, while the GAI teacher could handle aspects like controlling learning flow, personalized content delivery, instant feedback, and performance tracking."

Lan, Y.-J., & Chen, N.-S. (2024). Teachers' agency in the era of LLM and generative AI: Designing pedagogical AI agents. *Educational Technology & Society*, *27*(1), I-XVIII. https://doi.org/10.30191/ETS.202401_27(1).PP01

TEACHERS AS EPISTEMIC, SOCIAL AND EUDAIMONIC GUIDE

THANK YOU