Getting ready for the age of AI: Developing self-regulated learners

Dragan Gašević
@dgasevic

November 27th, 2024
ICCE'24
Manila, Philippines

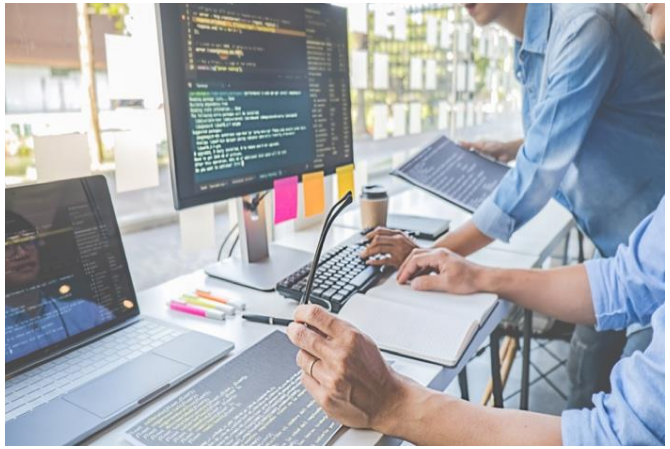
Artificial intelligence

Artificial intelligence will not go away

Source: https://bit.ly/47NbA7D

Over 80% of jobs, especially writing and IT, are predicted have at least 19% exposure to generative AI

Productivity in **problem solving support** increased by 35% for novice, but not for experienced workers



46% productivity increase in software engineers while maintaining code quality by using AI

Generative AI does not have inherent mechanisms to **distinguish facts from falsehoods**

Developing ***adaptive learners*** for the age of AI

nature human behaviour

Perspective

https://doi.org/10.1038/s41562-024-02004-5

Promises and challenges of generative artificial intelligence for human learning

Received: 25 February 2024

Accepted: 3 September 2024

Published online: 22 October 2024

Check for updates

Lixiang Yan[1], Samuel Greiff[2,3,4] ✉, Ziwen Teuber[2] & Dragan Gašević[1] ✉

Generative artificial intelligence (GenAI) holds the potential to transform the delivery, cultivation and evaluation of human learning. Here the authors examine the integration of GenAI as a tool for human learning, addressing its promises and challenges from a holistic viewpoint that integrates insights from learning sciences, educational technology and human–computer interaction. GenAI promises to enhance learning experiences by scaling personalized support, diversifying learning materials, enabling timely feedback and innovating assessment methods. However, it also presents critical issues such as model imperfections, ethical dilemmas and the disruption of traditional assessments. Thus, cultivating AI literacy and adaptive skills is imperative for facilitating informed engagement with GenAI technologies. Rigorous research across learning contexts is essential to evaluate GenAI's effect on human cognition, metacognition and creativity. Humanity must learn with and about GenAI, ensuring that it becomes a powerful ally in the pursuit of knowledge and innovation, rather than a crutch that undermines our intellectual abilities.

Human learning is a journey that shapes minds, fosters innovation and builds the foundations of society. Beyond merely acquiring knowledge and skills, learning is a path towards fostering critical thinking, creativity, collaboration and social cohesion. By nurturing the ability to question, analyse and innovate, learning empowers individuals to navigate **complex challenges and contribute to societal progress. Although education encompasses formalized systems that structure learning** processes, learning represents the dynamic and personal process that occurs within this framework (see Box 1 for key definitions of human learning concepts).

The history of human learning presents a narrative of continuous evolution and adaptation to technological breakthroughs. For example, the printing press democratized access to knowledge and **opened the opportunity of learning to many, whereas the Internet** and digital technologies transformed information dissemination and **collaborative learning across time and space. In this continuum of** innovation, recent advancements in artificial intelligence (AI) present another transformative opportunity to rethink learning processes and educational methodologies[1].

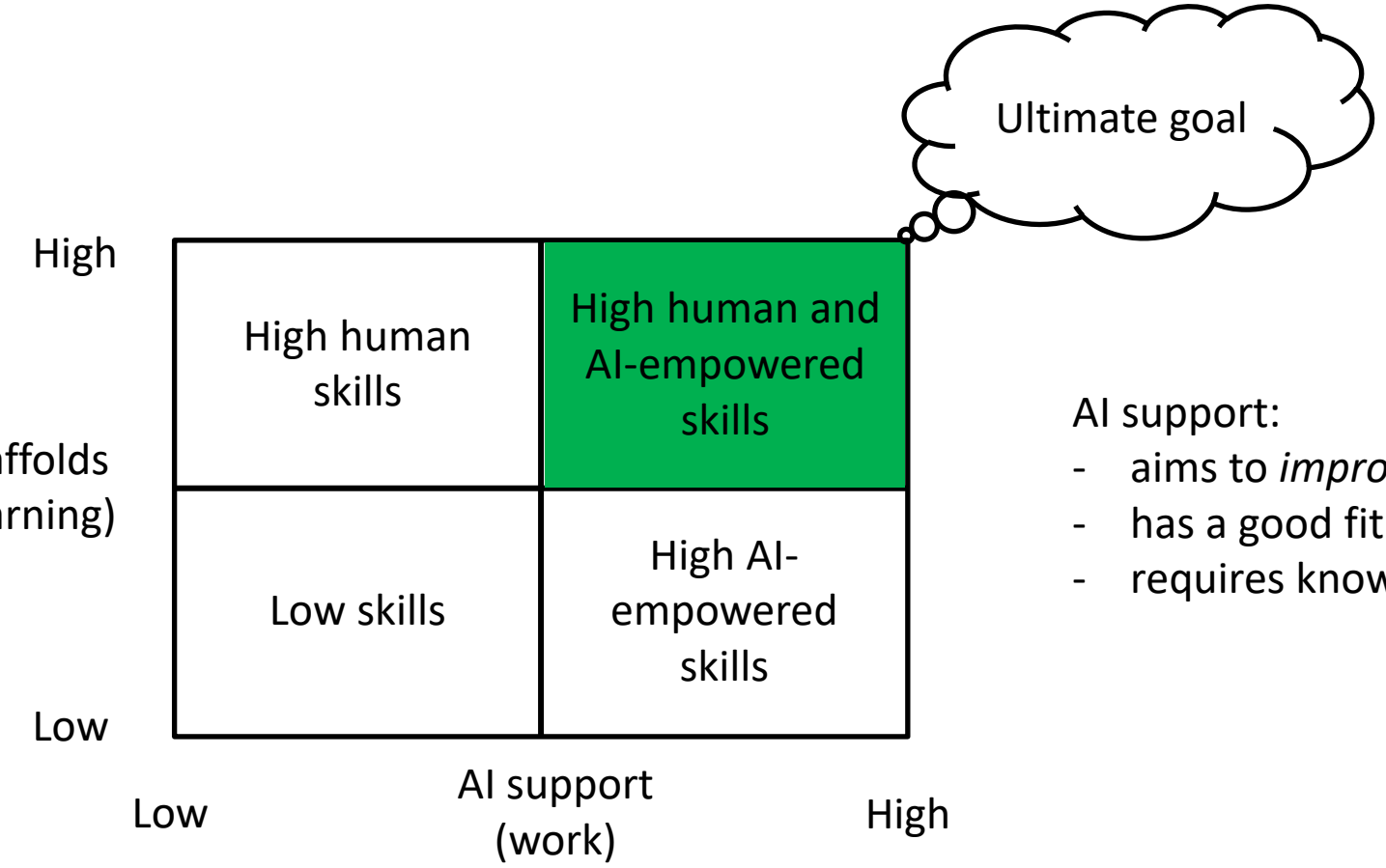
Generative AI (GenAI) technologies, such as large language models (LLMs) and diffusion models (see Box 2 for key definitions of AI terms), have shown promise in automating various learning tasks[2], delivering feedback on human efficacy[3], outperforming average students in reflective writing[4], innovating conversational assessments[5], creating dynamic learning resources[6] and supporting multimedia **learning[7]. However, these technologies also present challenges and ethical considerations that could outweigh their benefits[2,8].** One major concern is the digital divide, where unequal access to these powerful technologies can exacerbate existing inequalities in learning opportunities[9]. Additionally, over-reliance on GenAI may negatively affect learners' agency, critical thinking and creativity, warranting caution[10].

Consequently, it is essential to balance technological advancement and human-centred values in learning. The aim of this Perspective

[1]Faculty of Information Technology, Monash University, Melbourne, Victoria, Australia. [2]Department of Behavioral and Cognitive Sciences, University of Luxembourg, Esch-sur-Alzette, Luxembourg. [3]Department of Educational Psychology, Goethe-University Frankfurt, Frankfurt, Germany. [4]Present address: Centre for International Student Assessment (ZIB) & School of Social Sciences and Technology, Technical University of Munich, Munich, Germany.
✉e-mail: samuel.greiff@tum.de; dragan.gasevic@monash.edu

Towards high human and AI-empowered skills

Scaffolds:
- aim to *improve human skills*
- can be implemented with AI



AI support:
- aims to *improve performance*
- has a good fit for the task
- requires knowledge of AI tool

Inspired by, but different conceptualization from
Cukurova, M. (2024). The interplay of learning, analytics, and artificial intelligence in education. *British Journal of Educational Technology*, in press.
Shneiderman, B. (2022). *Human-centered artificial intelligence*. Oxford University Press

COLAM

Challenge

Learners already have profound limitations in SRL abilities

Today's talk

How do we develop
self-regulated learners for the age of AI?

Key takeaway #1

No free lunch for adaptive learners!

Difficult to develop combined human and AI-empowered skills without human skills first

Key takeaway #2

Lazy metacognition may emerge with unscaffolded use of generative AI

Fan, Y., Tang, L., Le, H., Shen, K., Zhao, S., Zhao, Y., Shen, Y., Li, X., Gašević, D. (2024). Beware of metacognitive laziness: Effects of generative artificial intelligence on learning motivation, processes, and performance. *British Journal of Educational Technology*, in press.

Key takeaway #3

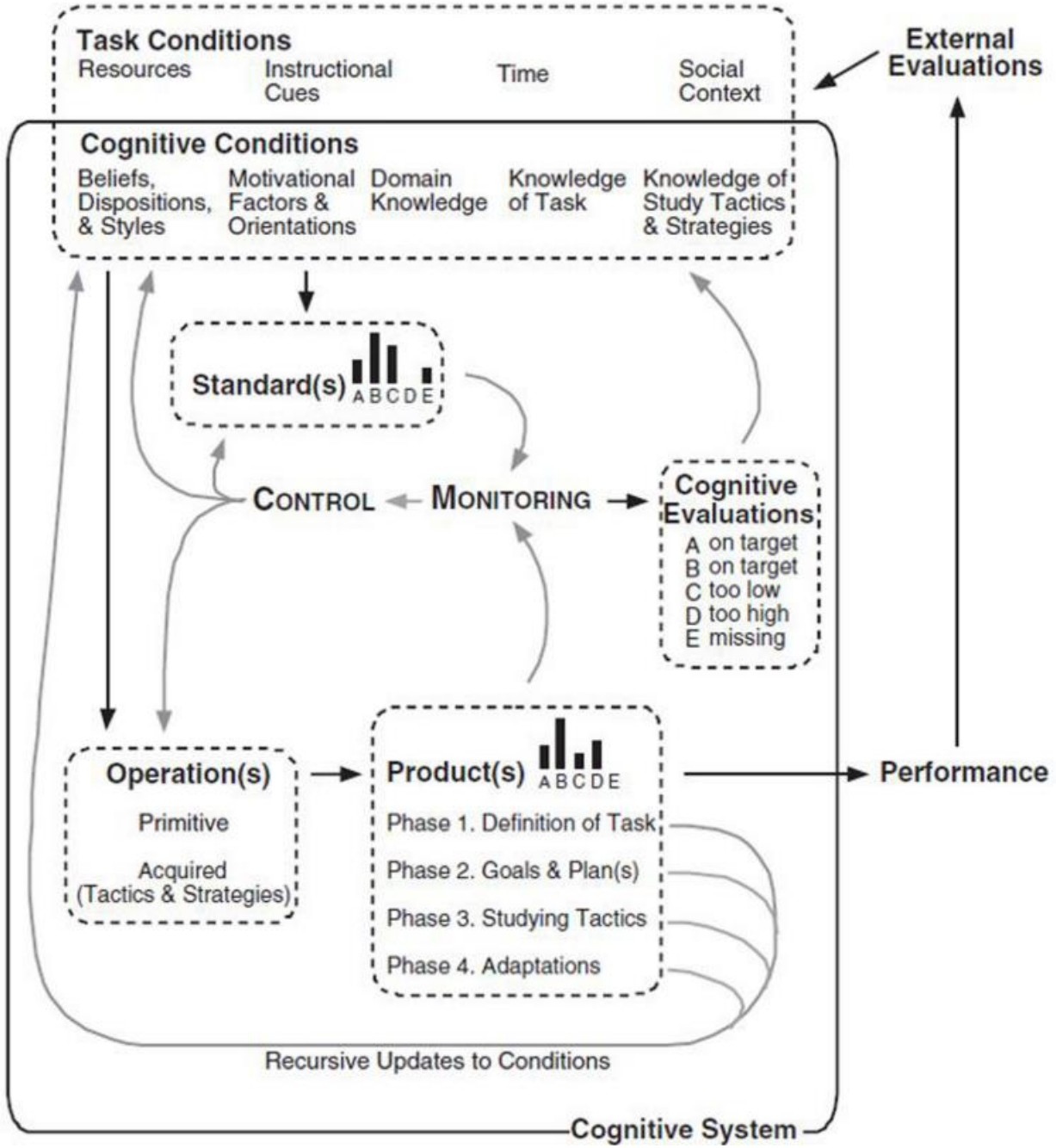
Longitudinal studies are ***urgently*** needed in combining scaffolds and AI supports

COLAM

FOUNDATIONS – IMPACT – DIRECTION – FINAL REMARKS

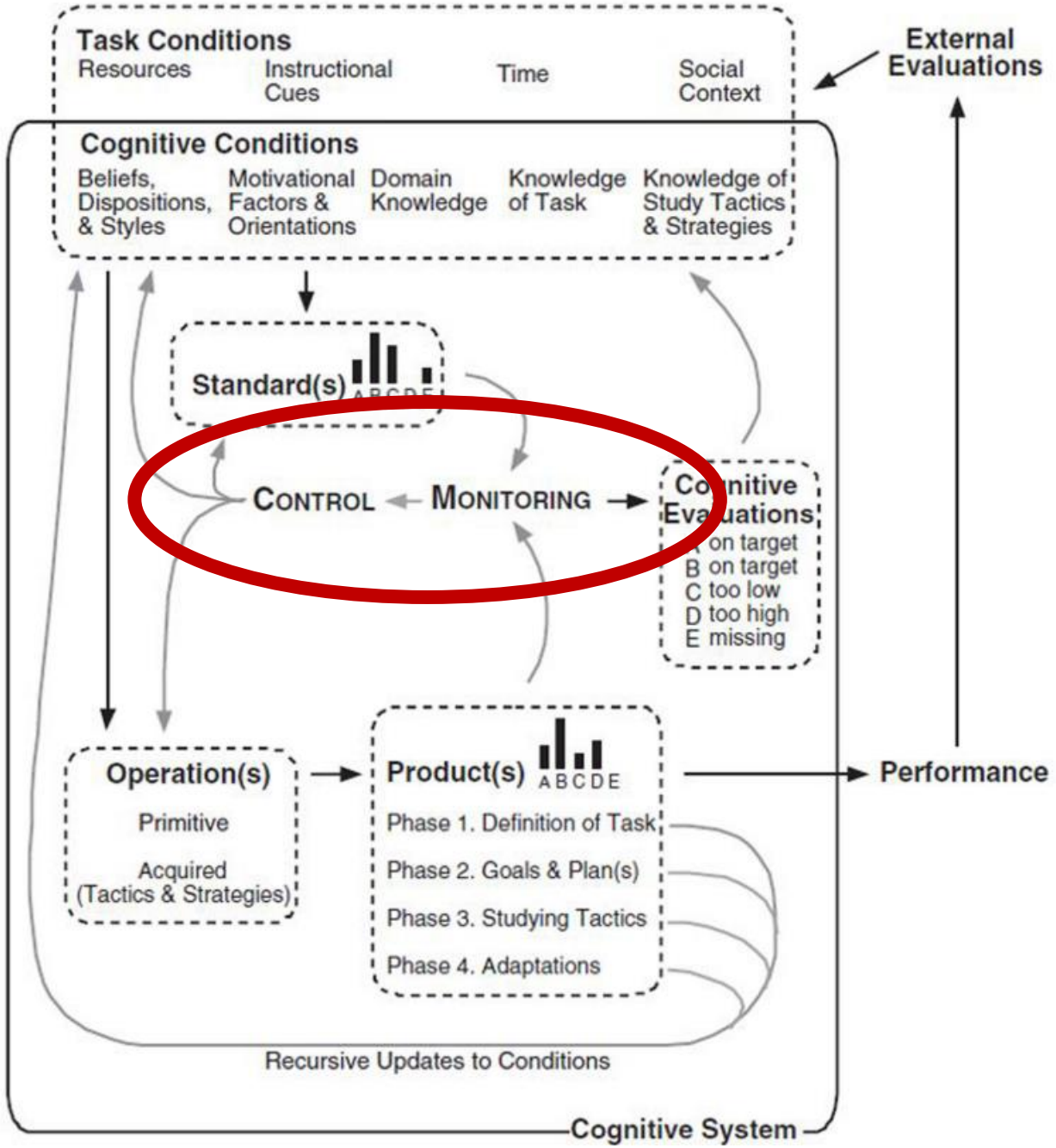
Towards adaptive learners

How do we currently prepare self-regulated learners for the age of AI?



Metacognition sits at the heart of self-regulated learning

Winne, P. H., & Hadwin, A. F. (1998). Studying as self-regulated learning. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Metacognition in educational theory and practice* (pp. 277–304). Lawrence Erlbaum Associates Publishers.



Metacognition sits at the heart of self-regulated learning

Winne, P. H., & Hadwin, A. F. (1998). Studying as self-regulated learning. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Metacognition in educational theory and practice* (pp. 277–304). Lawrence Erlbaum Associates Publishers.

1

Self-regulated learning – control

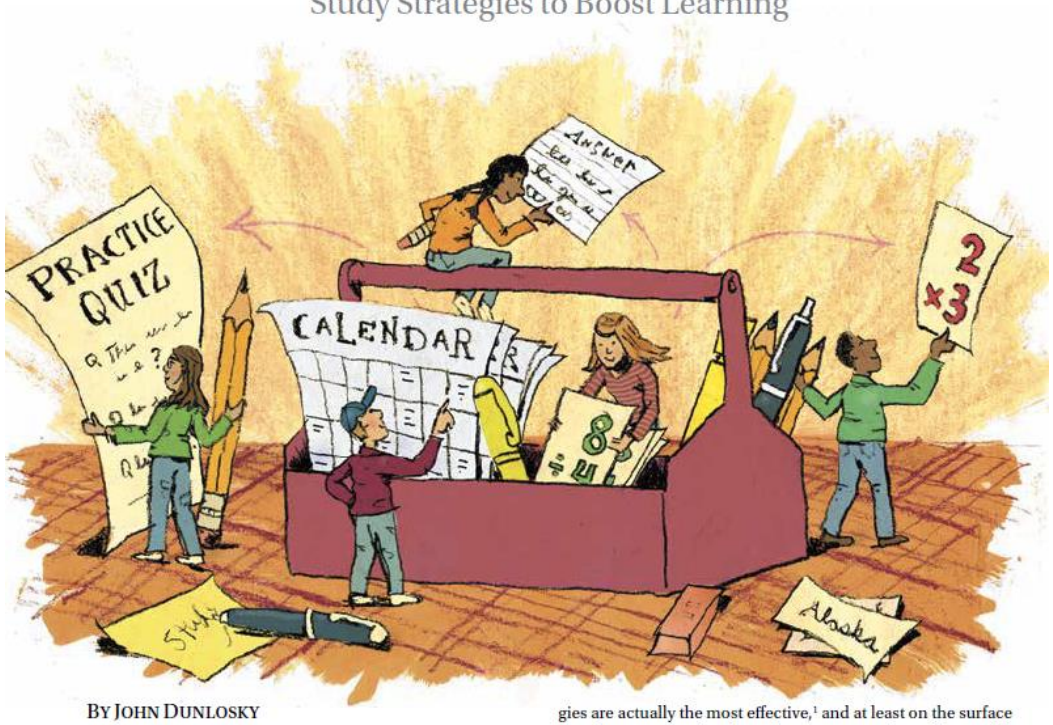
Learners construct knowledge through *learning strategies*

Winne, P. H. (2006). How software technologies can improve research on learning and bolster school reform. *Educational Psychologist*, *41*(1), 5–17.

Learning strategies

Strengthening the Student Toolbox

Study Strategies to Boost Learning



By John Dunlosky

It's the night before her biology exam, and the high school student has just begun to study. She takes out her highlighter and reads her textbook, marking it up as she goes along. She rereads sentences that seem most important and stays up most of the night, just hoping to get a good enough grasp of the material to do well on the exam. These are study strategies that she may have learned from her friends or her teachers or that she simply took to on her own. She is not unusual in this regard; many students rely on strategies such as highlighting, rereading, and cramming the night before an exam.

Quite often, students believe these relatively ineffective strategies are actually the most effective,[1] and at least on the surface they do seem sound, perhaps because, even after pulling an all-nighter, students manage to squeak by on exams. Unfortunately, in a recent review of the research, my colleagues and I found that these strategies are not that effective,[2] especially if students want to retain their learning and understanding of content well after the exam is over—obviously, an important educational goal.

So, why aren't students learning about the best strategies? I can only speculate, but several reasons seem likely. Curricula are developed to highlight the content that teachers should teach, so the focus is on providing content and not on training students how to effectively acquire it. Put differently, the emphasis is on *what* students need to learn, whereas little emphasis—if any—is placed on training students *how* they should go about learning the content and what skills will promote efficient studying to support robust learning. Nevertheless, teaching students *how* to learn is as important as teaching them content, because acquir-

John Dunlosky is a professor of psychology and the director of experimental training at Kent State University. His research focuses on self-regulated learning and how it can be used to improve student achievement across the lifespan.

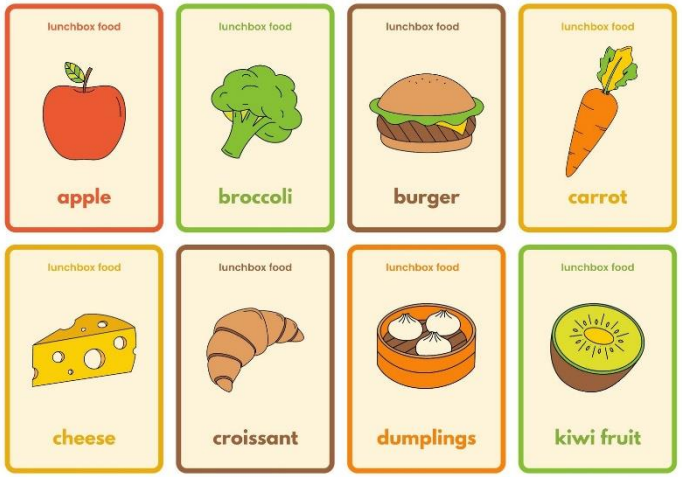
ILLUSTRATIONS BY DANIEL BAXTER

Table 1 Effectiveness of Techniques Reviewed

Technique	Extent and Conditions of Effectiveness
Practice testing	Very effective under a wide array of situations
Distributed practice	Very effective under a wide array of situations
Interleaved practice	Promising for math and concept learning, but needs more research
Elaborative interrogation	Promising, but needs more research
Self-explanation	Promising, but needs more research
Rereading	Distributed rereading can be helpful, but time could be better spent using another strategy
Highlighting and underlining	Not particularly helpful, but can be used as a first step toward further study
Summarization	Helpful only with training on how to summarize
Keyword mnemonic	Somewhat helpful for learning languages, but benefits are short-lived
Imagery for text	Benefits limited to imagery-friendly text, and needs more research

Dunlosky, J. (2013). Strengthening the Student Toolbox: Study Strategies to Boost Learning. *American Educator*, *37*(3), 12-21.

