

Human-AI collaboration in education

Inge Molenaar
17 maart 2026
ICO Spring School

What to expect

- **Getting to know each other**
 - **What are your expectations and questions?**
- **Introduction AI in education**
 - **I. Education & AI**
 - On the difference between generative and educational AI
 - **II. Students & AI**
 - On what students think of AI and how AI influences their learning
 - **III. Teachers & AI**
 - On teacher-AI collaboration and the changes in tasks
- **Workshop part or discussion**



"De computer van meester Bart
zei dat ik het woord fout zei.
Toen moest ik het opnieuw voorlezen."

Loek, 8 jaar



"Met dit programma weet je precies hoe
je voor een vak moet leren, en ook wanneer
je klaar bent met leren omdat je de stof kent."

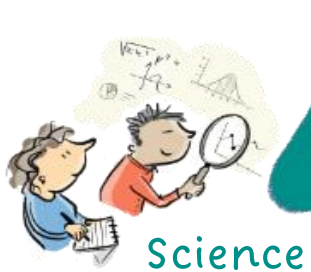
Maja, 12 jaar

CONTEXT

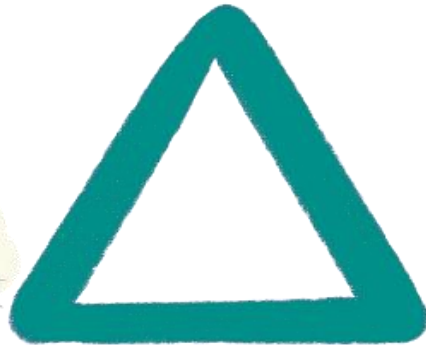
NOLAI



Education



Science



Business

Co-creation program



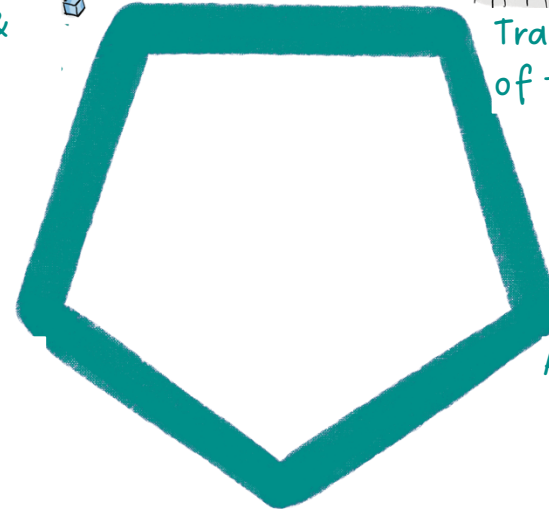
Pedagogical & didactical



Training & professionalization of teachers



Sustainable data

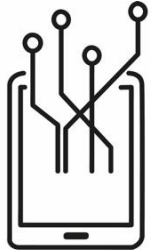


AI Technology



Ethics

Scientific program



WHAT DO WE WANT? WE CREATE EDUCATION TOGETHER!