Self-regulated learning – control



https://bit.ly/canva-flashcards

https://bit.ly/3star-highlight

Learners have a limited repertoire of learning strategies

Bjork, R. A., & Bjork, E. L. (2020). Desirable difficulties in theory and practice. *Journal of Applied research in Memory and Cognition*, *9*(4), 475.

2

Self-regulated learning – monitoring

Learners are agents who use own judgements to make decisions

Tauber, S. K. U., Dunlosky, J., & Rawson, K. A. (2015). The influence of retrieval practice versus delayed judgments of learning on memory: Resolving a memory-metamemory paradox. *Experimental psychology*, *62*(4), 254.

Self-regulated learning – monitoring

Learners are *highly inaccurate* about their judgements of learning

Prinz, A., Golke, S., & Wittwer, J. (2020). To what extent do situation-model-approach interventions improve relative metacomprehension accuracy? Meta-analytic insights. *Educational Psychology Review*, *32*(4), 917-949.

Self-regulated learning – monitoring

Processing fluency: illusion of truth effect

Reber, R., & Schwarz, N. (1999). Effects of perceptual fluency on judgments of truth. *Consciousness and Cognition*, *8*(3), 338-342.

Self-regulated learning – monitoring

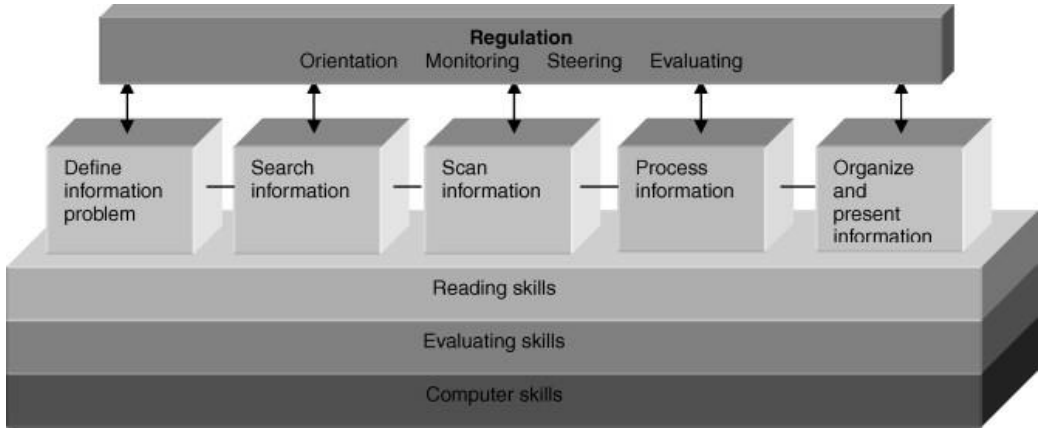
Processing fluency: selection of strategy

Alter, A. L., Oppenheimer, D. M., Epley, N., & Eyre, R. N. (2007). Overcoming intuition: metacognitive difficulty activates analytic reasoning. *Journal of Experimental Psychology: General, 136*(4), 569.

3

Information problem solving

Metacognition critical for seeking, selecting, and using information



Brand-Gruwel, S., Wopereis, I., & Walraven, A. (2009). A descriptive model of information problem solving while using internet. *Computers & Education*, *53*(4), 1207-1217.

Information problem solving

Learners use unreliable sources and suboptimal search strategies

Judd, T., & Kennedy, G. (2011). Expediency-based practice? Medical students' reliance on Google and Wikipedia for biomedical inquiries. *British Journal of Educational Technology, 42* (2), 351-360.

Information problem solving

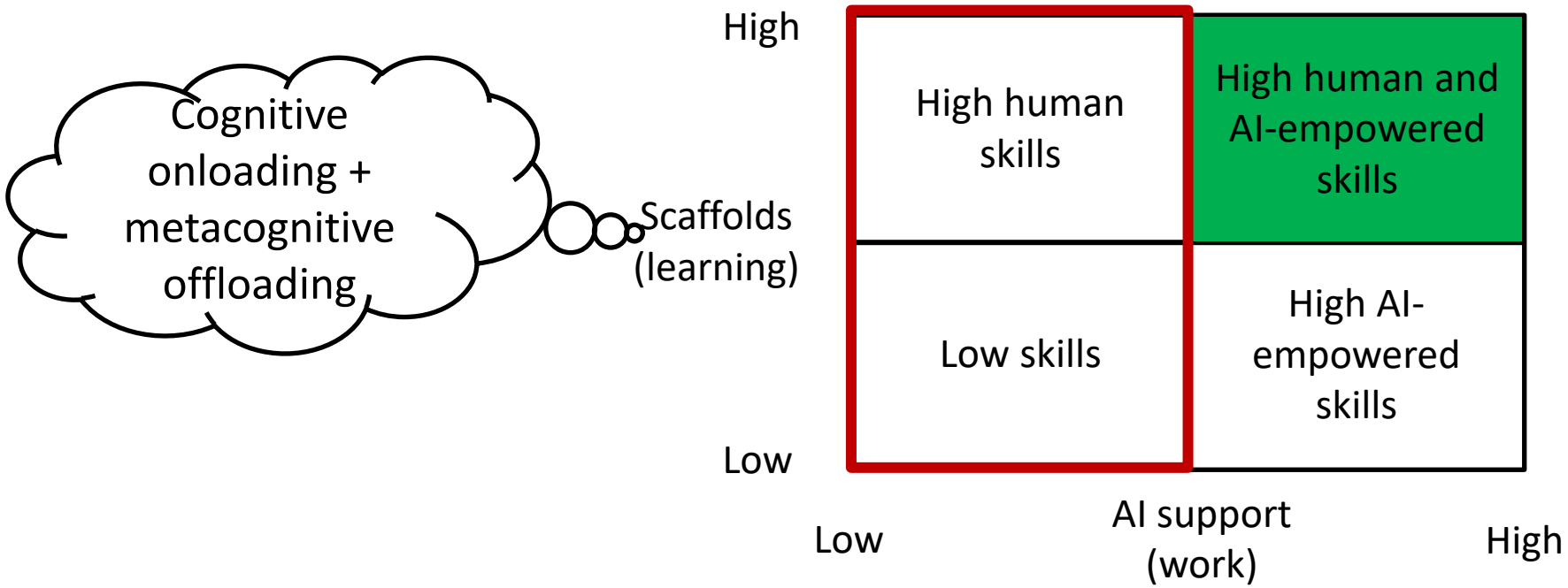
https://www.lisedunetwork.com/what-information-seeking/

Sensemaking paradox

Butcher, K. R., & Sumner, R. (2011). Self-Directed Learning and the Sensemaking Paradox. *Human–Computer Interaction, 26*(1-2), 123-159.

Risk #1

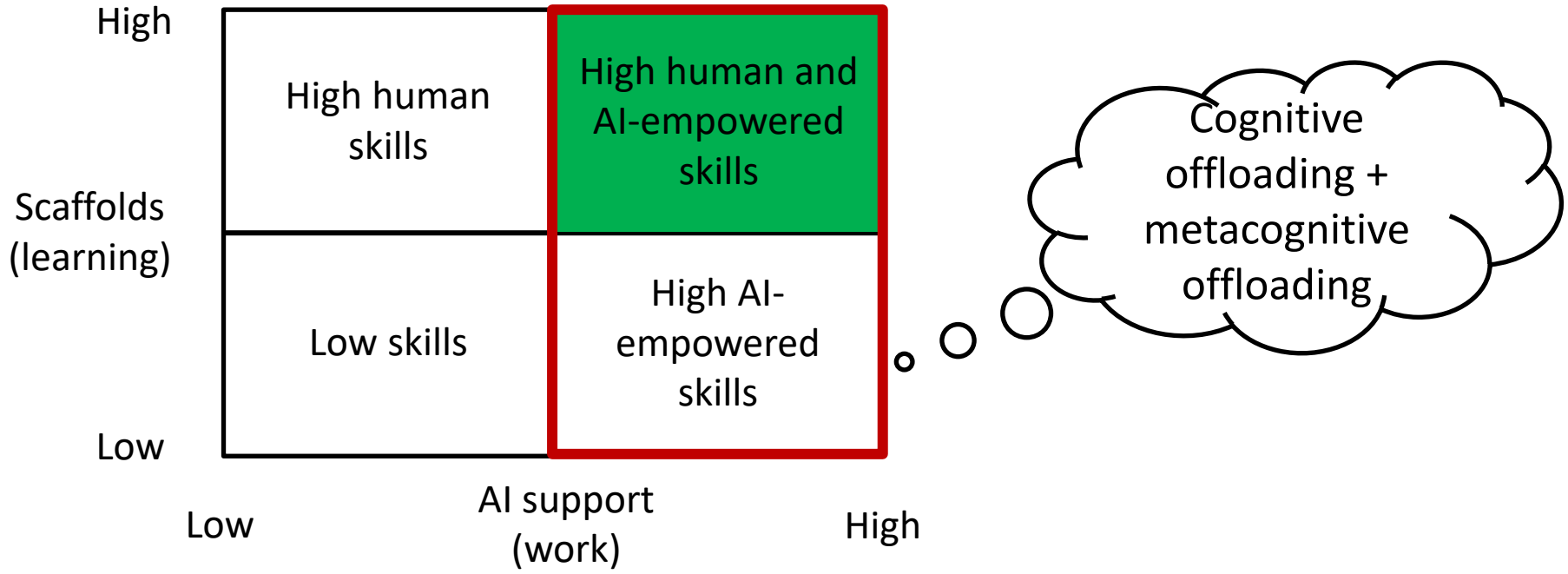
Existing adaptive learning systems



Molenaar, I. (2022). The concept of hybrid human-AI regulation: Exemplifying how to support young learners' self-regulated learning. *Computers and Education: Artificial Intelligence*, *3*, 100070.

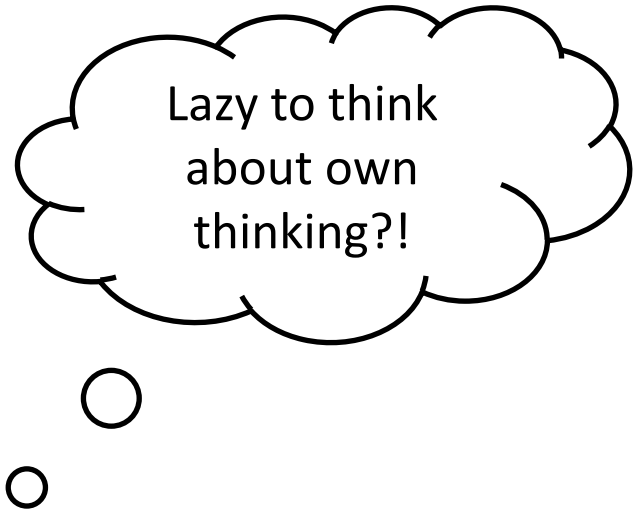
Risk #2

Cognitive offloading



Risko, E. F., & Gilbert, S. J. (2016). Cognitive offloading. *Trends in Cognitive Sciences*, *20*(9), 676-688.

Open challenge



Are we getting metacognitively lazy with so much offloading?

COLAM

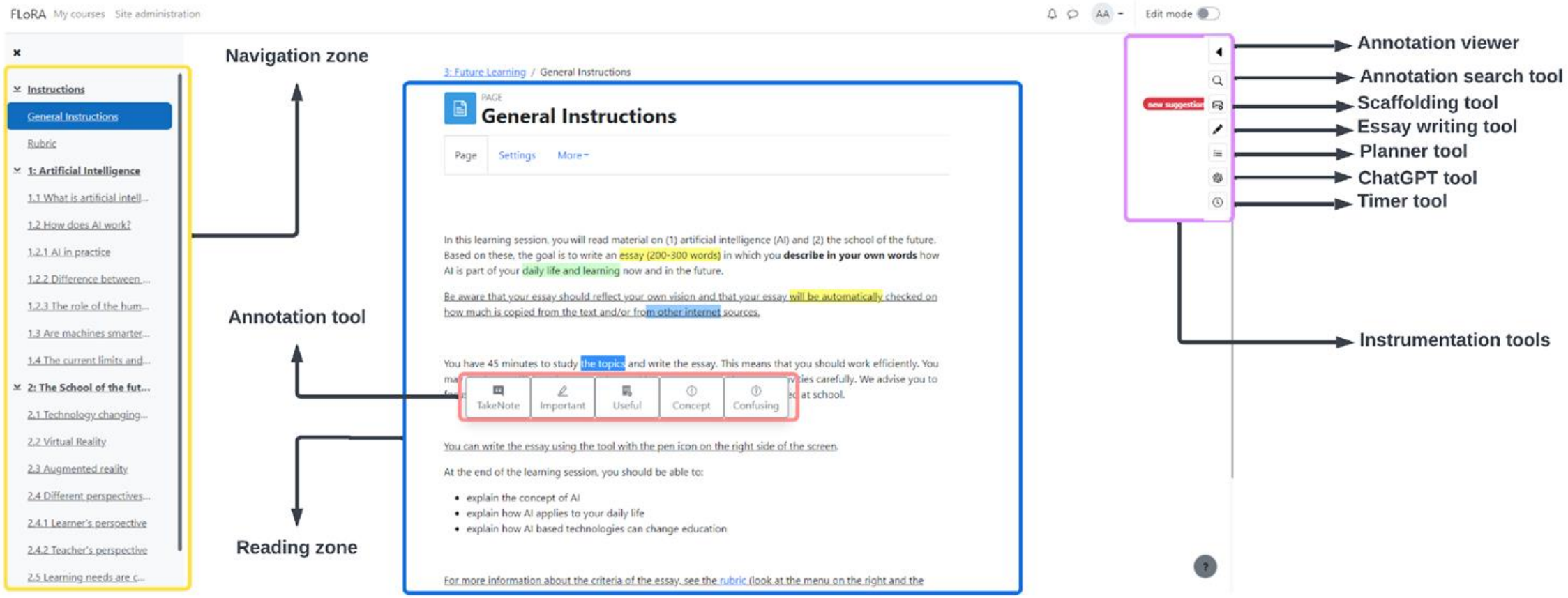
FOUNDATIONS – **IMPACT** – DIRECTION –
FINAL REMARKS

Direction

Using data to understand and enhance self-regulated learning for the age of AI

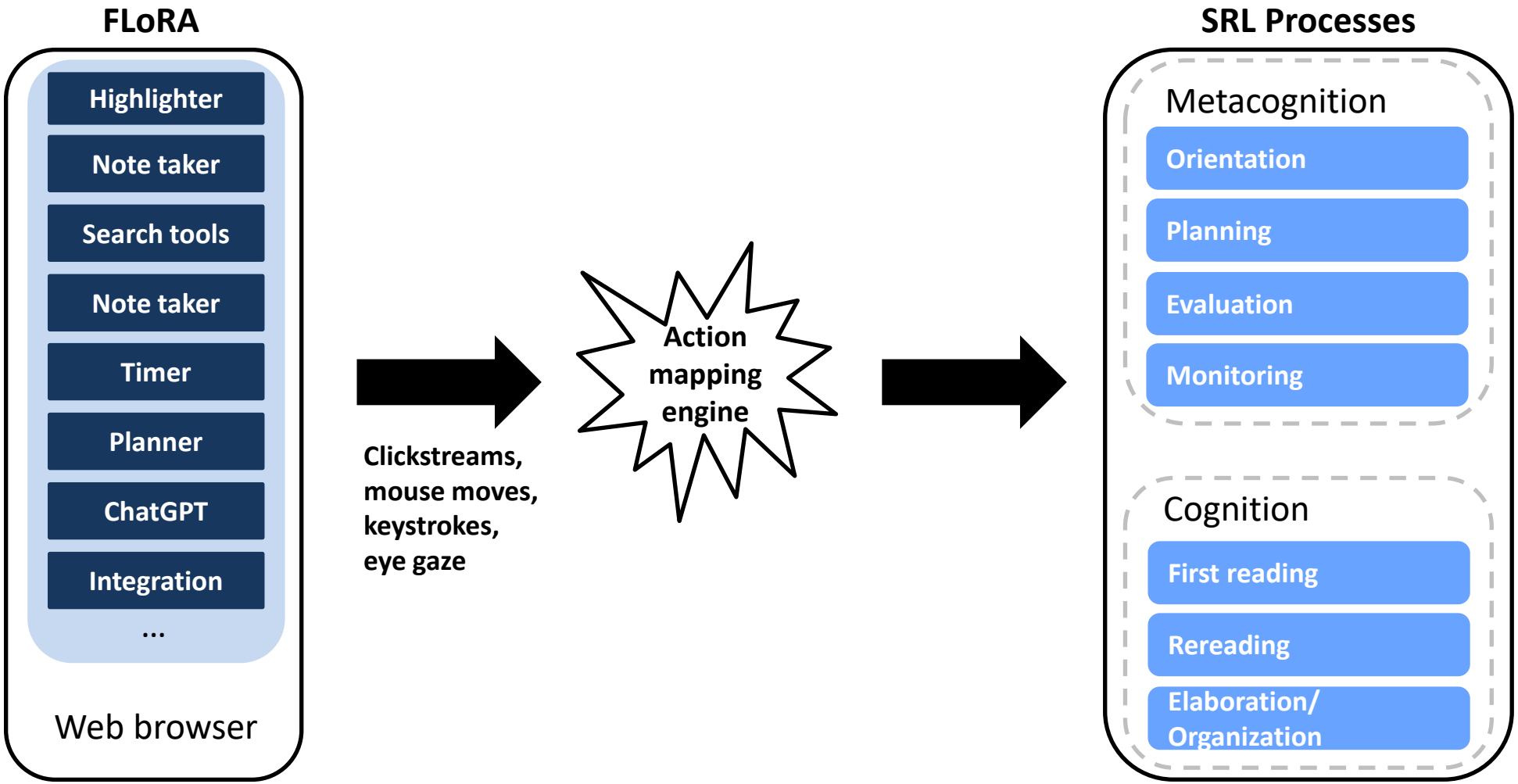
Gašević, D., Tsai, Y-S., Dawson, S., & Pardo, A. (2019). How do we start? An approach to learning analytics adoption in higher education. *International Journal of Information and Learning Technology, 36*(4), 342-353.

FLoRA



http://floraproject.org

Mapping trace data to processes



Fan, Y., van der Graaf, J., Lim, L., Raković, M., Singh, S., Kilgour, J., ... & Gašević, D. (2022). Towards investigating the validity of measurement of self-regulated learning based on trace data. *Metacognition and Learning, 17*(3), 949 - 987.

Framework

Hybrid human-AI regulation

Molenaar, I. (2022). The concept of hybrid human-AI regulation: Exemplifying how to support young learners' self-regulated learning. *Computers and Education: Artificial Intelligence*, *3*, 100070.

Hybrid human-AI regulation

Degrees of hybrid regulation	AI regulation	Human regulation	Function of dashboard
AI regulation	AI monitors and adjusts extensively	Aware of AI regulation	Raising awareness of AI regulation
Co-regulation	AI monitors and adjusts in small steps	Understanding how AI monitors and controls	Showing AI monitoring and modelling AI control
Shared-regulation	AI monitors and proposes control actions to the learner	Understanding monitoring and executing control	Showing monitoring and scaffolding learners' control
Self-regulation	Observing regulation	Monitoring and self-initiation of control	Showing learners' regulation to support their understanding

Molenaar, I. (2022). The concept of hybrid human-AI regulation: Exemplifying how to support young learners' self-regulated learning. *Computers and Education: Artificial Intelligence*, *3*, 100070.

Hybrid human-AI regulation

Degrees of hybrid regulation	AI regulation	Human regulation	Function of dashboard
AI regulation	AI monitors and adjusts extensively	Aware of AI regulation	Raising awareness of AI regulation
Co-regulation	AI monitors and adjusts in small steps	Understanding how AI monitors and controls	Showing AI monitoring and modelling AI control
Shared-regulation	AI monitors and proposes control actions to the learner	Understanding monitoring and executing control	Showing monitoring and scaffolding learners' control
Self-regulation	Observing regulation	Monitoring and self-initiation of control	Showing learners' regulation to support their understanding

Molenaar, I. (2022). The concept of hybrid human-AI regulation: Exemplifying how to support young learners' self-regulated learning. *Computers and Education: Artificial Intelligence*, *3*, 100070.

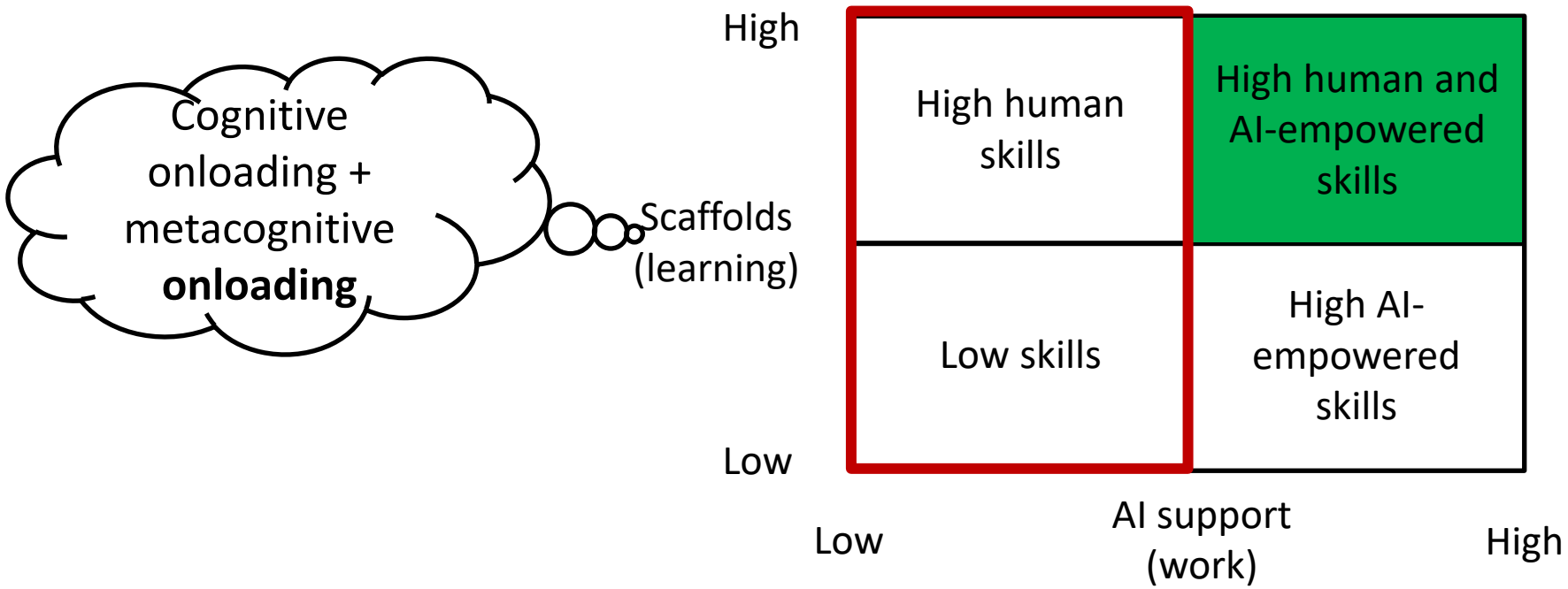
Hybrid human-AI regulation

Degrees of hybrid regulation	AI regulation	Human regulation	Function of dashboard
AI regulation	AI monitors and adjusts extensively	Aware of AI regulation	Raising awareness of AI regulation
Co-regulation	AI monitors and adjusts in small steps	Understanding how AI monitors and controls	Showing AI monitoring and modelling AI control
Shared-regulation	AI monitors and proposes control actions to the learner	Understanding monitoring and executing control	Showing monitoring and scaffolding learners' control
Self-regulation	Observing regulation	Monitoring and self-initiation of control	Showing learners' regulation to support their understanding

Molenaar, I. (2022). The concept of hybrid human-AI regulation: Exemplifying how to support young learners' self-regulated learning. *Computers and Education: Artificial Intelligence*, *3*, 100070.