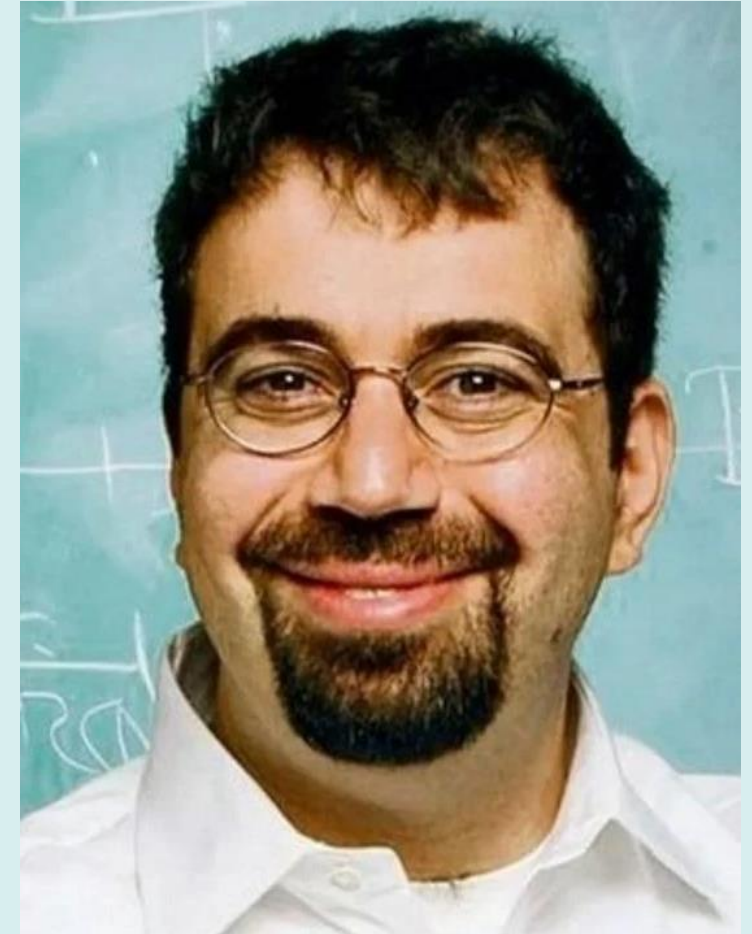
NOBEL PRIZE WINNER

Daran Acemoğlu

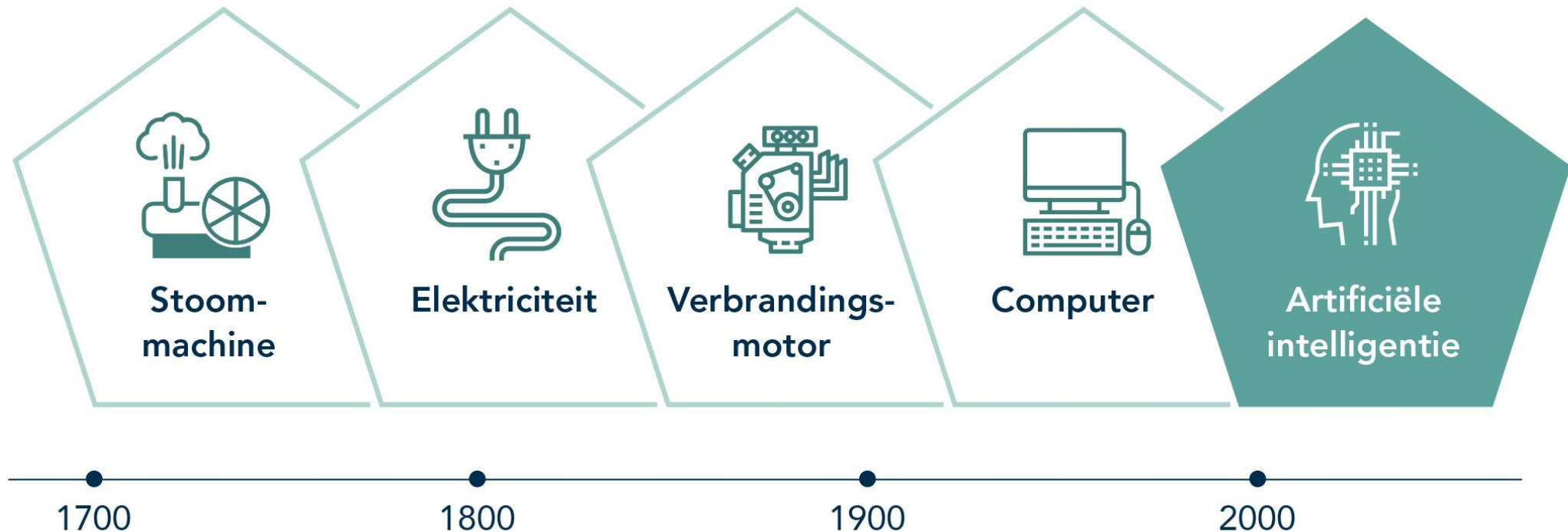
We currently have the **wrong direction** for AI. We're using it too much for automation and not enough for providing expertise and information to workers.

I don't think **complementary uses** of AI will miraculously appear by themselves unless the industry devotes significant energy and time to them.

The faster you go, and the more hype you have, that **course correction** becomes less likely. It's very difficult, if you're driving 200 miles an hour, to make a 180-degree turn.



Development of the future



Focus

Learning
about AI



Learning
with AI



Learning
for AI

EDUCATION & AI

*Generative AI versus
educational AI*

Generative versus educational



Generative AI

- General purpose AI applications
- Not designed for education



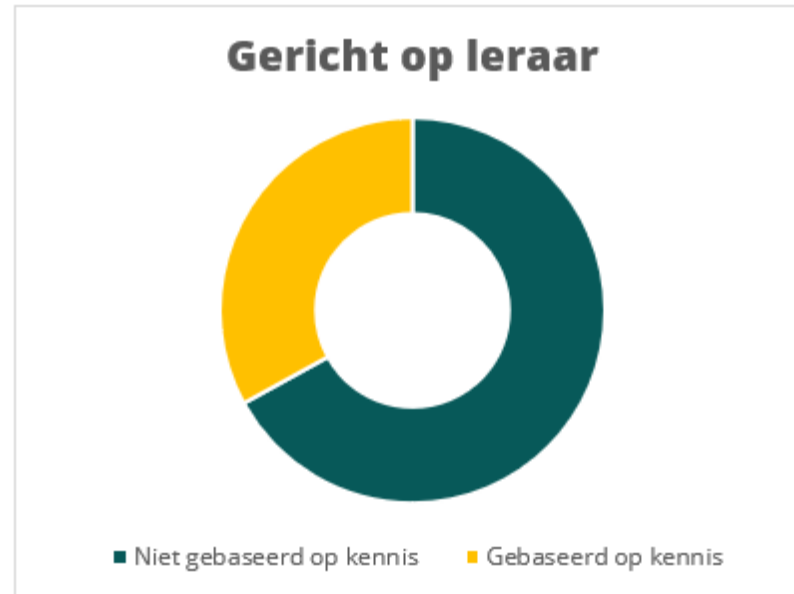
Educational AI

- Educational purpose for AI applications
- Specifically designed/ developed for education
- Aimed at improving learning and teaching

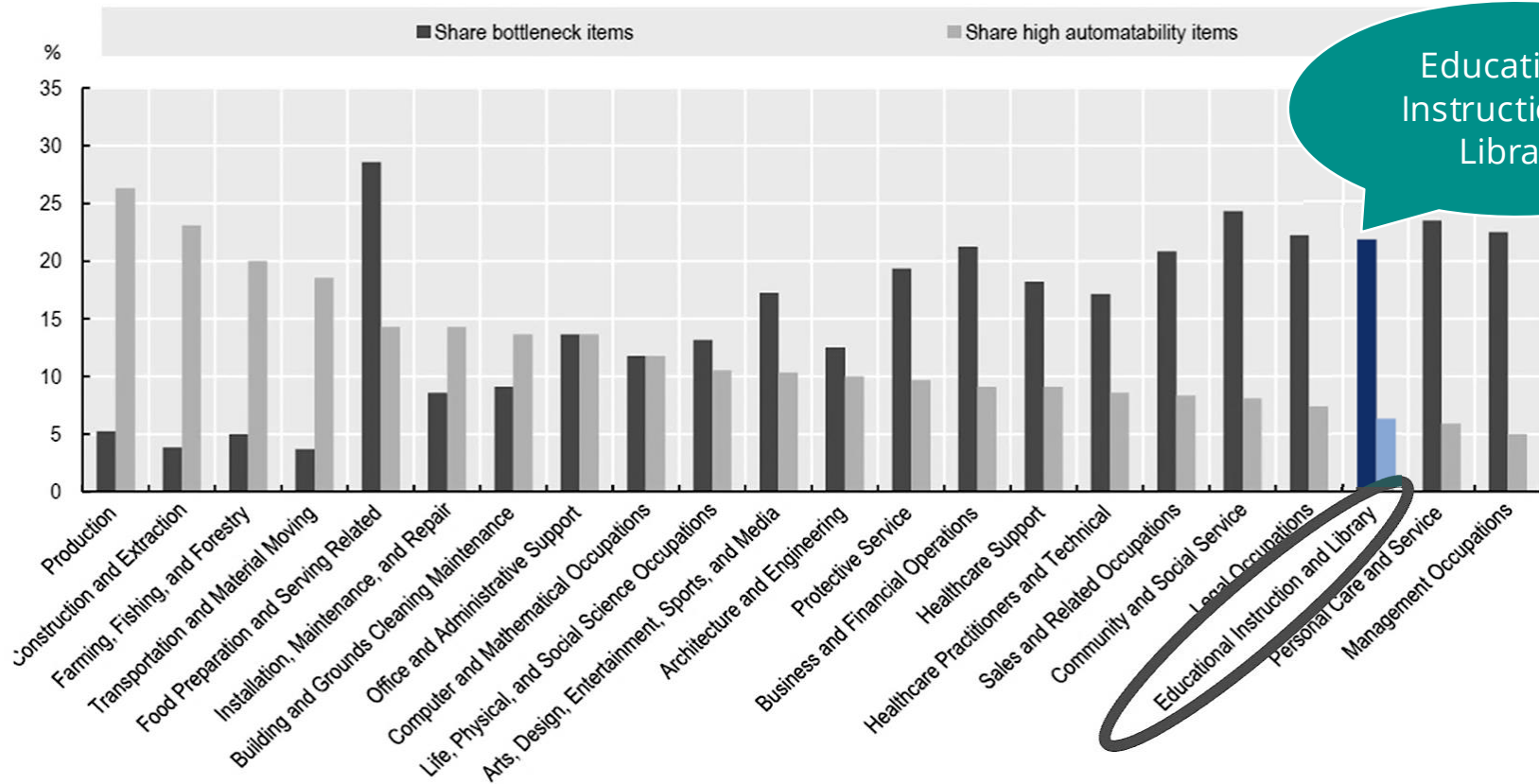
What could be better?