Framework

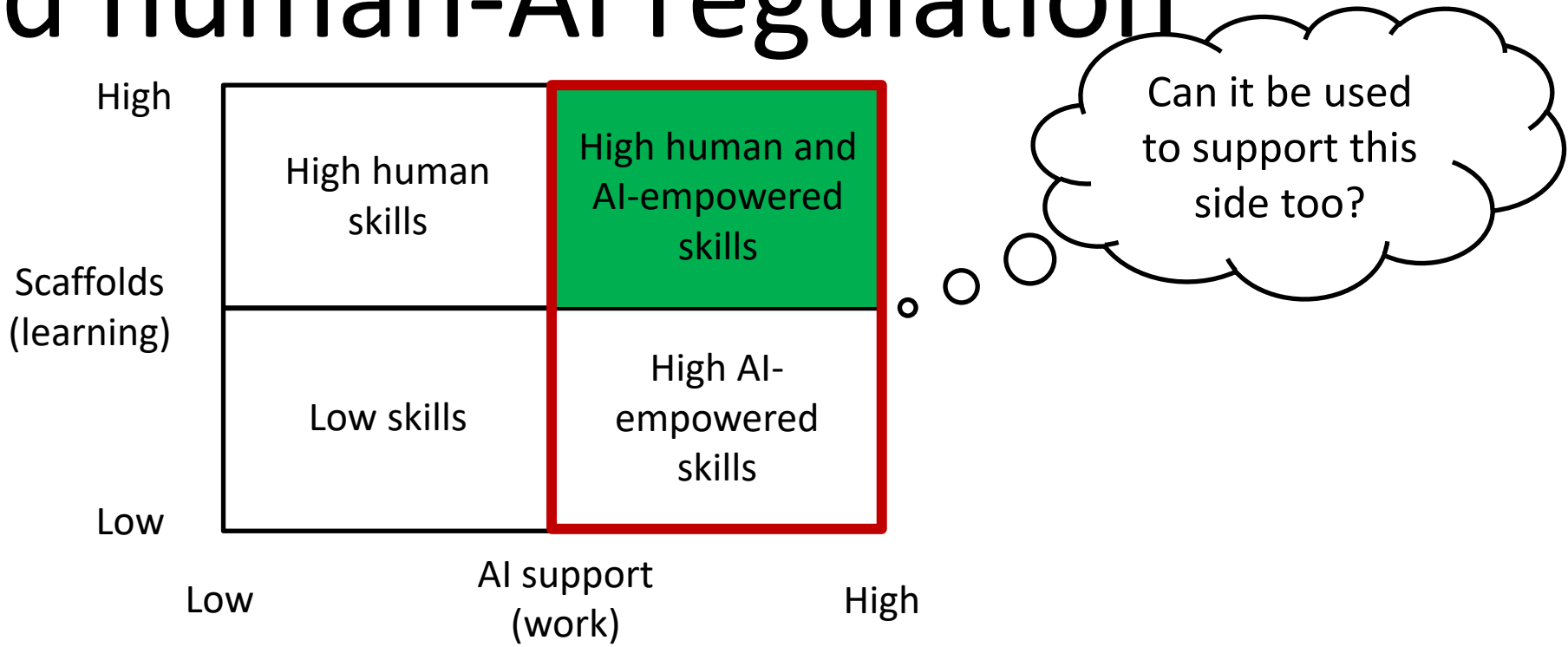
Hybrid human-AI regulation



Molenaar, I. (2022). The concept of hybrid human-AI regulation: Exemplifying how to support young learners' self-regulated learning. *Computers and Education: Artificial Intelligence*, *3*, 100070.

Framework

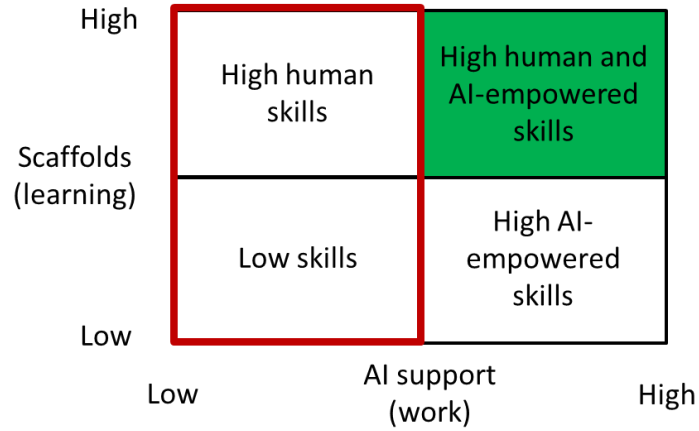
Hybrid human-AI regulation



Risko, E. F., & Gilbert, S. J. (2016). Cognitive offloading. *Trends in cognitive sciences*, *20*(9), 676-688.

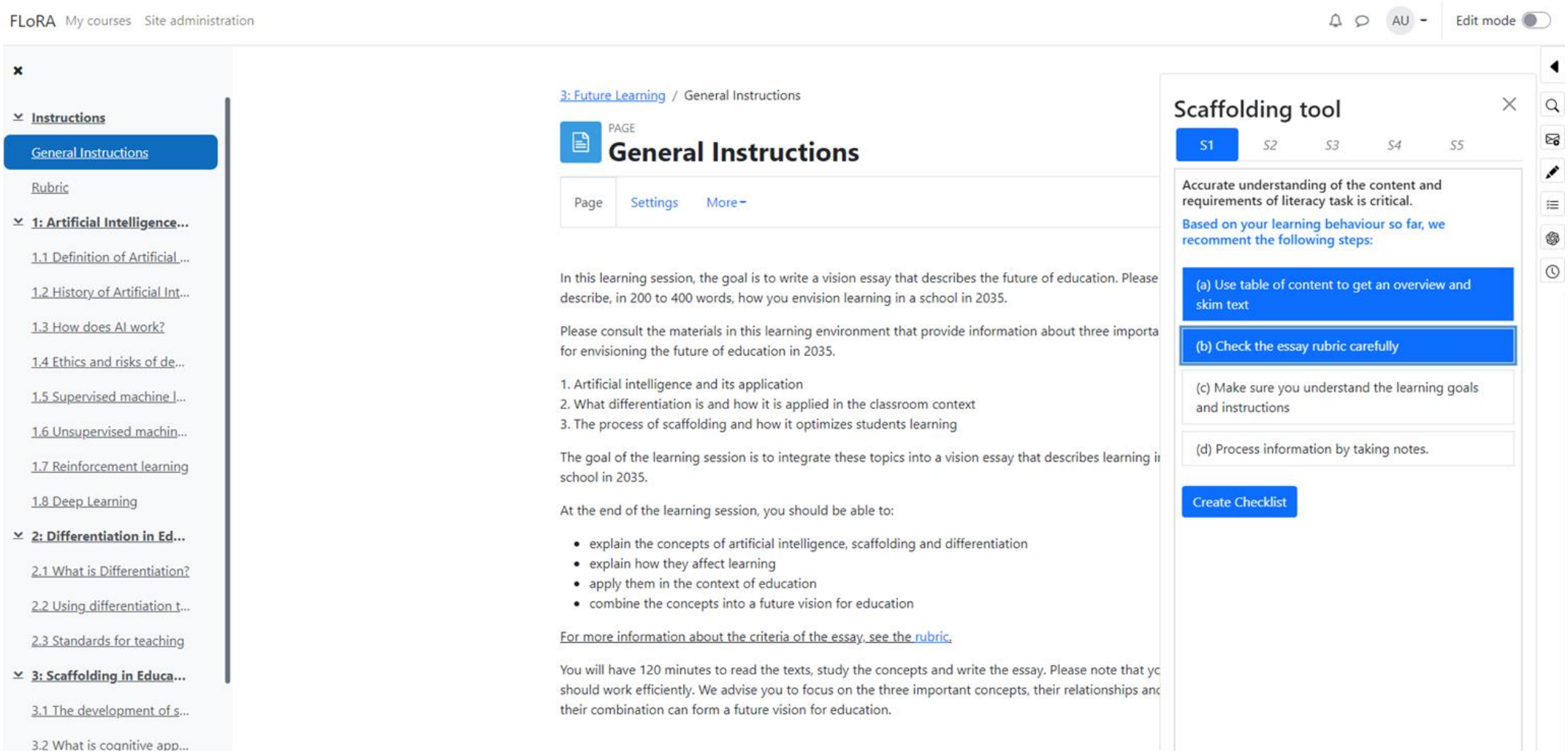
1

Control

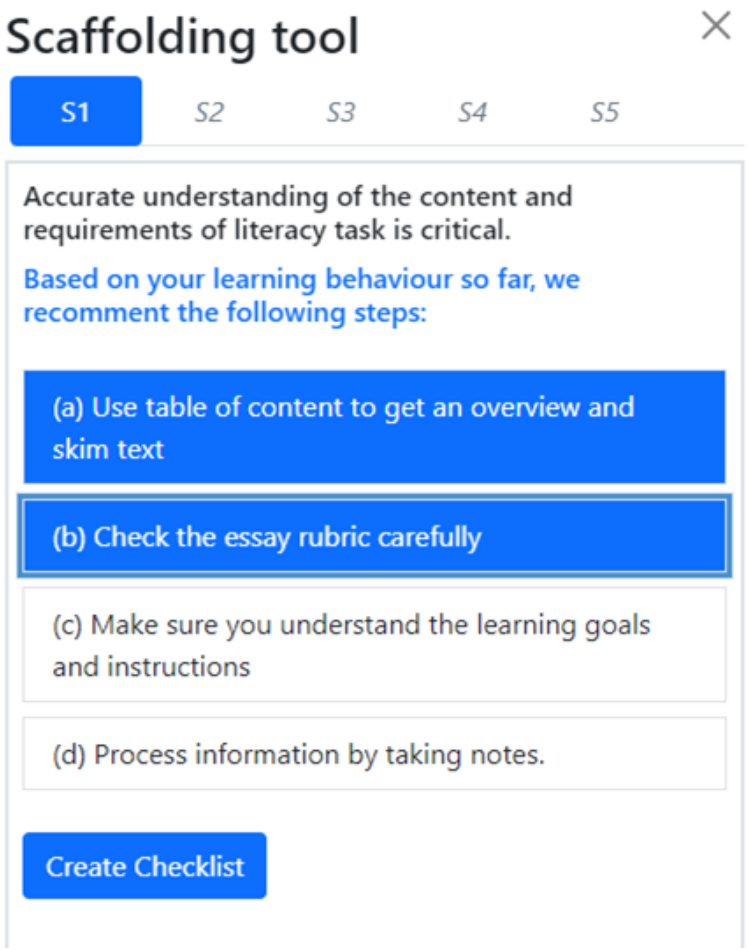


How can AI-powered scaffolds influence learning strategies?

AI-powered scaffolding tool



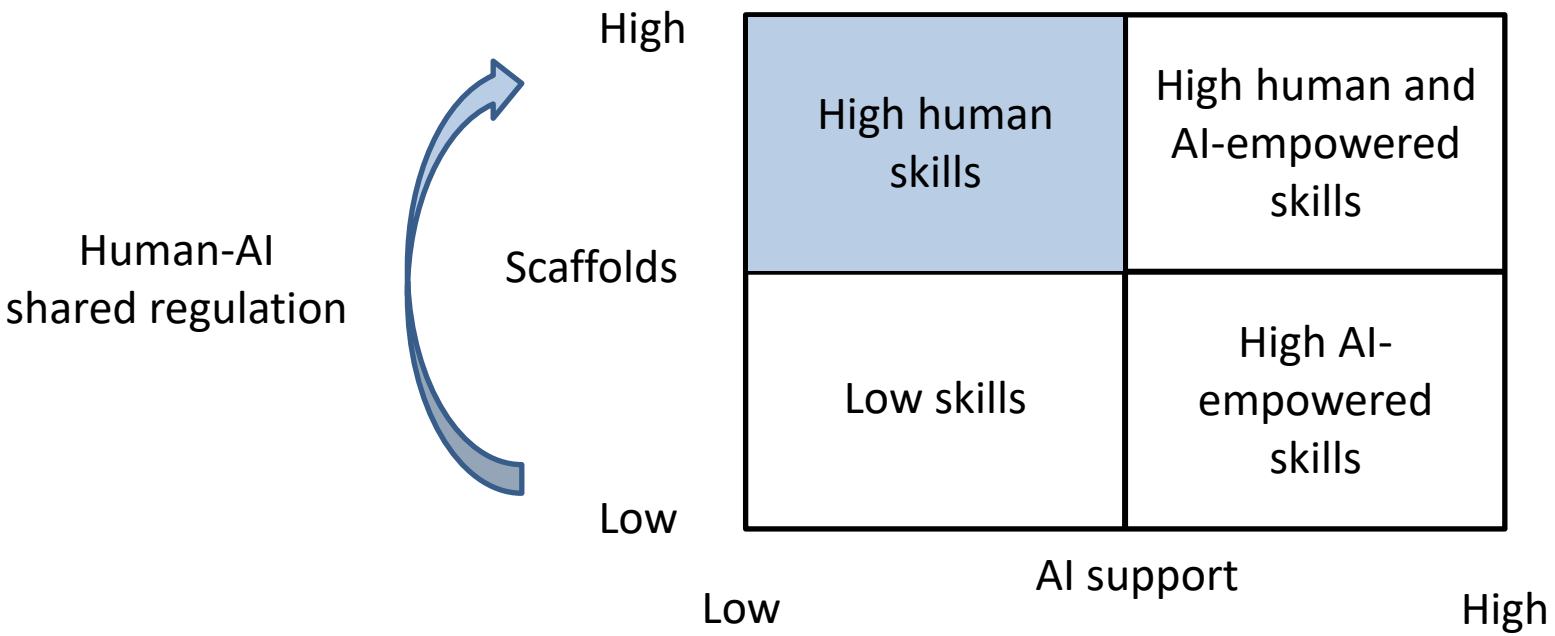
AI-powered scaffolds and learning strategies



Moderate association between scaffolding and learning strategy

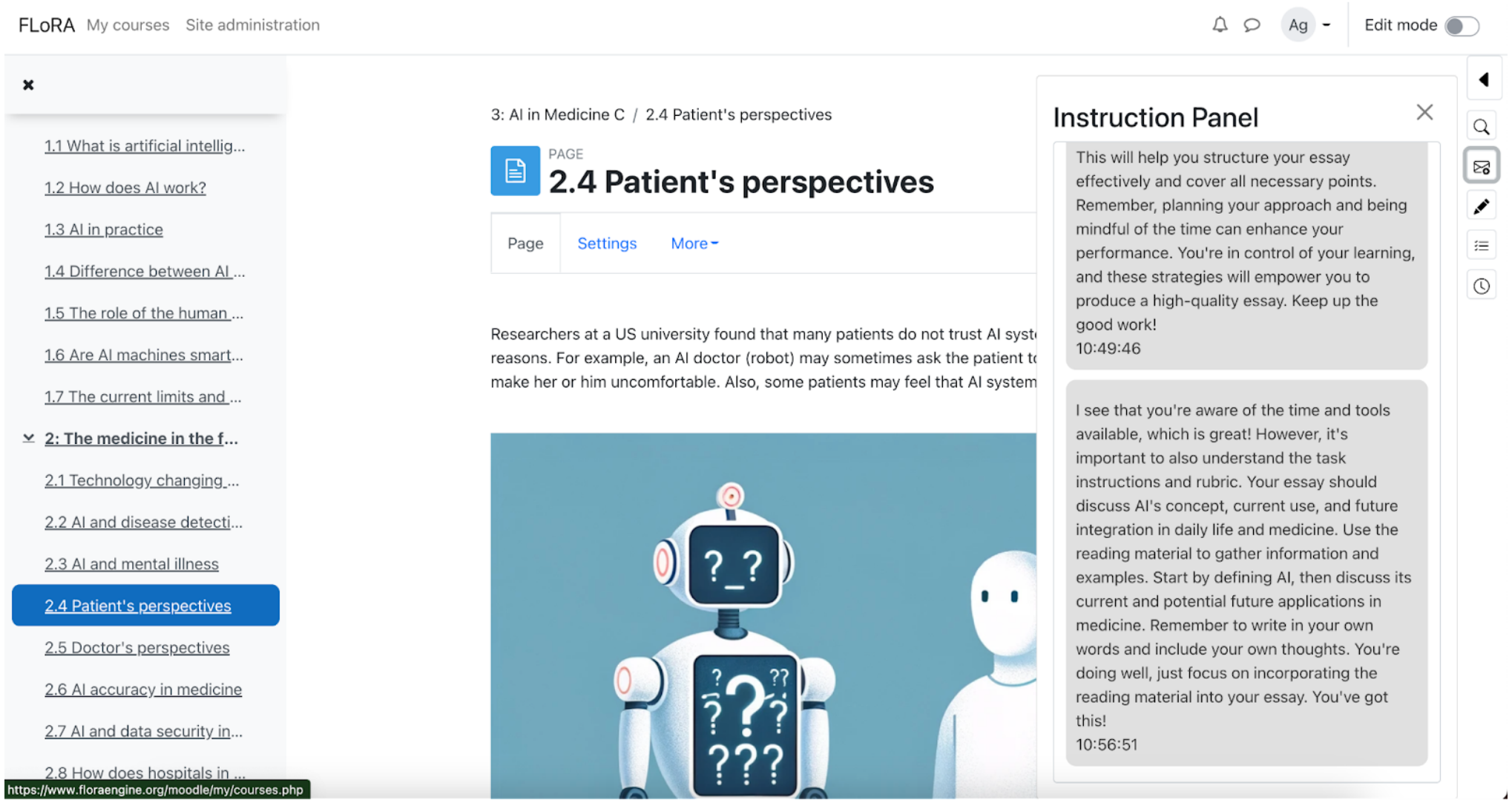
Srivastava, N., Fan, Y., Rakovic, M., Singh, S., Jovanovic, J., van der Graaf, J., ... & Gasevic, D. (2022). Effects of Internal and External Conditions on Strategies of Self-regulated Learning: A Learning Analytics Study. In *Proceedings of the 12th International Learning Analytics and Knowledge Conference* (pp. 392-403).

Towards metacognitive onloading

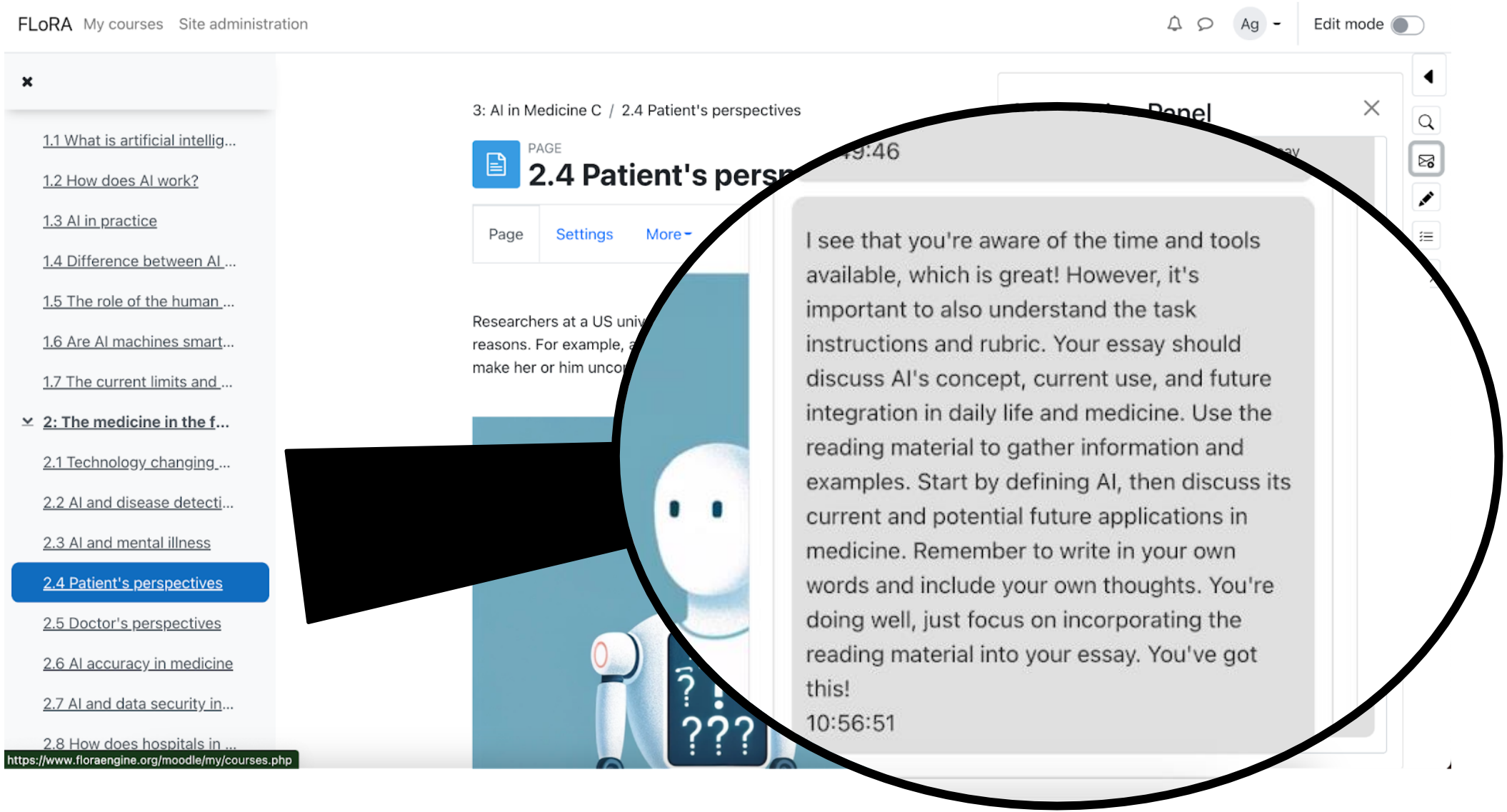


Integrating scaffolds with AI support

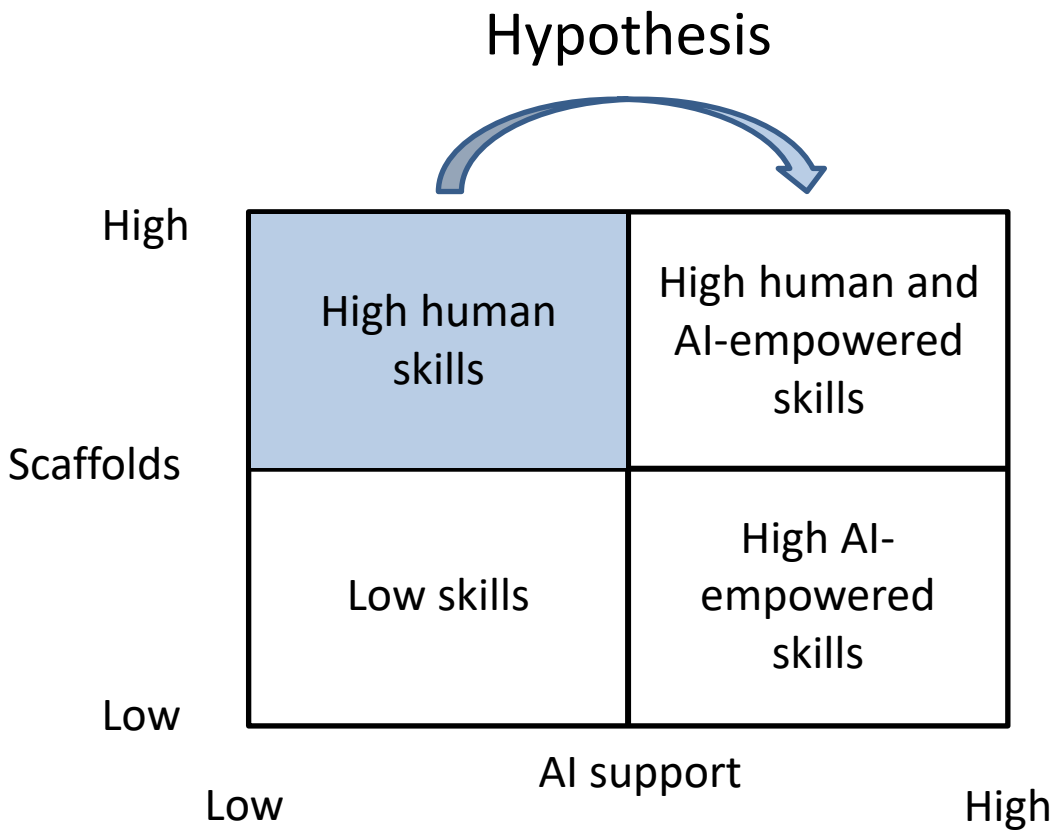
AI-powered scaffolds and learning strategies



AI-powered scaffolds and learning strategies



Towards high human and AI-empowered skills



Li, T., Nath, D., Cheng, Y., Fan, Y., Li, X., Raković, M., Khosravi, H., Swiecki, Z., Tsai, Y-S., Gašević, D. (2025). Turning real-time analytics into adaptive scaffolds for self-regulated learning using generative artificial intelligence. *Proceedings of the 15th International Conference on Learning Analytics and Knowledge* (in press).

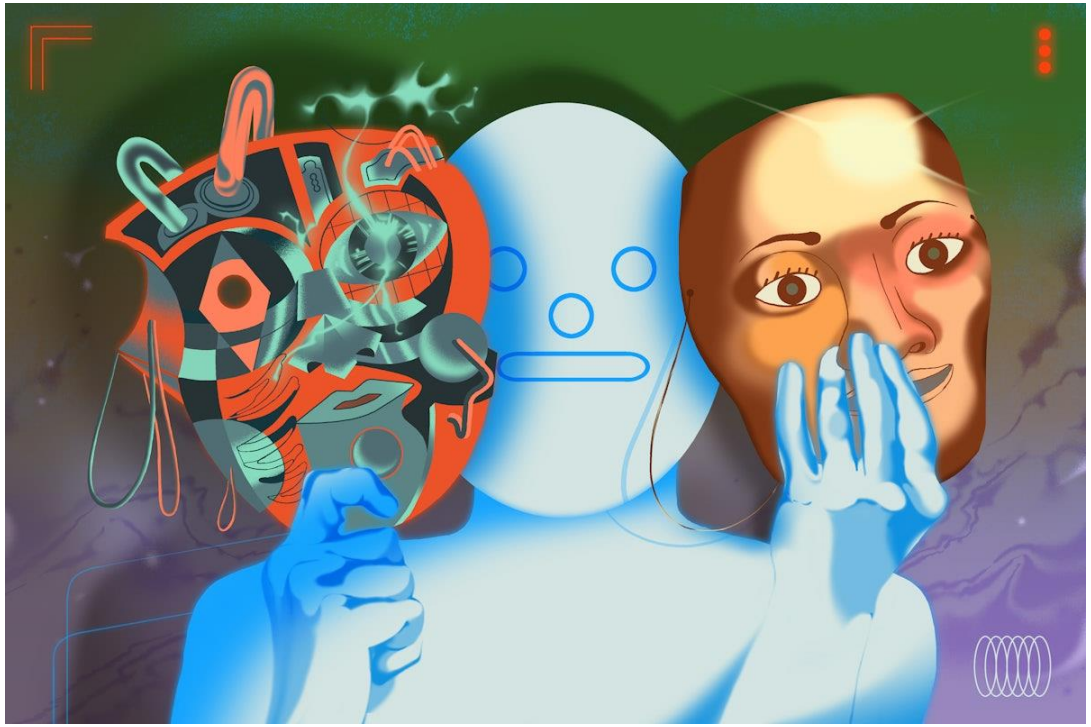
COLAM

2

Monitoring

What are effects of gen AI on monitoring?

Effects of gen AI on processing fluency



https://bit.ly/nr-genai-hallucinate

Gen AI can worsen monitoring

Metacognitive offloading

Kabir, S., Udo-Imeh, D. N., Kou, B., & Zhang, T. (2024). Is Stack Overflow obsolete? An empirical study of the characteristics of ChatGPT answers to stack overflow questions. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems* (Article # 935, pp. 1-17).

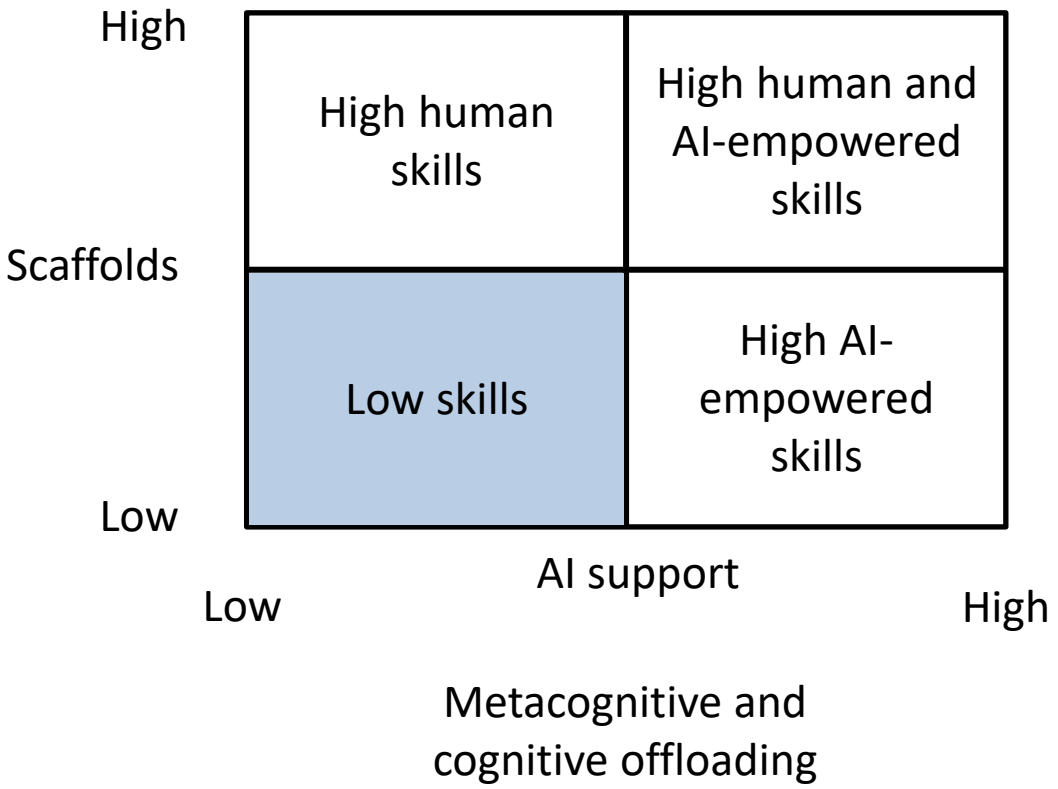
Inadvertent deception of ChatGPT

Inaccurate and verbose, but users prefer ChatGPT responses

Processing fluency – illusion of truth effect

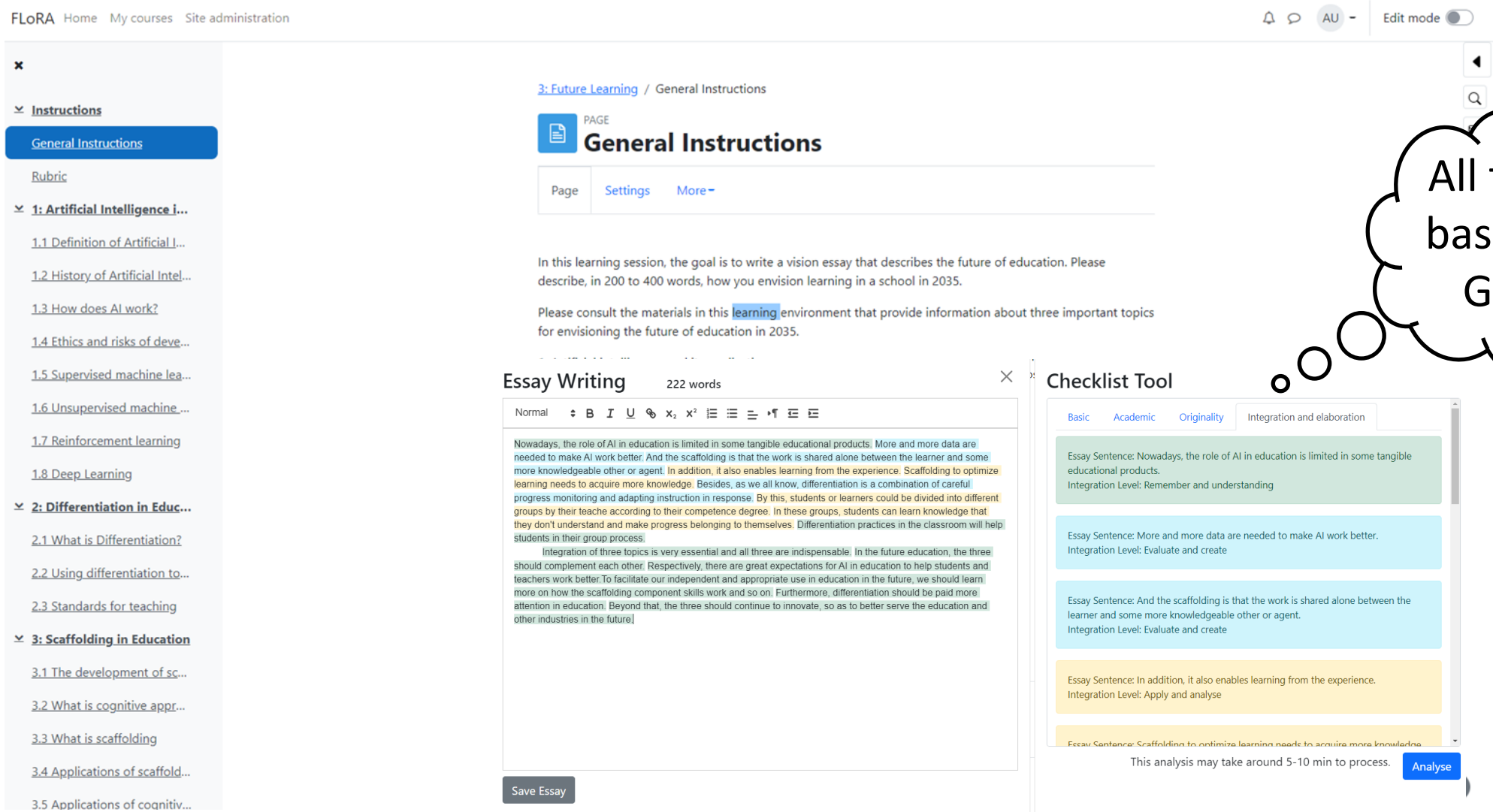
Kabir, S., Udo-Imeh, D. N., Kou, B., & Zhang, T. (2024). Is Stack Overflow obsolete? An empirical study of the characteristics of ChatGPT answers to stack overflow questions. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems* (Article # 935, pp. 1-17).

Towards high human and AI-empowered skills



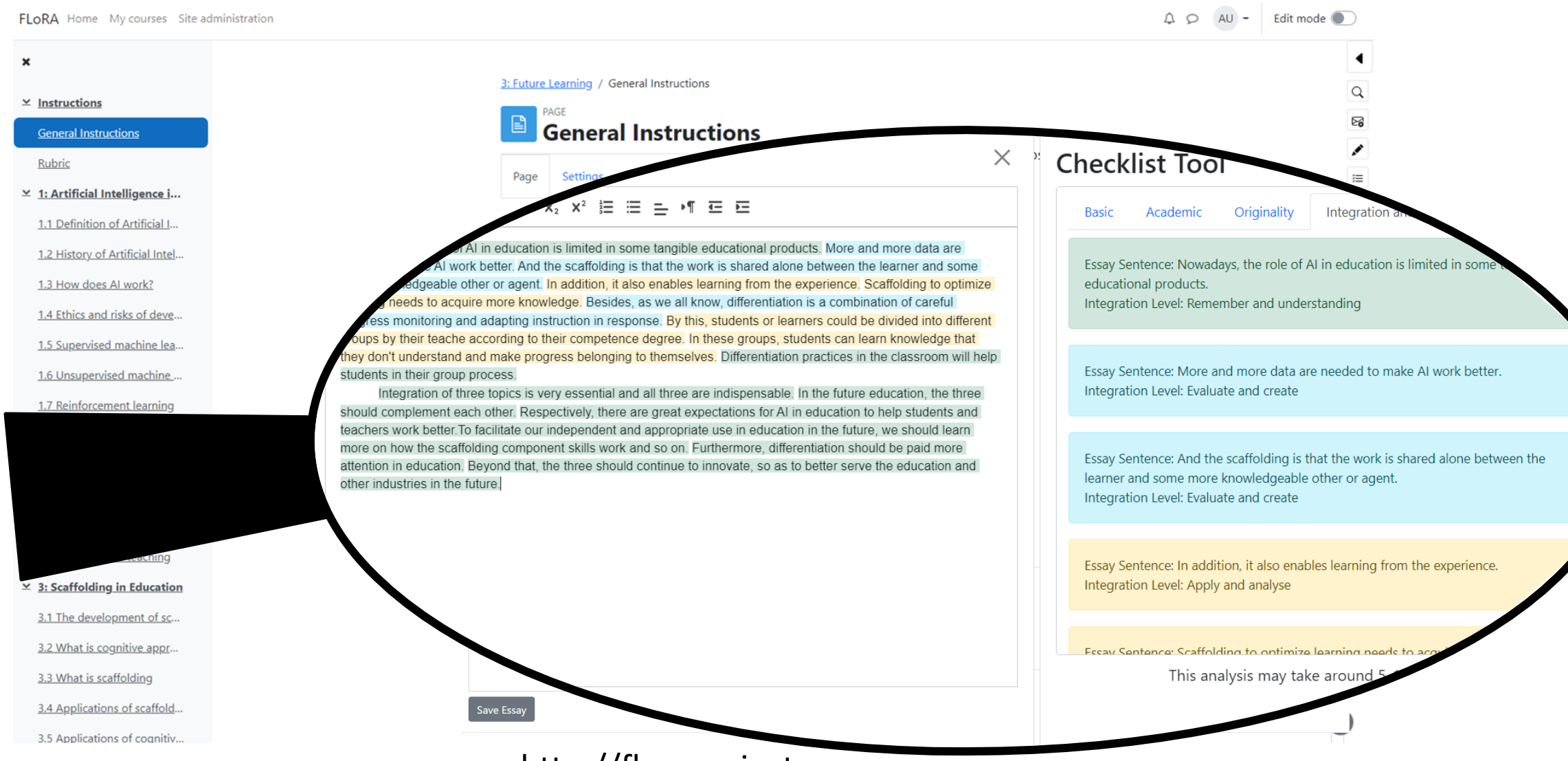
AI support:
- aims to improve performance
- ~~has a fit for the task~~
- knowledge of AI tool

AI-powered scaffolds

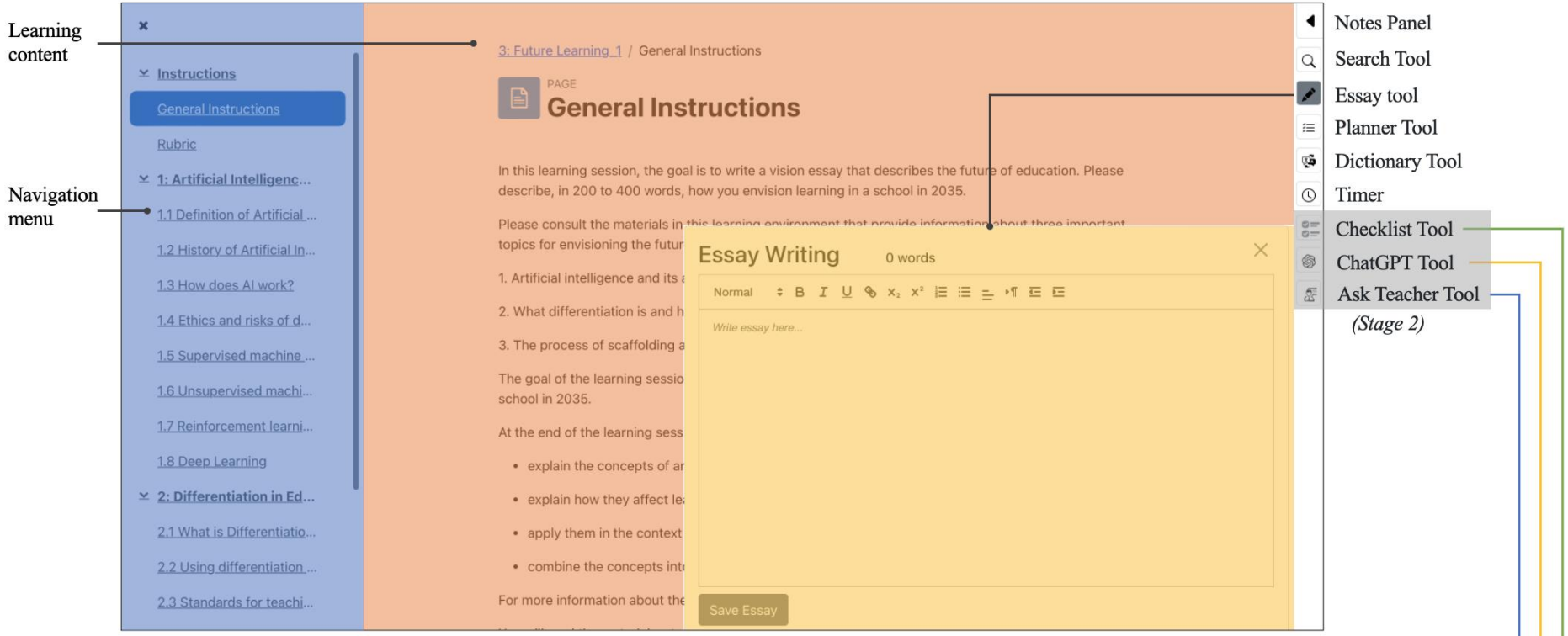


http://floraproject.org

AI-powered scaffolds

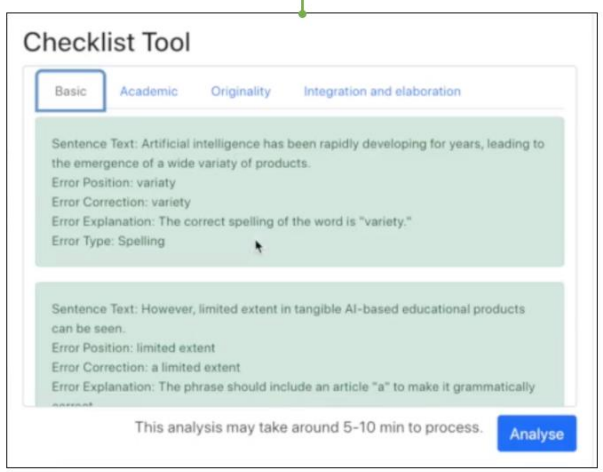


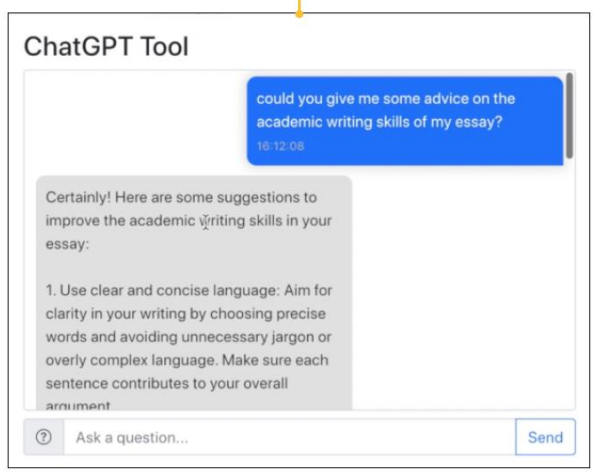
http://floraproject.org

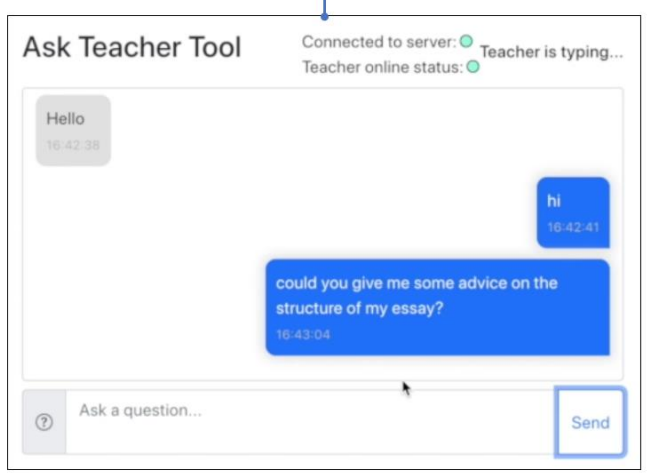


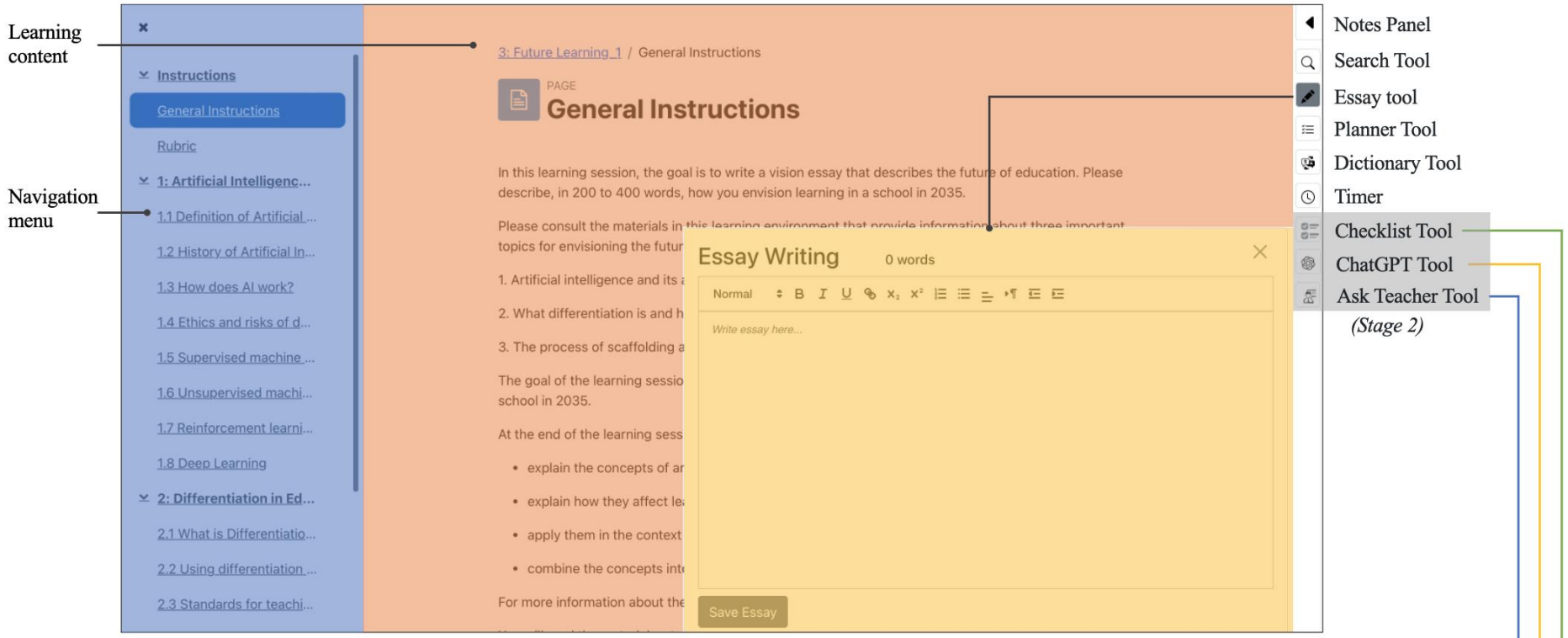
(Stage 1)