1. + Engaging teachers and education
2. + Application of scientific insights
3. + Reflecting on the role of AI
4. + Designing successful huma-AI collaboration

Application of scientific insights



Role of AI in education



Educational
Instructions &
Library

Successful human-AI collaboration

85%

Augmentation

$$1 + 1 = 2$$

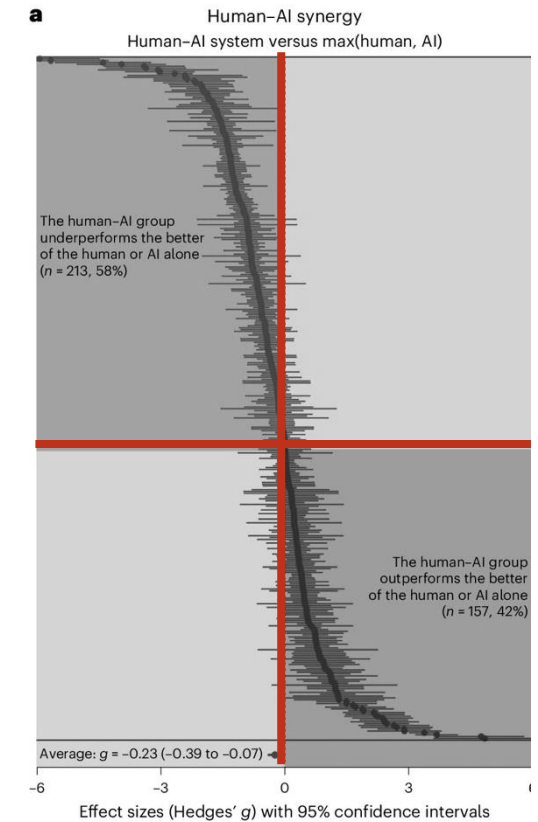
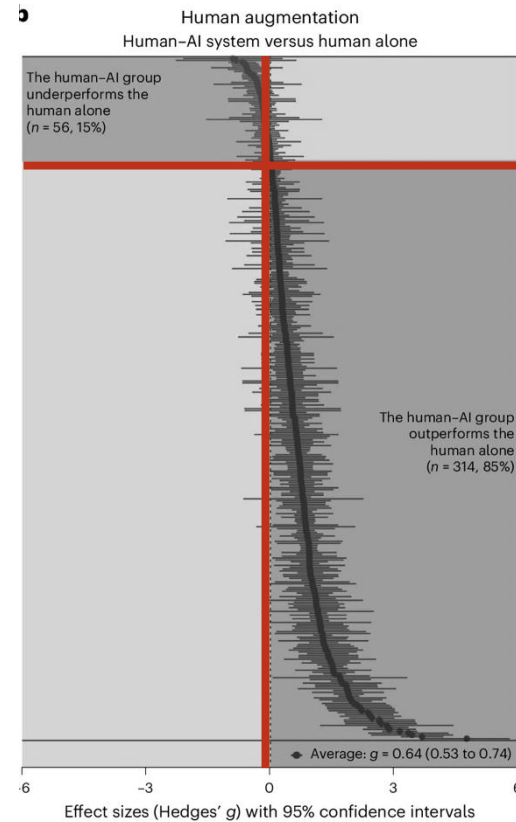
Better performance with AI versus human itself

42%

'Synergy'

$$1 + 1 = 3$$

Better performance in with regards to AI or human separately



LEARNERS & AI

In search of a new balance

Learners about AI

74%

of learners think that AI will play **an important role** in their lives.

49%

Of learners fear that AI will contribute to inequality of opportunity.

44%

of learners feel that their teachers are **well-prepared** to work with AI.

44 %

Of learners worry that education will become too dependent on AI.

In search of balance

Former situation

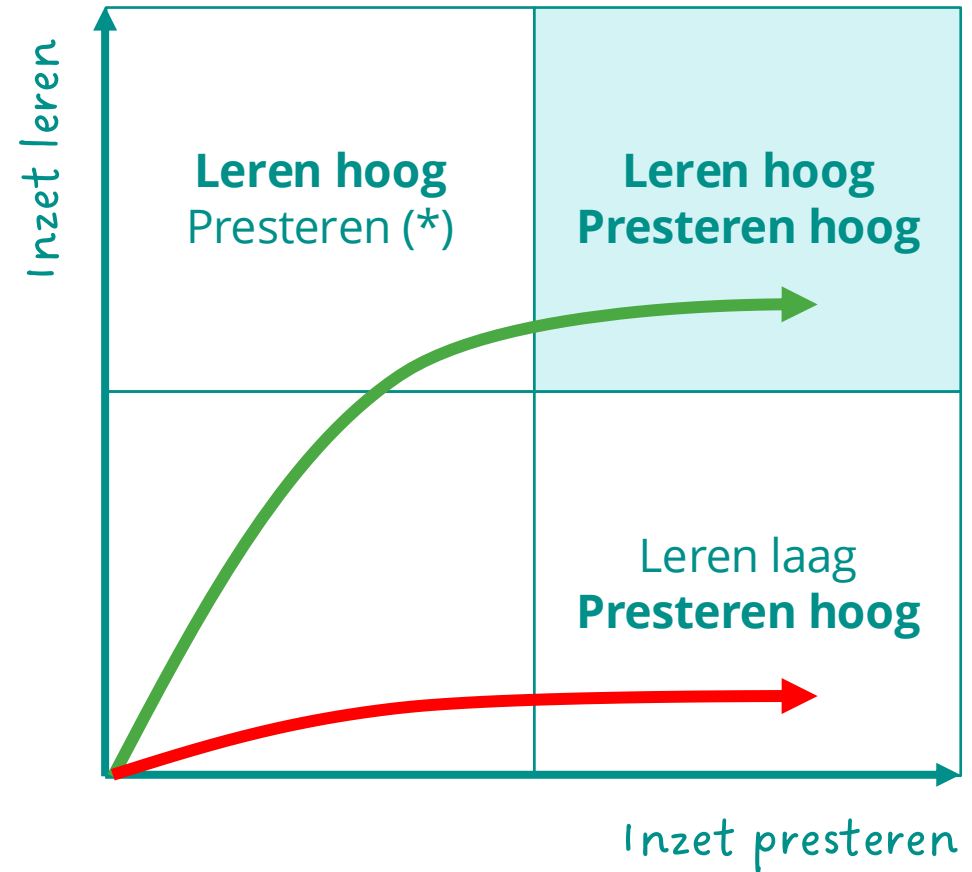
Good results mainly depend on effort.

Current situation

Good results with AI can be achieved, even without much effort.



Do I want a good grade?
Do I want to learn something?