(Stage 2)









(Stage 1)

(Stage 2)

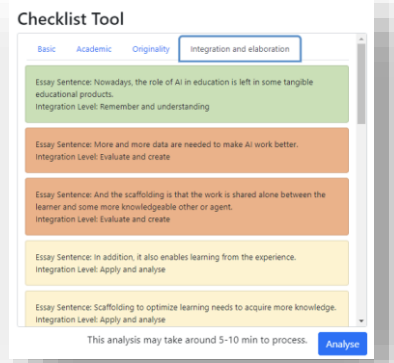
CN

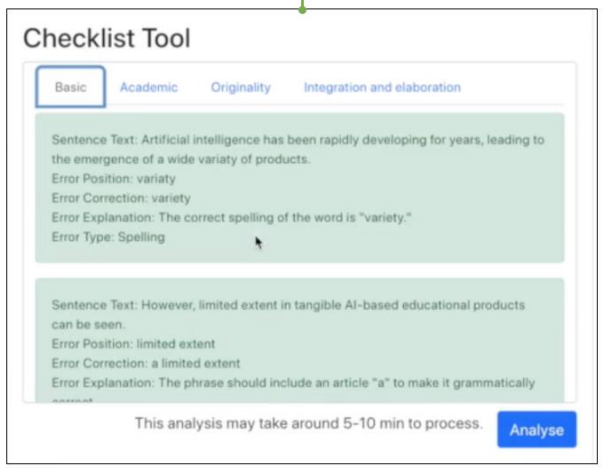
Revise essay by themselves

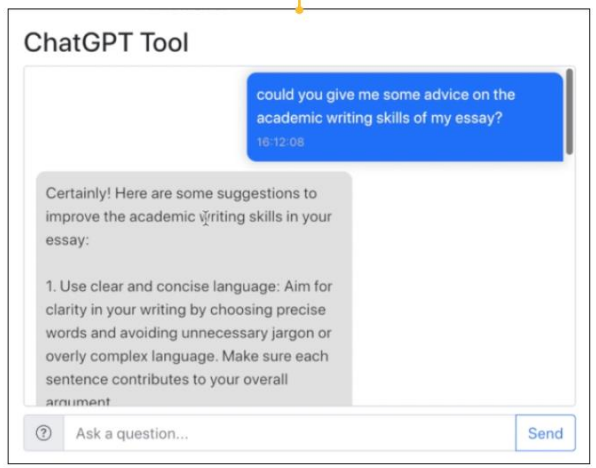
AI

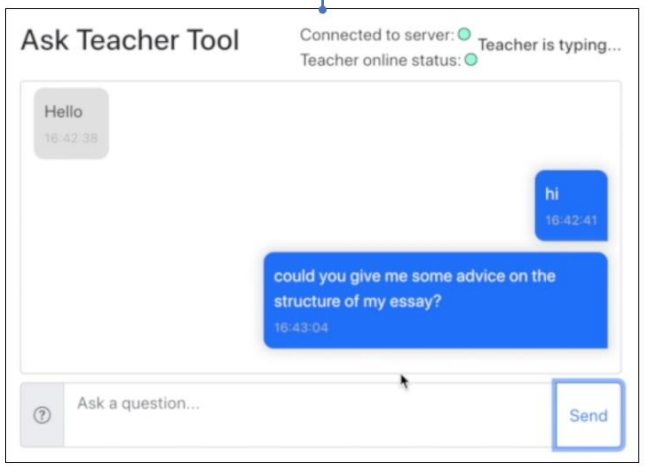
HE

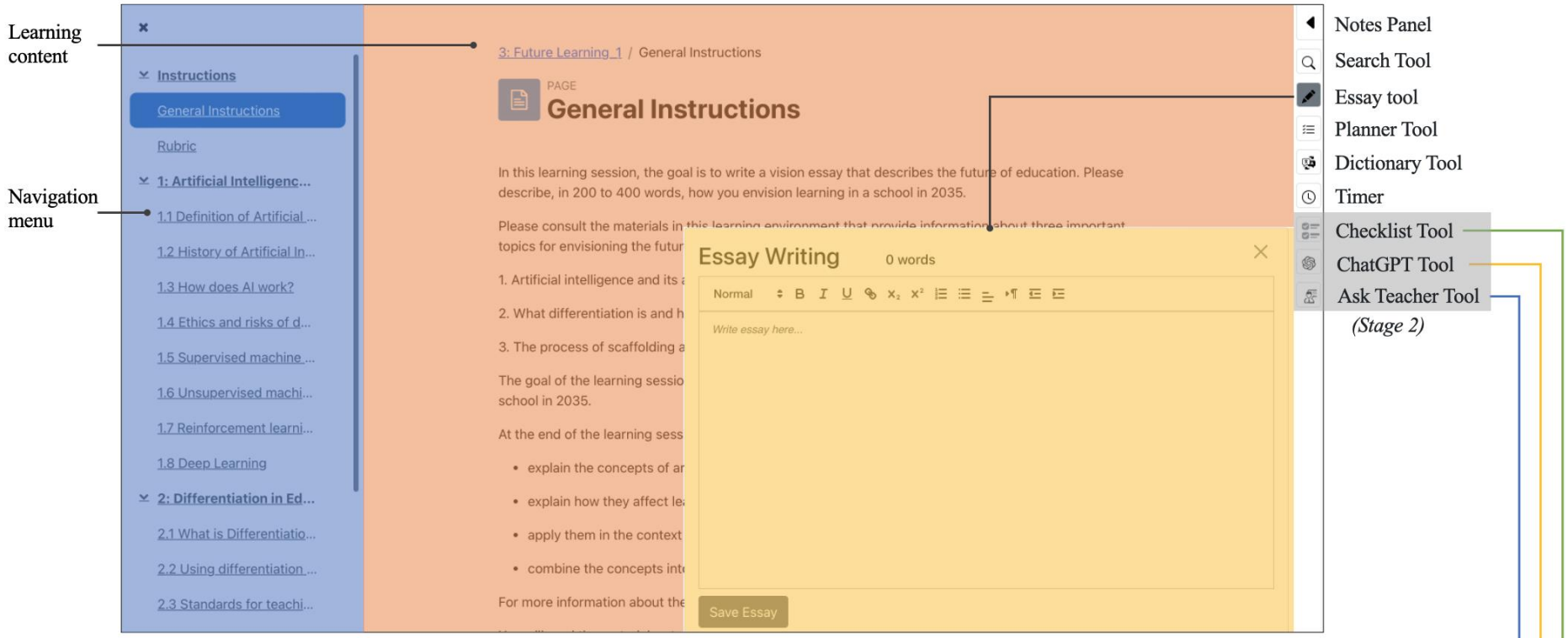
CL











(Stage 1)

(Stage 2)

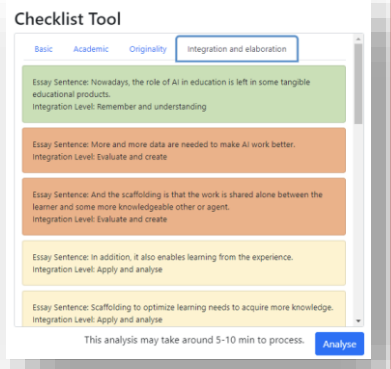
CN

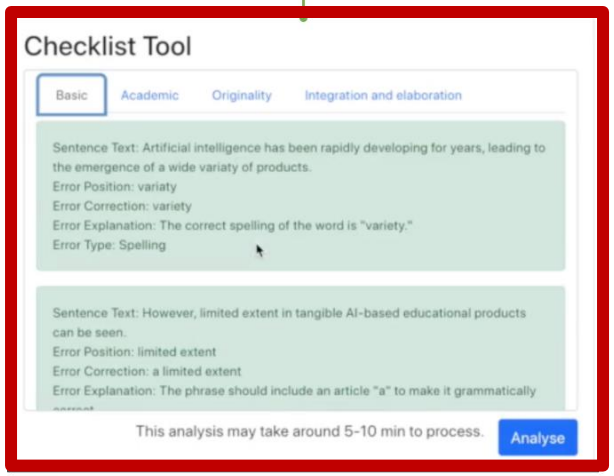
Revise essay by themselves

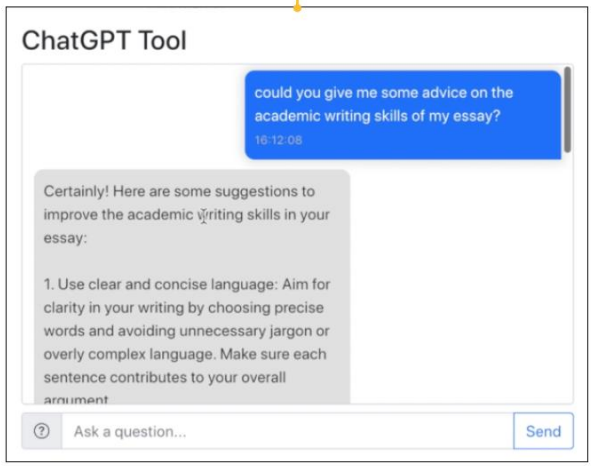
AI

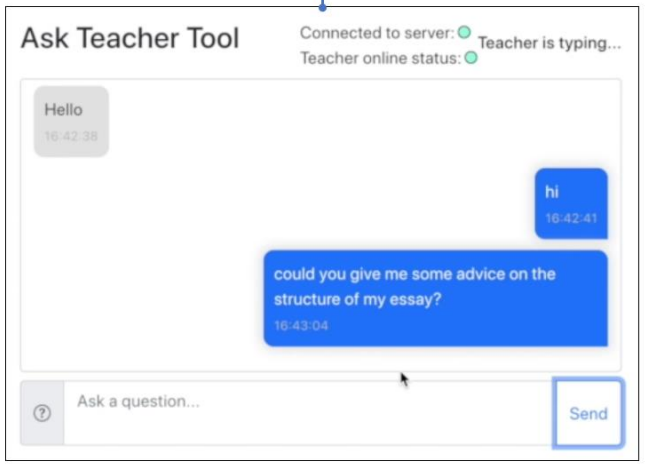
HE

CL







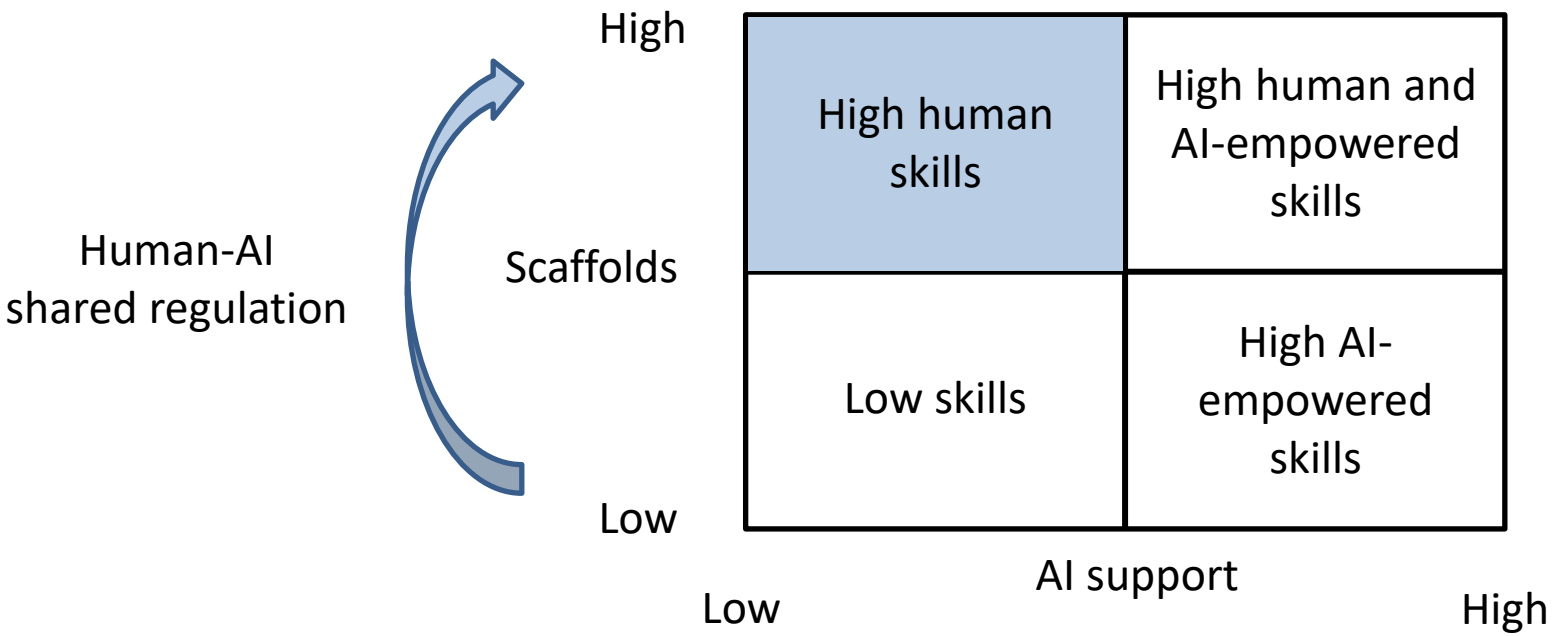


Towards metacognitive onloading

Increased monitoring accuracy with AI scaffolds for writing

Tang, L., Shen, K., Le, H., Shen, Y., Tan, S., Zhao, S., Juelich, T., Li, X., Gašević, D., Fan, Y. (2024). Facilitating learners' self-assessment during formative writing tasks using writing analytics toolkit. *Journal of Computer Assisted Learning*, in press.

Towards metacognitive onloading



Challenge

AI-powered scaffolds may have inadvertent side effects on learning

External locus of control is increased
(i.e., learners blame AI-powered scaffolds for any issues)

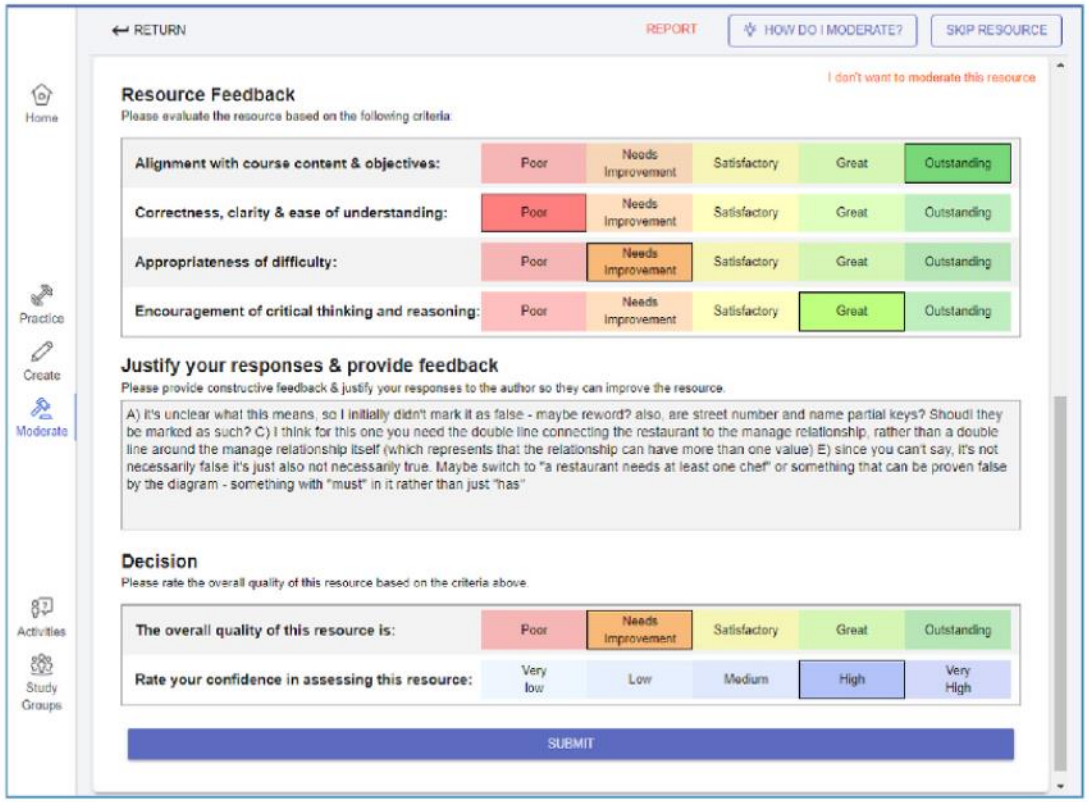
Tang, L., Shen, K., Le, H., Shen, Y., Tan, S., Zhao, S., Juelich, T., Li, X., Gašević, D., Fan, Y. (2024). Facilitating learners' self-assessment during formative writing tasks using writing analytics toolkit. *Journal of Computer Assisted Learning*, in press.

AI scaffolds and monitoring

What is long-term effect of *AI scaffolds* as shared regulation on monitoring?

Darvishi, A., Khosravi, H., Sadiq, S., Gašević, D., Siemens, G. (2024). Impact of AI assistance on student agency. *Computers & Education, 210*, 104967.

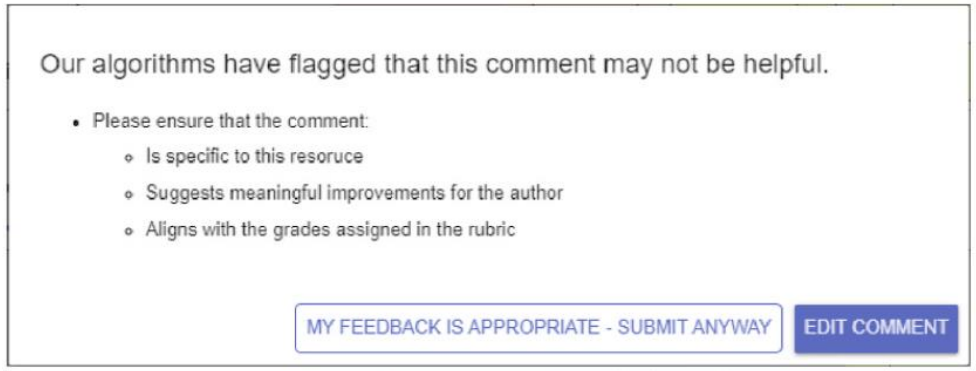
AI support and monitoring

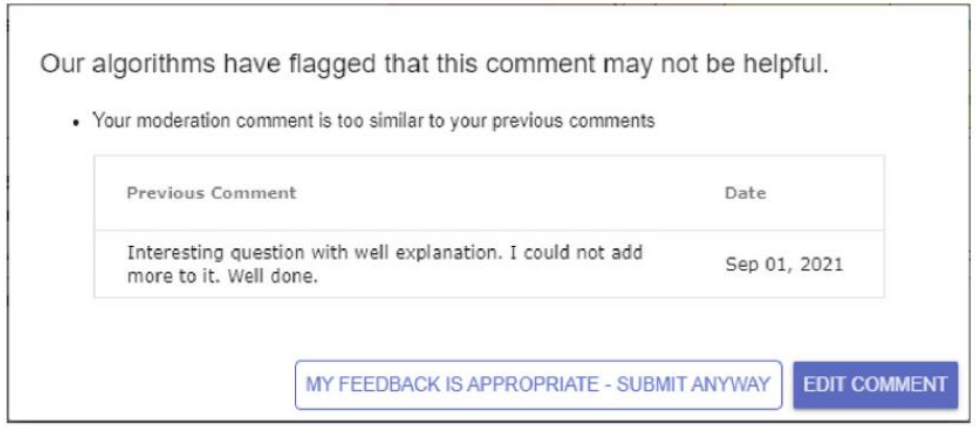


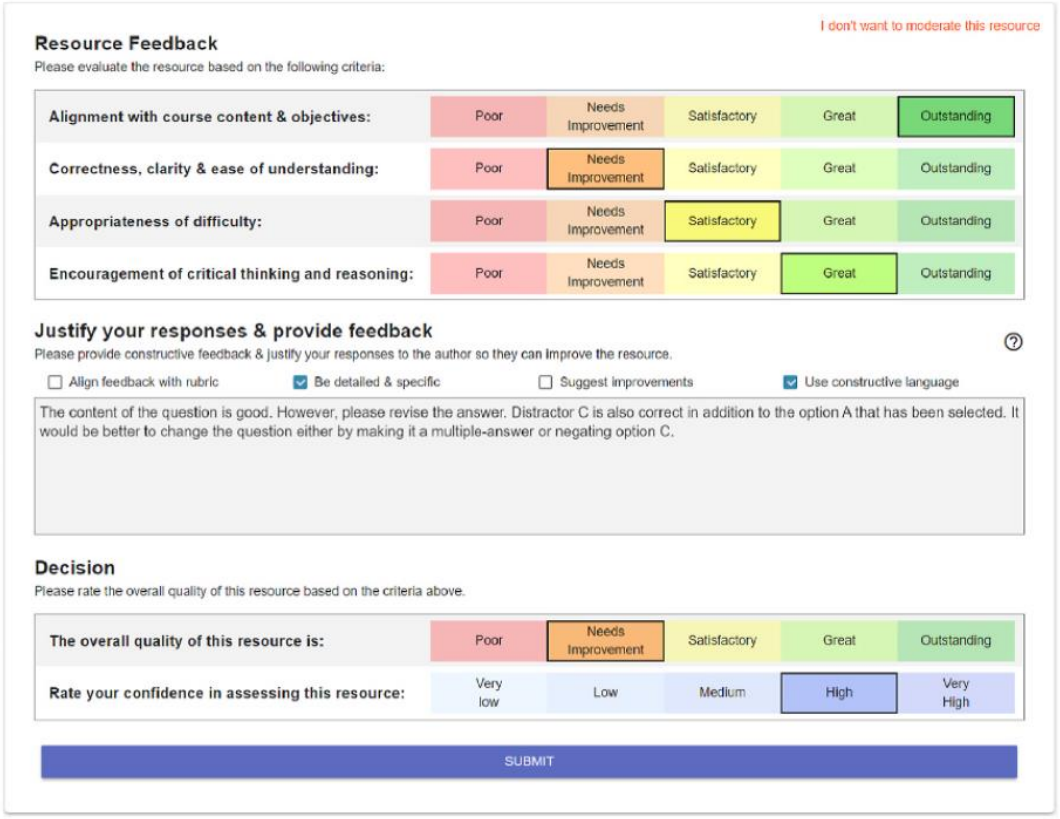
Moderator	Decision	Weight	Comment	
1	2	16%	A) it's unclear what this means, so I initially didn't mark it as false - maybe reword? also, are street number and name partial keys? Shoudl they be marked as such? C) I think for this one you need the double line connecting the restaurant to the manage relationship, rather than a double line around the manage relationship itself (which represents that the relationship can have more than one value) E) since you can't say, it's not necessarily false it's just also not necessarily true. Maybe switch to "a restaurant needs at least one chef" or something that can be proven false by the diagram - something with "must" in it rather than just "has"	2 0
2	3	13%	Most of the answers which you say are false are right but I am unsure if the second answer is entirely false. That might just be me.	0 0
3	5	20%	good question with complex attributes	0 1
4	4	16%	great question	0 0
5	2	13%	1. Making "A restaurant" a weak entity is entirely incorrect here as it is not dependent on a key of another owner entity as it has its own unique key. Thus, both "a restaurant" and "manage" should not be double lined. 2. Remove F. It's just a weird option to have. For all we know, the restaurant does have 2 chefs and they just didn't want it recorded in the ER diagram.	1 0
6	5	22%	This question is very useful for students to understand the details of ER-model , and reduce mistake they make when painting their own ER diagram. But there is a problem in this ER diagram, the line between "A restaurant" and "manage" need to be two lines, because the weak entity set must necessarily participate totally in their identifying relationship.	0 0
Result: Approved (3.7)				

Darvishi, A., Khosravi, H., Sadiq, S., Gašević, D., Siemens, G. (2024). Impact of AI Assistance on Student Agency. *Computers & Education, 210*, 104967.

AI support and monitoring

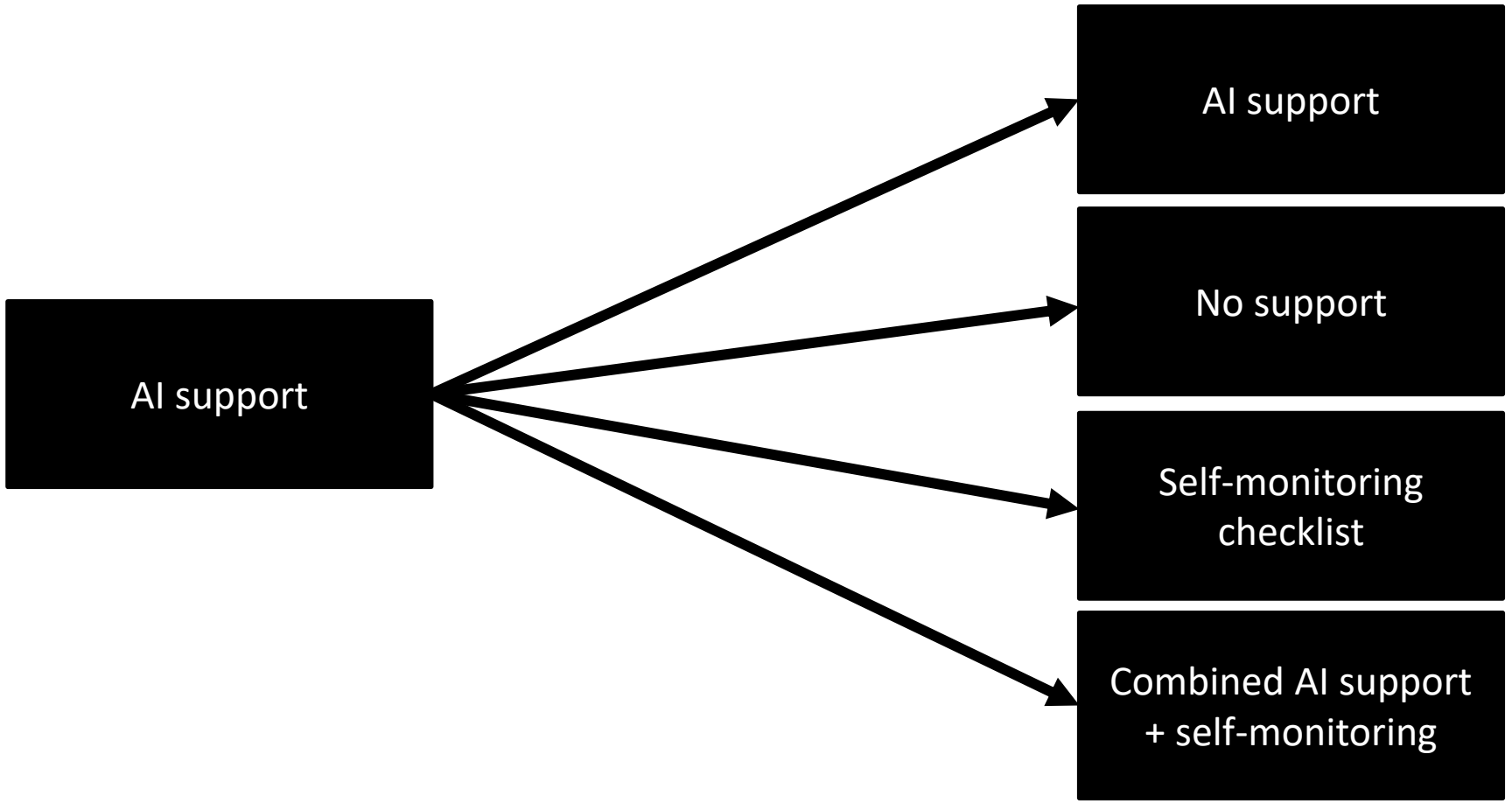






Darvishi, A., Khosravi, H., Sadiq, S., Gašević, D., Siemens, G. (2024). Impact of AI Assistance on Student Agency. *Computers & Education, 210*, 104967.

Longitudinal impact on monitoring



Darvishi, A., Khosravi, H., Sadiq, S., Gašević, D., Siemens, G. (2024). Impact of AI Assistance on Student Agency. *Computers & Education, 210*, 104967.

AI support and monitoring

Benefits deteriorate when AI support is removed

Darvishi, A., Khosravi, H., Sadiq, S., Gašević, D., Siemens, G. (2024). Impact of AI Assistance on Student Agency. *Computers & Education, 210*, 104967.

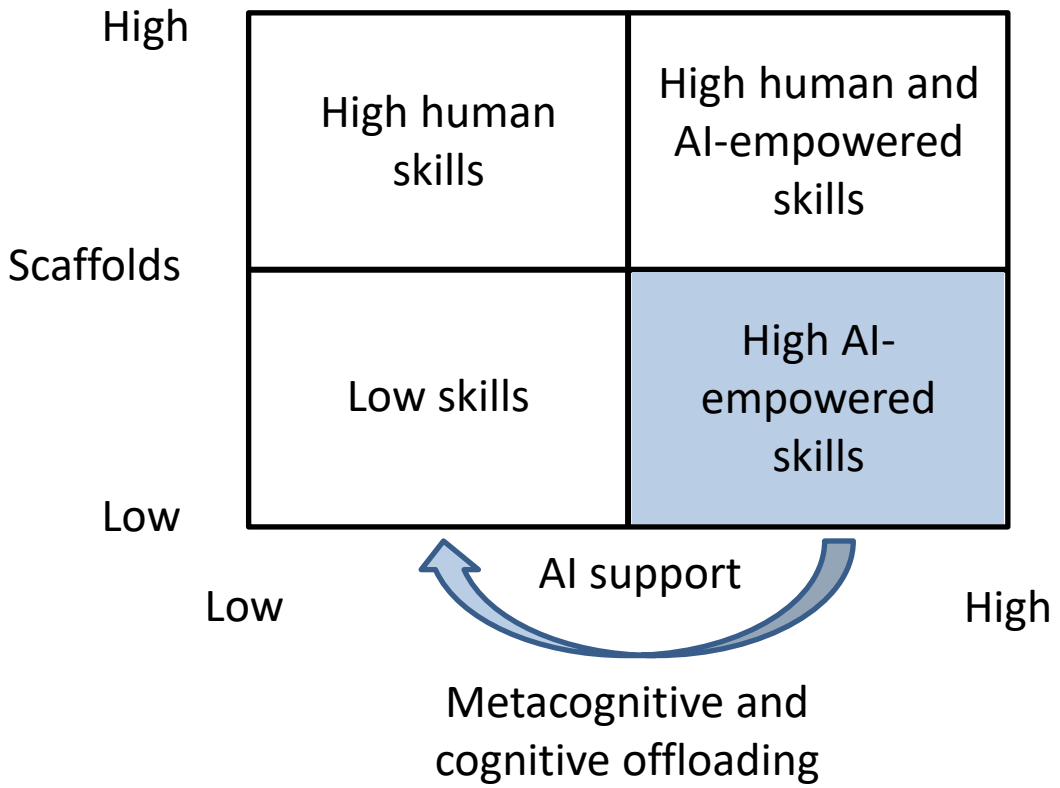
AI support and monitoring

Benefits deteriorate when AI support is removed

"Generative AI can harm learning"

Bastani, H., Bastani, O., Sungu, A., Ge, H., Kabakcı, Ö., & Mariman, R. (2024). Generative AI can harm learning. Available at SSRN 4895486. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4895486

Long term effects of unscaffolded AI-support



Atrophy of (meta)cognitive ability

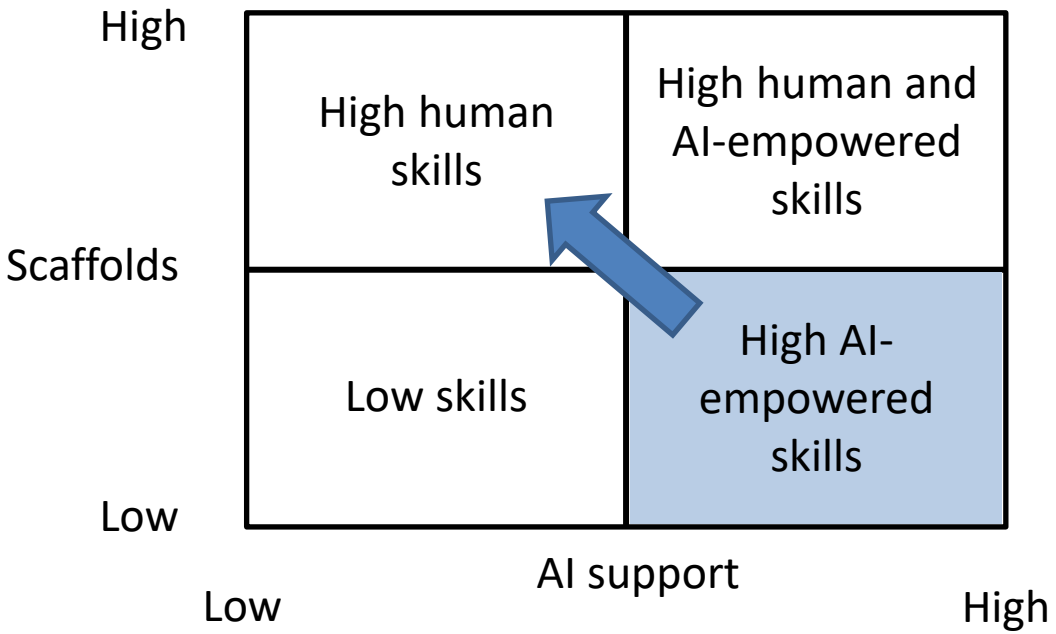
AI support and judgment of learning

Benefits present* when AI support replaced by scaffolds

*But not as high as they are with AI support

Darvishi, A., Khosravi, H., Sadiq, S., Gašević, D., Siemens, G. (2024). Impact of AI Assistance on Student Agency. *Computers & Education, 210*, 104967.

AI-support after replaced with scaffolds



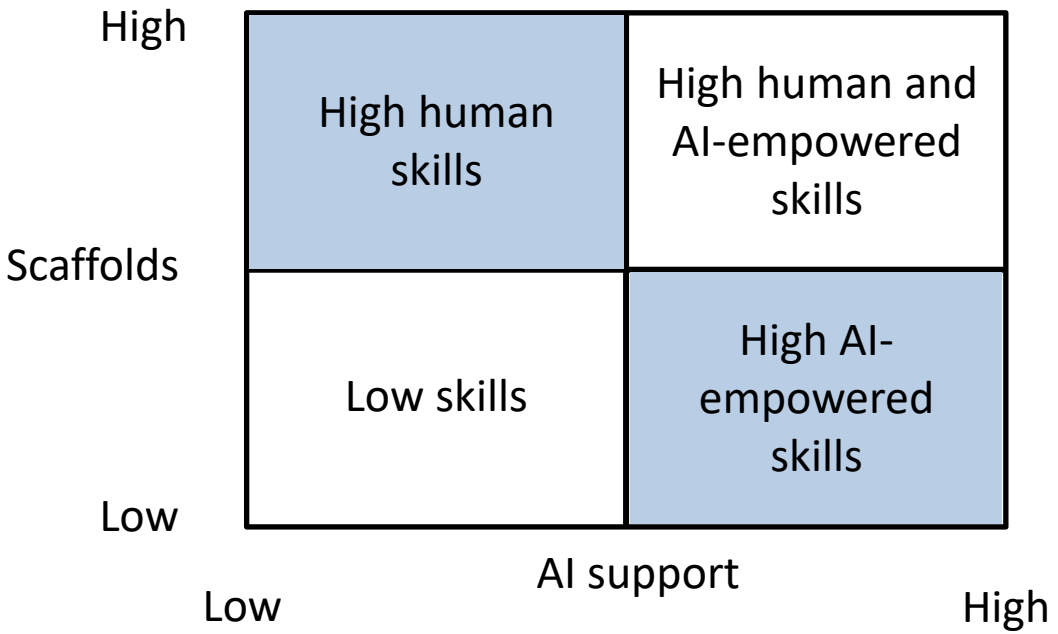
Positive, but not novel

AI support and judgment of learning

Combining scaffolds and AI support does not produce additive effects

Darvishi, A., Khosravi, H., Sadiq, S., Gašević, D., Siemens, G. (2024). Impact of AI Assistance on Student Agency. *Computers & Education, 210*, 104967.

Towards high human and AI-empowered skills



No additive effect of scaffolds and AI support

Open challenge

How do we develop high human and AI-empowered skills?

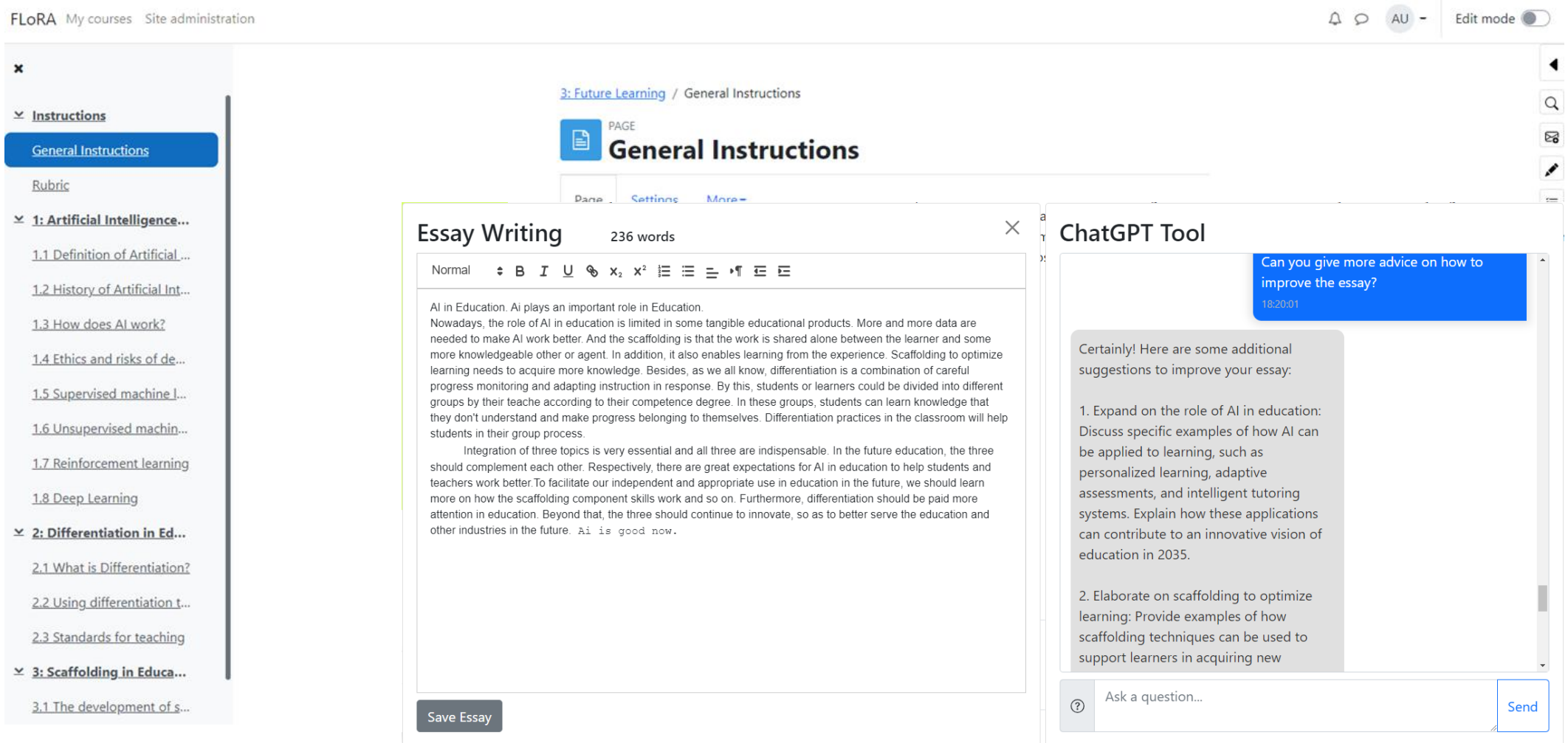
Darvishi, A., Khosravi, H., Sadiq, S., Gašević, D., Siemens, G. (2024). Impact of AI Assistance on Student Agency. *Computers & Education, 210*,104967.

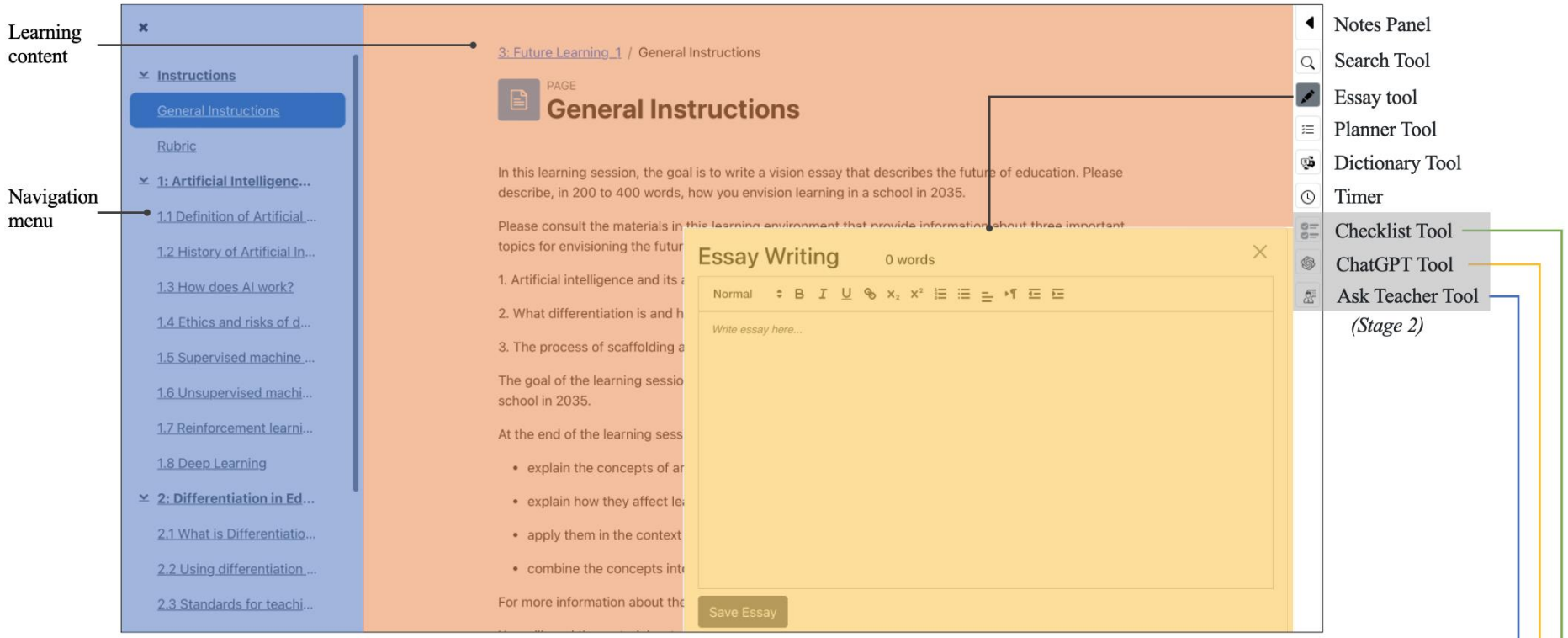
3

Information problem solving

What effect does generative AI have on information problem solving?