In practice

Self-regulation while writing

FLORA-algorithm applicable for secondary education

Metacognition : orientation | planning | evaluation | monitoring

Cognition : read | reread | note | copy



Part 1

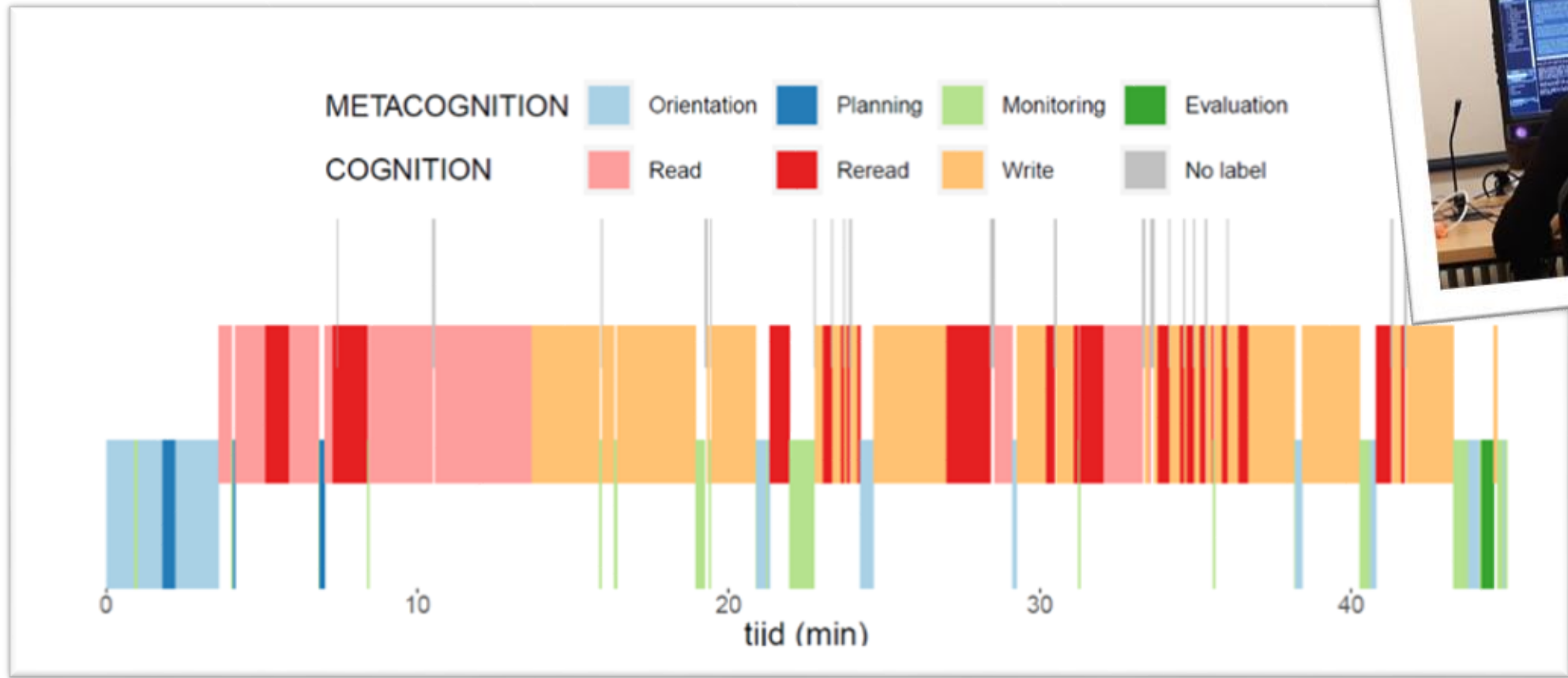
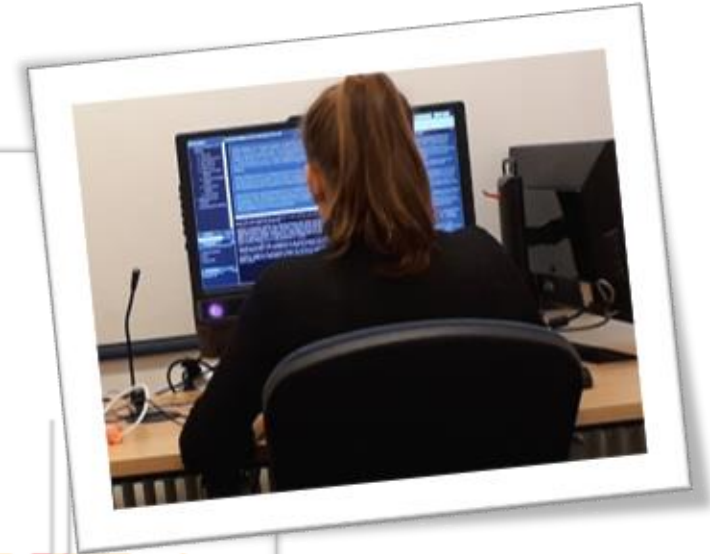
Understanding Learning and teaching with AI

PART I. UNDERSTANDING LEARNING AND TEACHING WITH AI

Understanding the learning process



Importance theoretical lens



Self-regulated learning Multimodal data & Analysis (SMA)grid



	Cognition	Metacognition	Affective states	Motivation
Self-report				
Survey				
Interview				
Voice data				
Dialogue				
Think aloud				
Log data				
Eye tracking				
Mouse and keyboard				
Video data				
Physiological data				
EDA				
EEG				



1. Unimodal Approach

Studies chose to investigate one CAMM process with one data stream.