ChatGPT in FLoRA





(Stage 1)

(Stage 2)

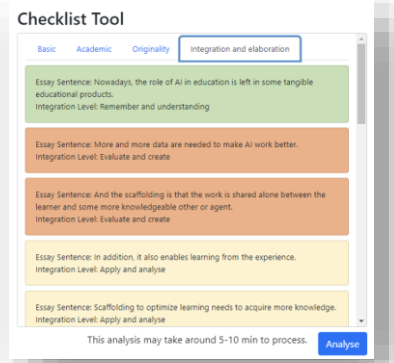
CN

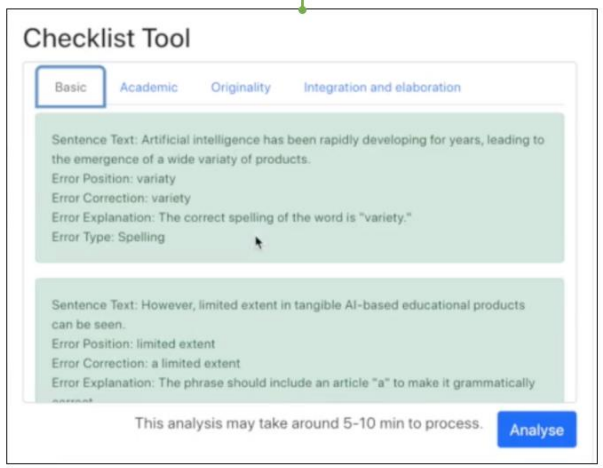
Revise essay by themselves

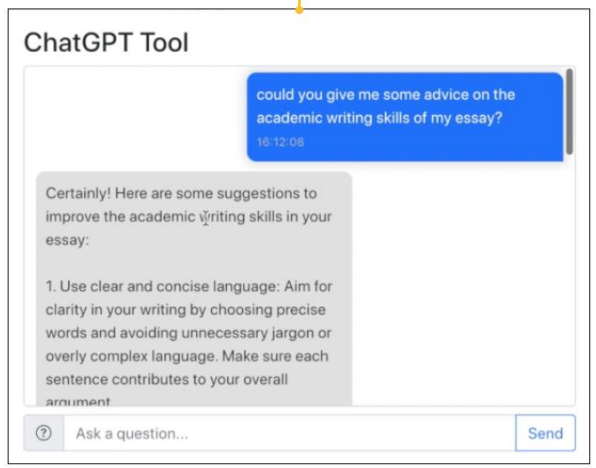
AI

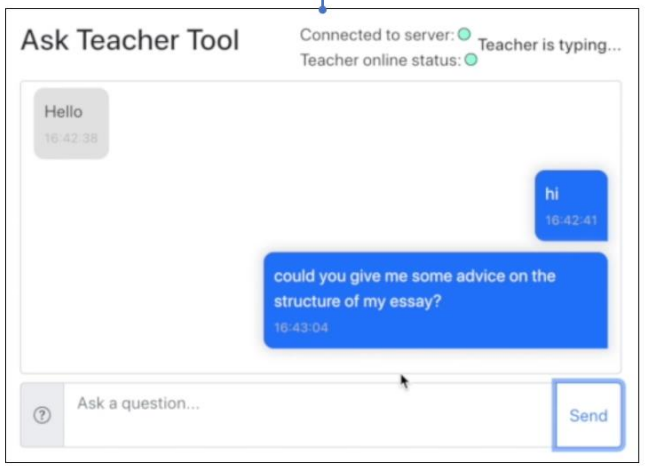
HE

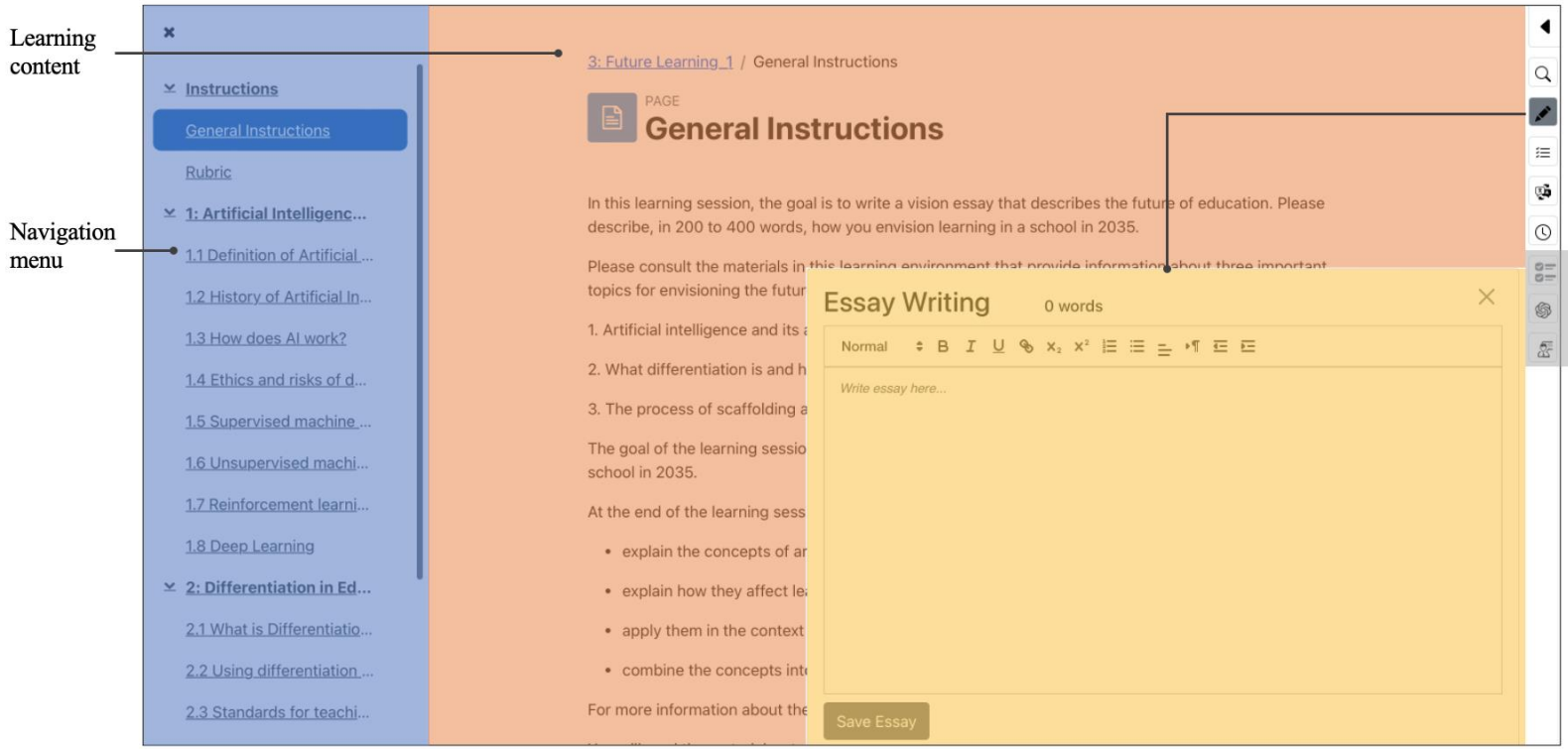
CL











(Stage 1)

(Stage 2)

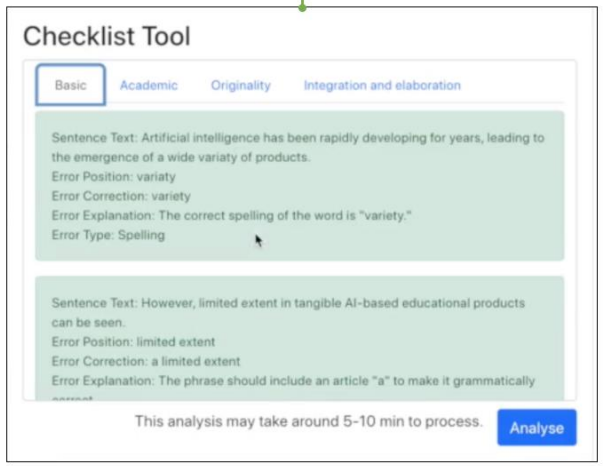
CN

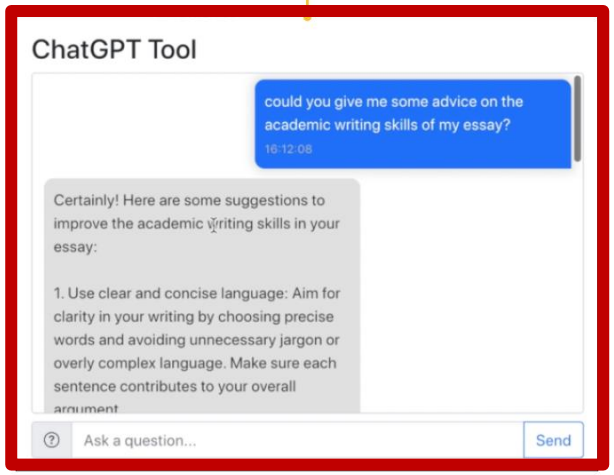
Revise essay by themselves

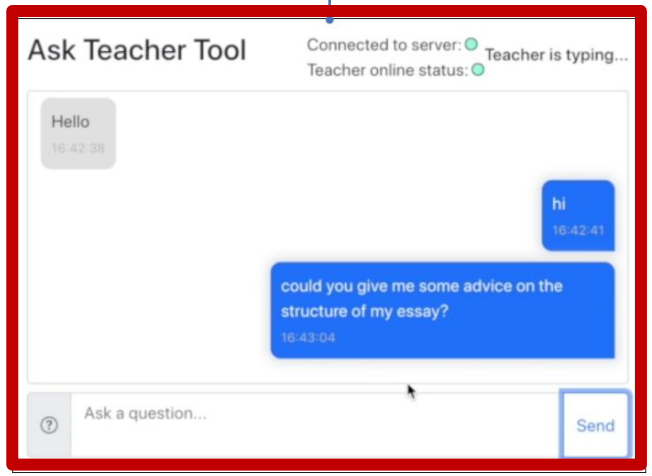
AI

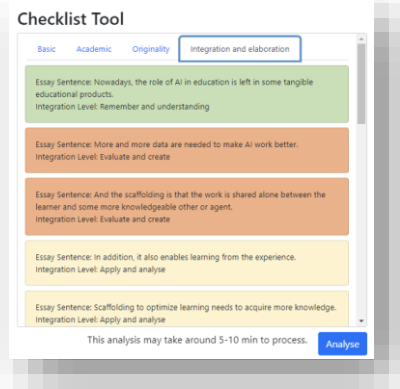
HE

CL









Writing performance

Unsurprisingly writing performance is improved when using ChatGPT

ChatGPT significantly higher essay scores than the other three

Chen, A., Xiang, M., Zhou, J., Jia, J., Shang, J., Li, X., Gašević, Fan, Y. (2025). Unpacking help-seeking processes through multimodal learning analytics: A comparative study of learning facilitated by ChatGPT and human expert. *Computers & Education, 226*, 105198.

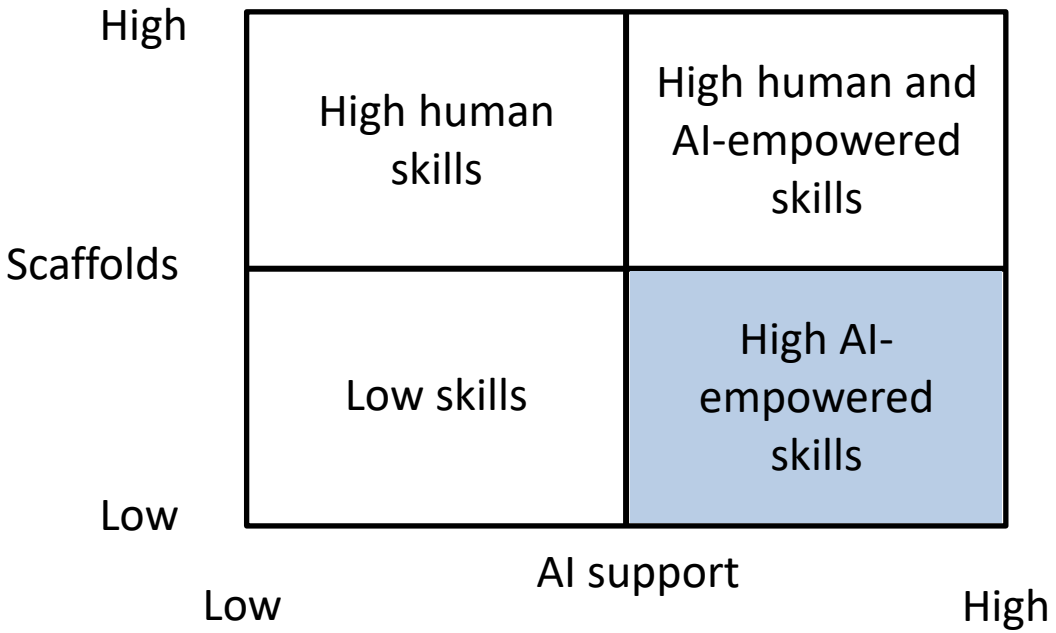
Metacognition in information problem solving

Limited monitoring when information provided by generative AI

Chen, A., Xiang, M., Zhou, J., Jia, J., Shang, J., Li, X., Gašević, Fan, Y. (2025). Unpacking help-seeking processes through multimodal learning analytics: A comparative study of learning facilitated by ChatGPT and human expert. *Computers & Education, 226*, 105198.

Towards high human and AI-empowered skills

Ask ChatGPT

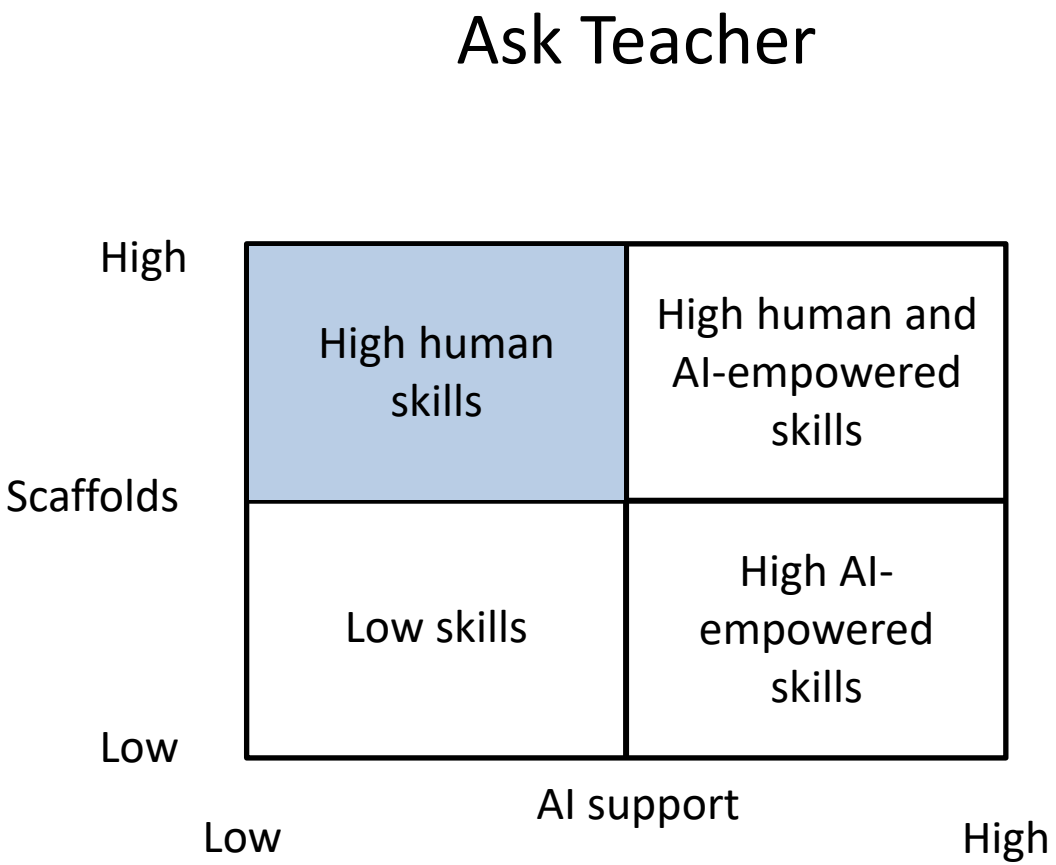


Metacognition in information problem solving

Always observed evidence of monitoring of human provided information

Chen, A., Xiang, M., Zhou, J., Jia, J., Shang, J., Li, X., Gašević, Fan, Y. (2025). Unpacking help-seeking processes through multimodal learning analytics: A comparative study of learning facilitated by ChatGPT and human expert. *Computers & Education, 226*, 105198.

Towards high human and AI-empowered skills



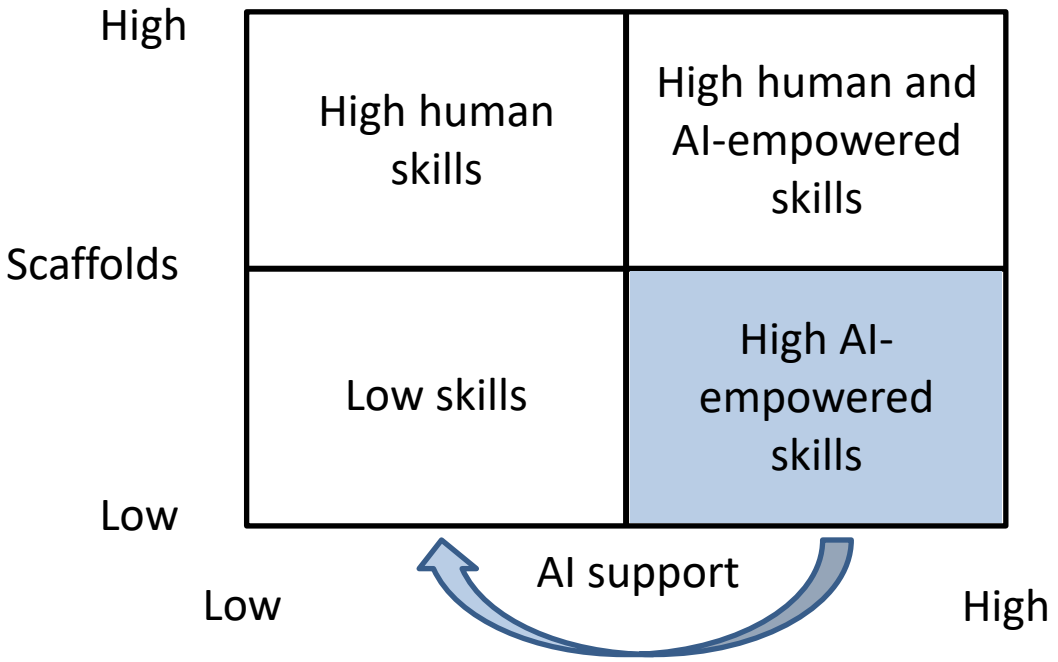
Metacognitive engagement

What are long term implications of limited monitoring?

Unreliable information produced by GenAI

Fan, Y., Tang, L., Le, H., Shen, K., Zhao, S., Zhao, Y., Shen, Y., Li, X., Gašević, D. (2024). Beware of metacognitive laziness: Effects of generative artificial intelligence on learning motivation, processes, and performance. *British Journal of Educational Technology*, in press.

Long term effects of unscaffolded AI-support



Atrophy of (meta)cognitive ability

Cognitive offloading coupled with high processing fluency

Metacognitive laziness

Generative AI Can Harm Learning

Hamsa Bastani,[1*] Osbert Bastani,[2*] Alp Sungu,[1*†]
Haosen Ge,[3] Özge Kabakcı,[4] Rei Mariman

[1]Operations, Information and Decisions, University of Pennsylvania
[2]Computer and Information Science, University of Pennsylvania
[3]Wharton AI & Analytics, University of Pennsylvania
[4]Budapest British International School

Bastani, H., Bastani, O., Sungu, A., Ge, H., Kabakcı, Ö., & Mariman, R. (2024). Generative AI can harm learning. Available at SSRN 4895486. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4895486

Metacognitive laziness

Computers in Human Behavior 160 (2024) 108386

Contents lists available at ScienceDirect

Computers in Human Behavior

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

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]

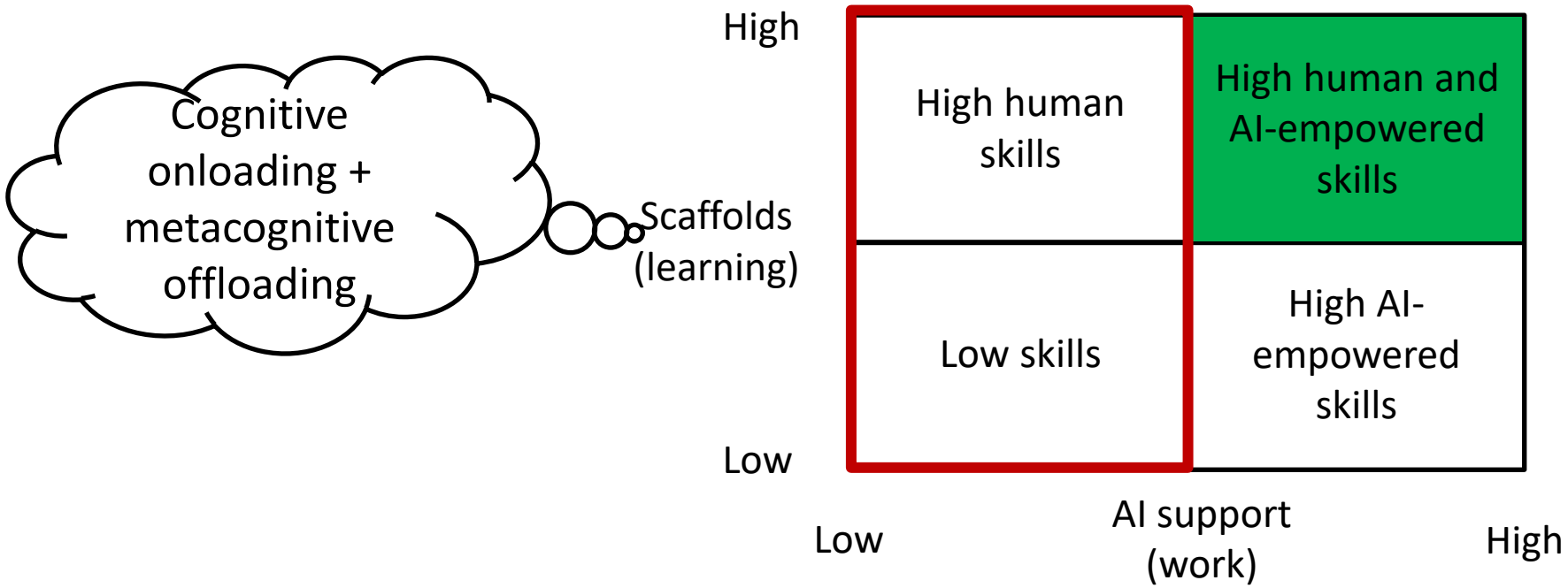
[a] Institute of Medical Education, LMU University Hospital, LMU Munich, Germany
[b] Chair for Teaching and Learning with Digital Media, Technical University of Munich, Germany
[c] Learning Analytics and Educational Data Mining, University of Augsburg, Augsburg, Germany

Stadler, M., Bannert, M., & Sailer, M. (2024). Cognitive ease at a cost: LLMs reduce mental effort but compromise depth in student scientific inquiry. *Computers in Human Behavior*, 160, 108386.

FOUNDATIONS – IMPACT – **DIRECTION** – FINAL REMARKS

Risk #1

Existing adaptive learning systems



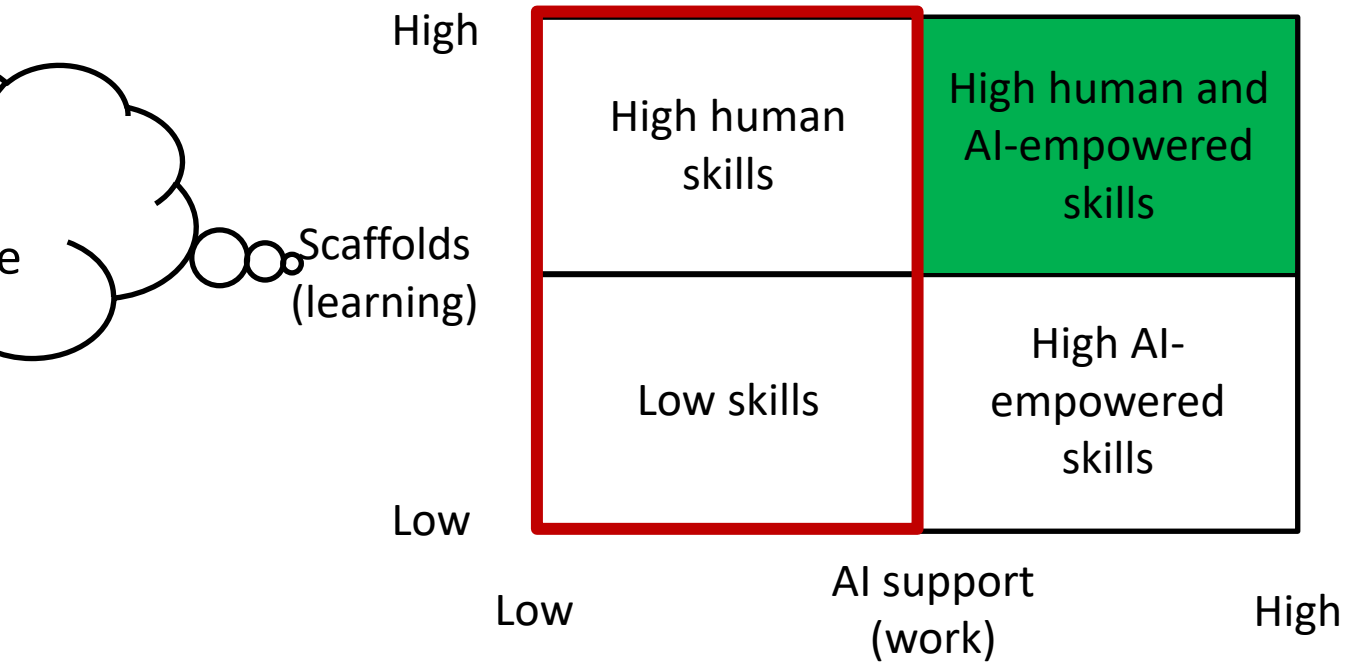
Molenaar, I. (2022). The concept of hybrid human-AI regulation: Exemplifying how to support young learners' self-regulated learning. *Computers and Education: Artificial Intelligence*, *3*, 100070.