2. Horizontal approach

The relations between multiple CAMM processes measured by one data stream



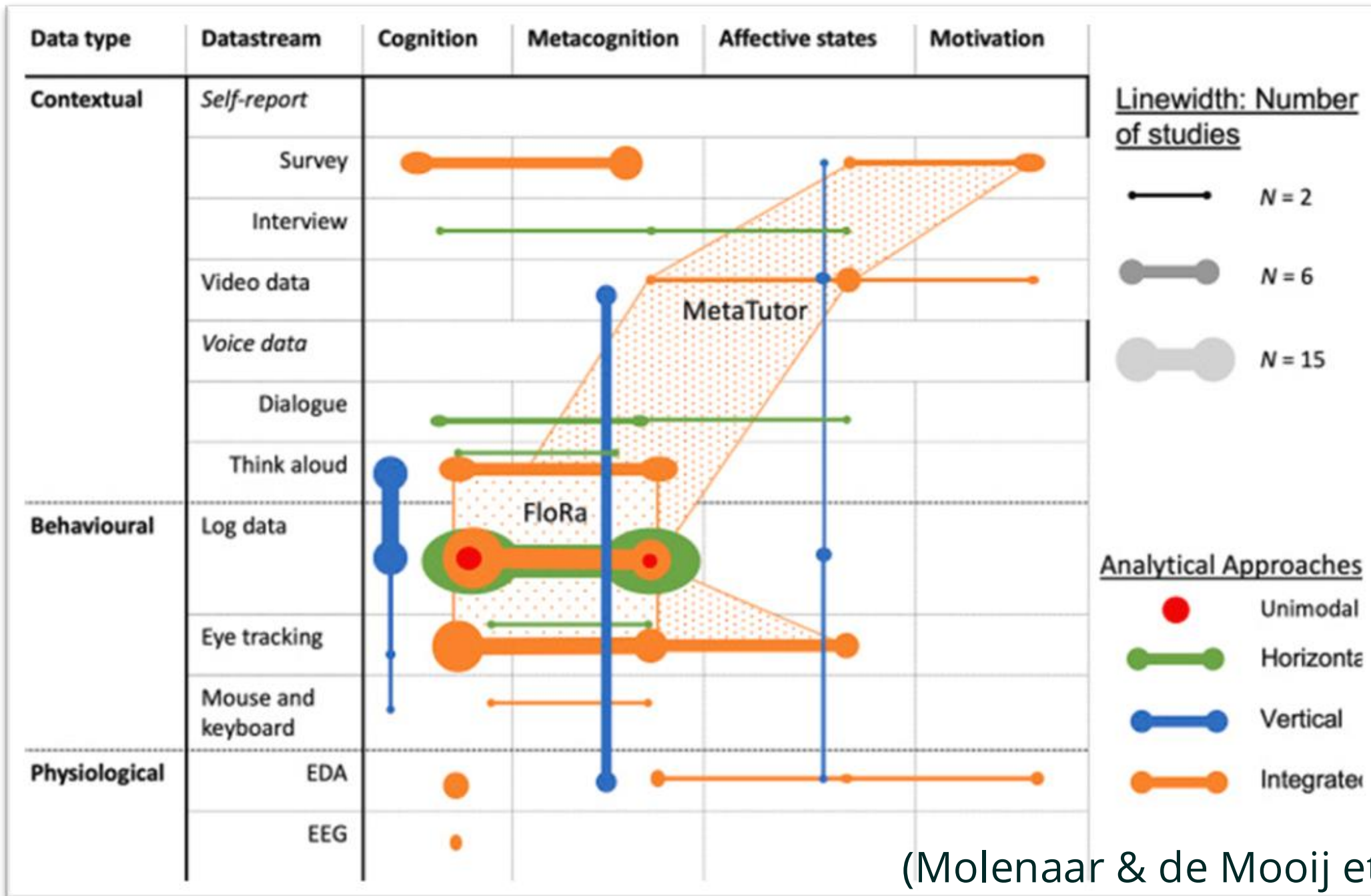
3. Vertical approach

- Different multiple data streams measure one CAMM process.