Opportunity #1

AI-powered personalized scaffolds

Hybrid human-AI regulation

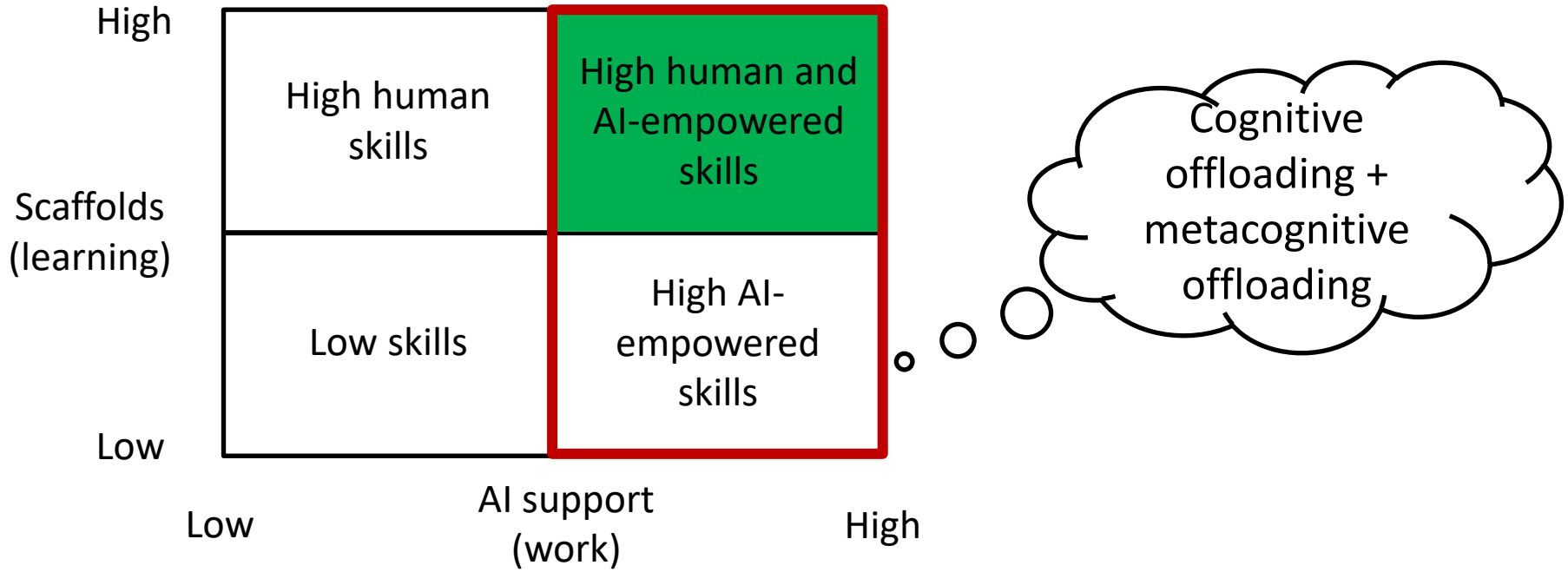
Cognitive onloading + metacognitive **onloading**



Molenaar, I. (2022). The concept of hybrid human-AI regulation: Exemplifying how to support young learners' self-regulated learning. *Computers and Education: Artificial Intelligence*, *3*, 100070.

Risk #2

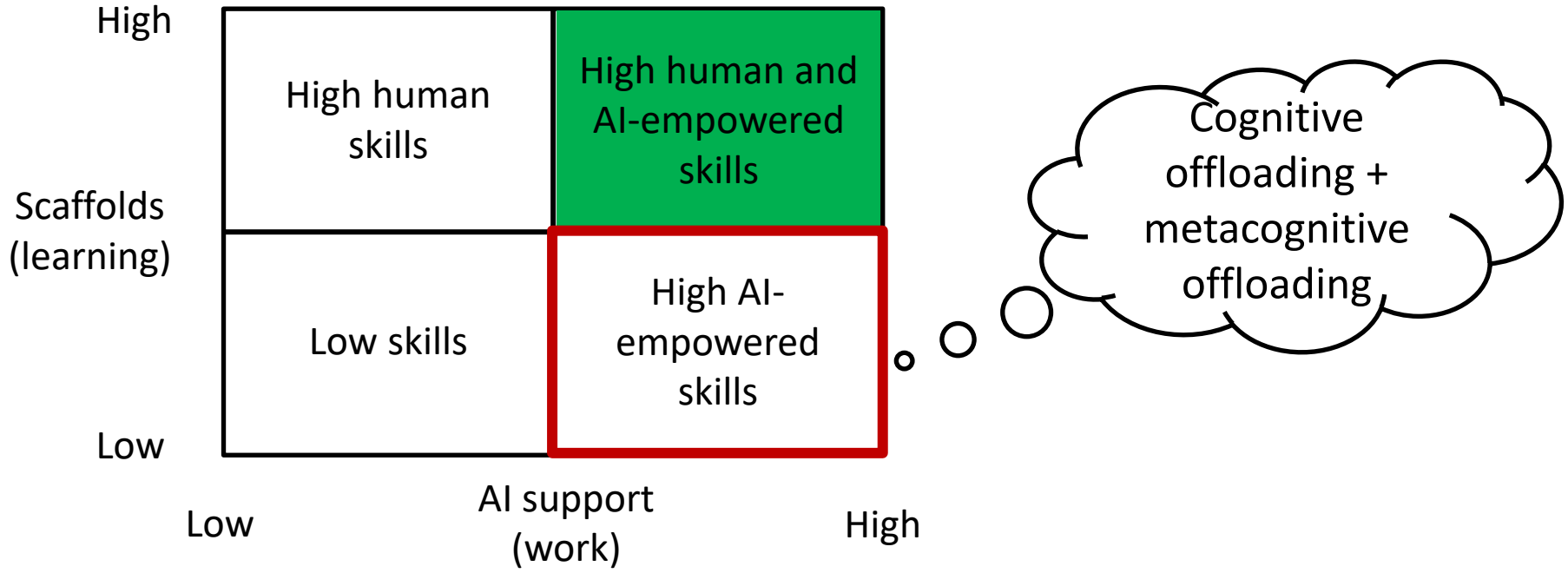
Cognitive offloading



Risko, E. F., & Gilbert, S. J. (2016). Cognitive offloading. *Trends in cognitive sciences*, *20*(9), 676-688.

Risk #2

Cognitive offloading



Risko, E. F., & Gilbert, S. J. (2016). Cognitive offloading. *Trends in cognitive sciences*, *20*(9), 676-688.

Metacognitive engagement

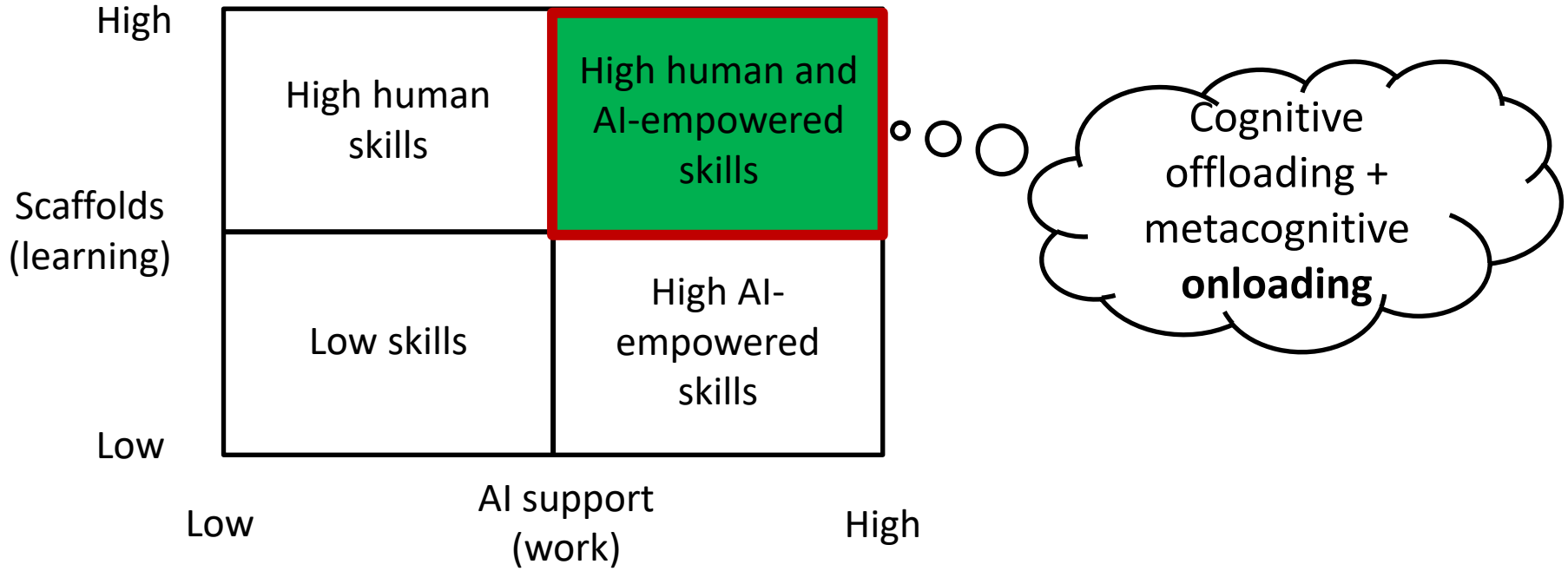
How to minimize risks of AI-empowered skills?

Makes developing human skills worse

Bastani, H., Bastani, O., Sungu, A., Ge, H., Kabakcı, Ö., & Mariman, R. (2024). Generative AI Can Harm Learning. Available at SSRN 4895486. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4895486

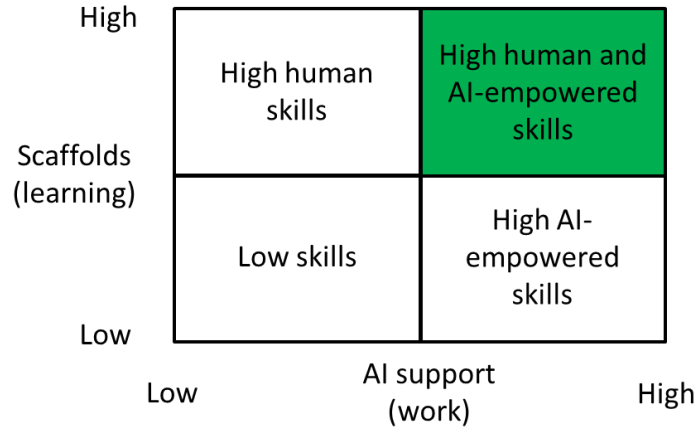
Opportunity #2

Metacognitive onloading



Risko, E. F., & Gilbert, S. J. (2016). Cognitive offloading. *Trends in cognitive sciences*, *20*(9), 676-688.

Proposition

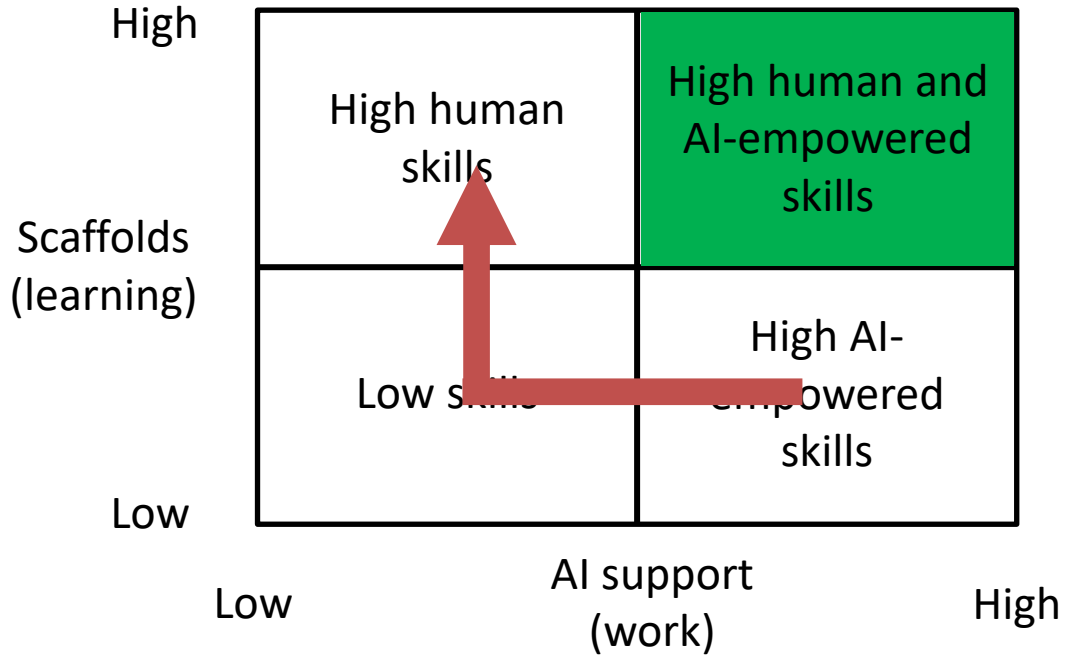


Combined human and AI-empowered only at high expertise levels

Regulation needed in complex authentic tasks

Opportunity #2

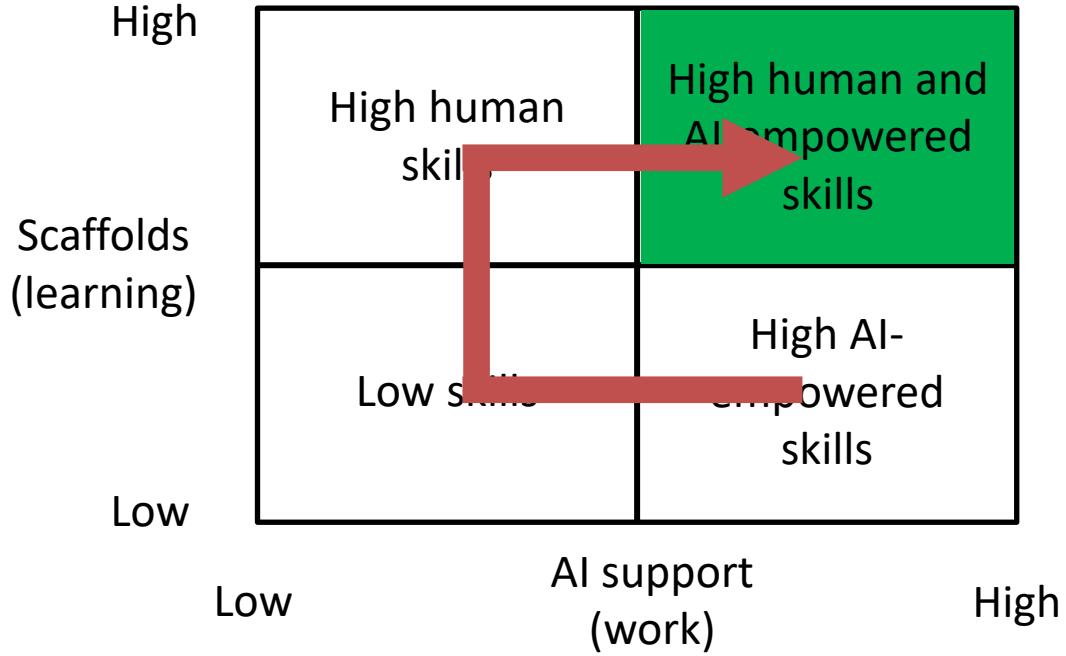
Metacognitive onloading



Risko, E. F., & Gilbert, S. J. (2016). Cognitive offloading. *Trends in cognitive sciences*, *20*(9), 676-688.

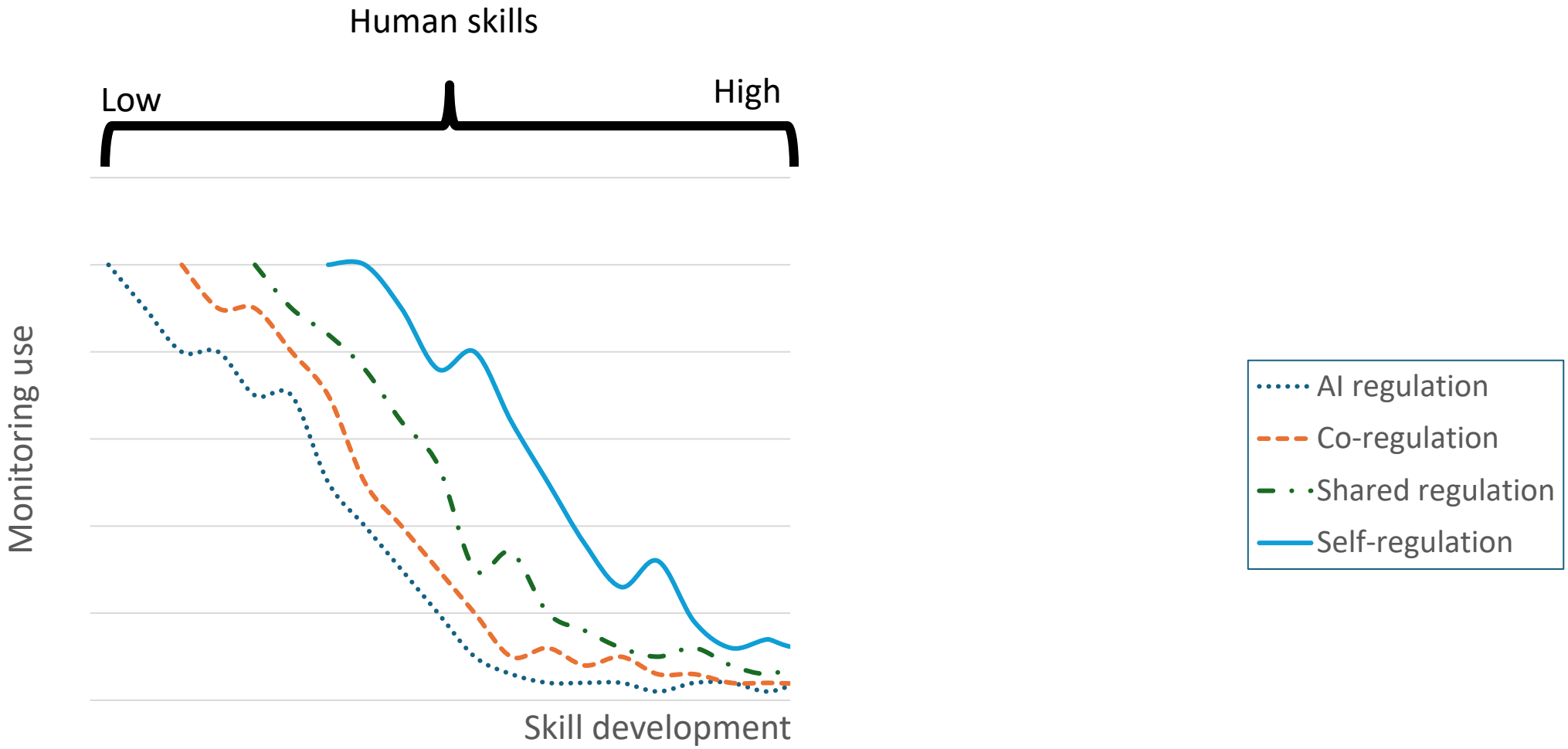
Opportunity #2

Metacognitive onloading



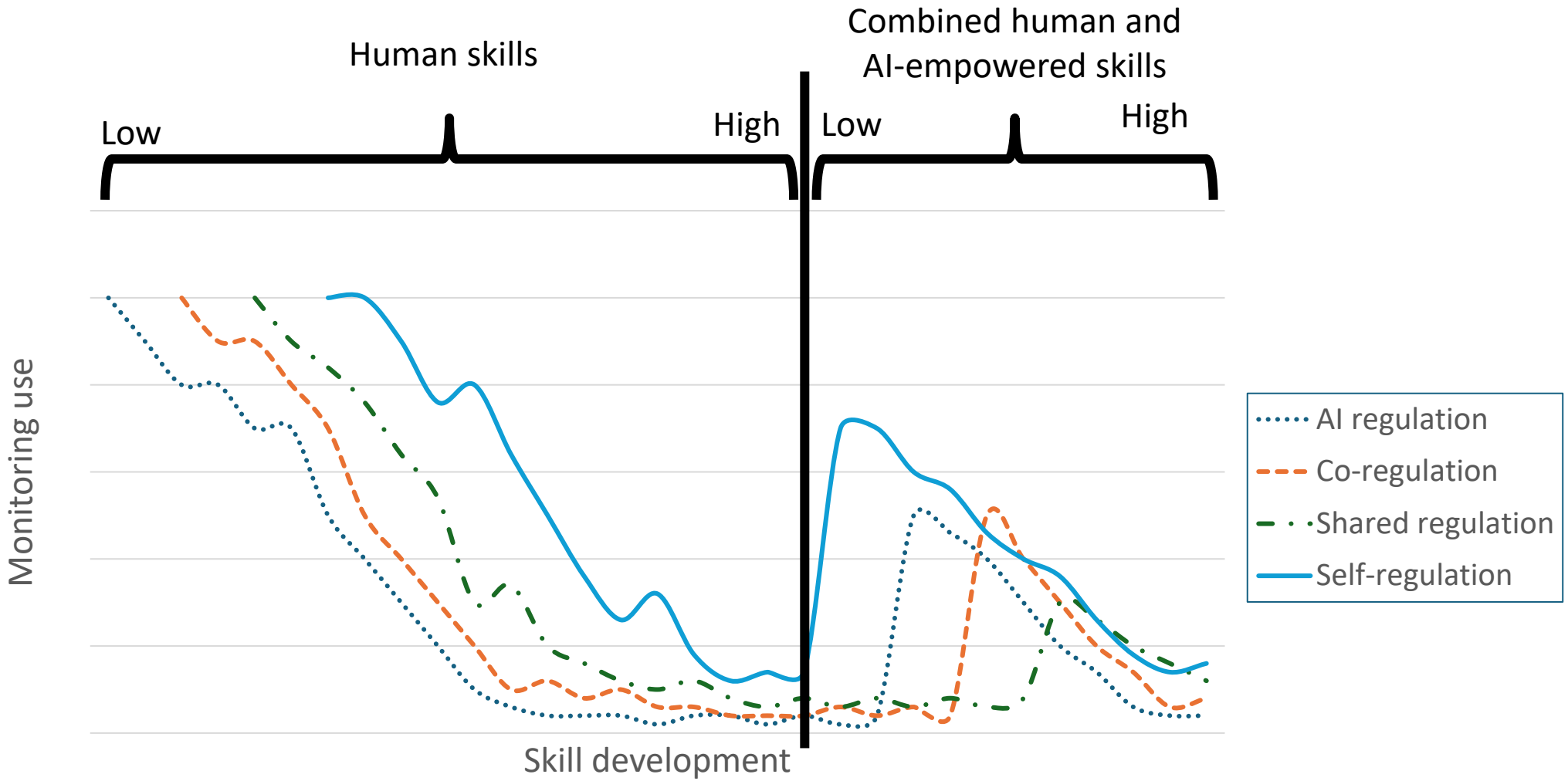
Risko, E. F., & Gilbert, S. J. (2016). Cognitive offloading. *Trends in cognitive sciences*, *20*(9), 676-688.

Proposition



This image is not based on actual data. It is fully hypothesized based on existing research on hybrid human-AI regulation and cognitive offloading.

Proposition



This image is not based on actual data. It is fully hypothesized based on existing research on hybrid human-AI regulation and cognitive offloading.

FOUNDATIONS – IMPACT – DIRECTION –

FINAL REMARKS

Tacking open challenges

AI can help enhance SRL, but
it can also inhibit it if used carelessly

Tacking open challenges

Effective AI-empowered skills require strong human skills

Opportunity

Human and AI
to learn together and from each other

Collins, K. M., Sucholutsky, I., Bhatt, U.,…, Griffiths, T. L. (2024). Building machines that learn and think with people. *Nature Human Behavior, 8,* 81851–1863.

Getting ready for the age of AI: Developing self-regulated learners

Dragan Gašević
@dgasevic

November 27th, 2024
ICCE'24
Manila, Philippines