4. Integrated approach

- Combinations of unimodal, horizontal, and vertical approaches

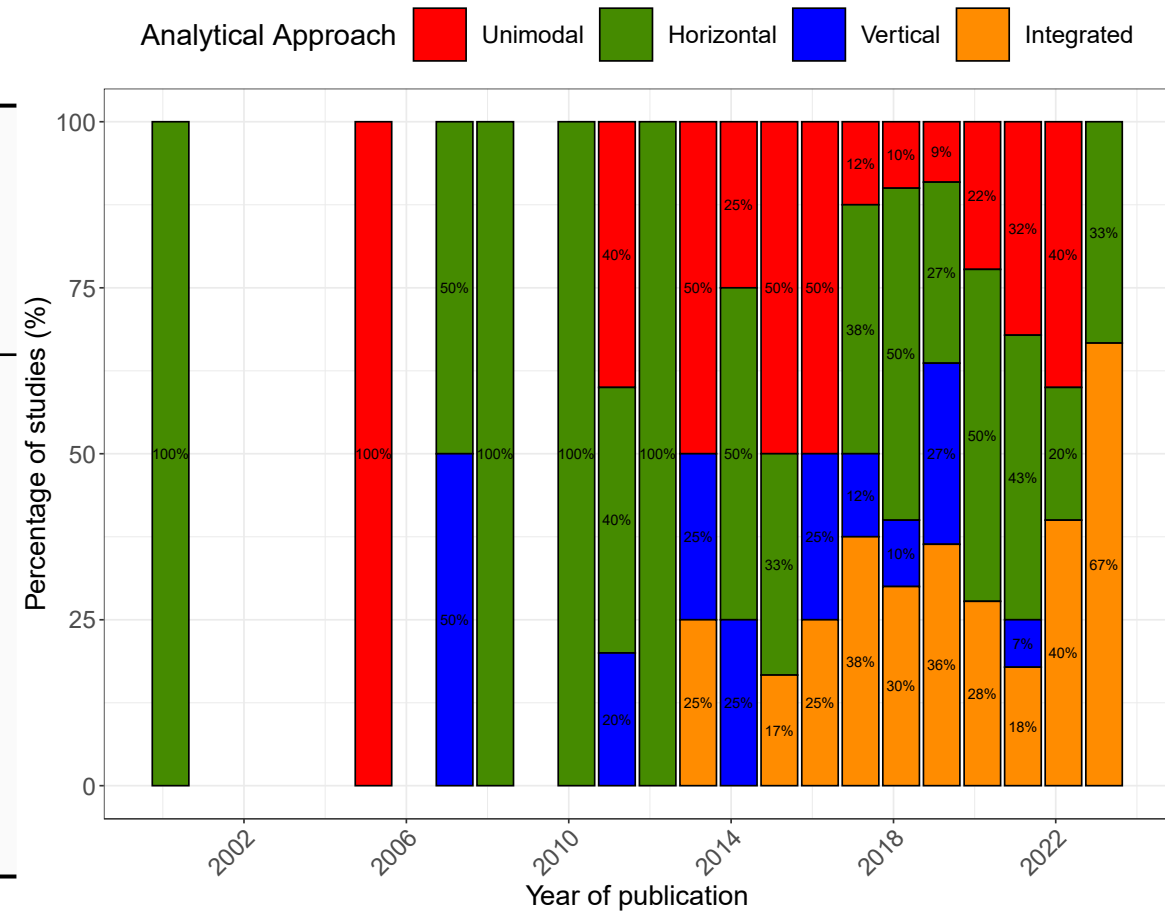


(Molenaar & de Mooij et al, 2023)

Shift in analytical approach

Table 1: Comparison of percentages analytical approaches studies used over time

Analytical Approach used by studies	Publication Year 2010-2016	Publication Year 2017- 2023
Unimodal	35.7% (<i>N</i> = 10)	23.6% (<i>N</i> = 22)
Horizontal	39.3% (<i>N</i> = 11)	38.7% (<i>N</i> = 36)
Vertical	14.2% (<i>N</i> = 4)	7.5% (<i>N</i> = 7)
Integrated	10.7% (<i>N</i> = 3)	30.1% (<i>N</i> = 28)

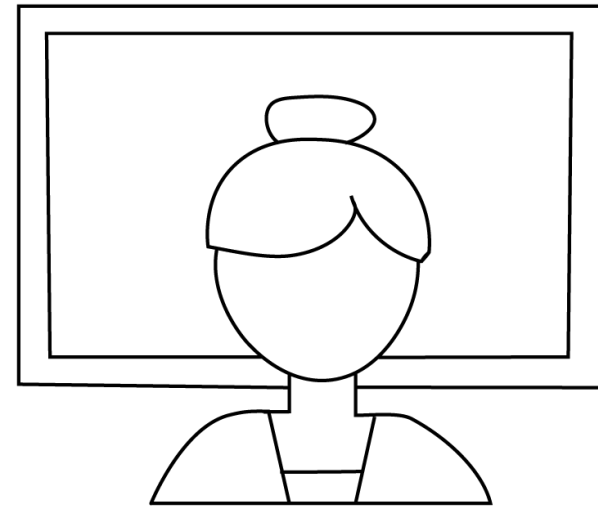
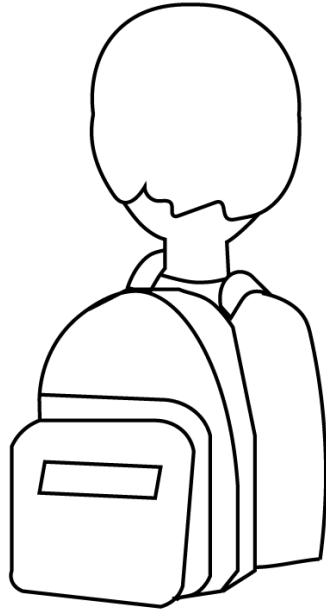


Part II

Supporting Learning and teaching with AI

PART II. SUPPORTING LEARNING AND TEACHING WITH AI

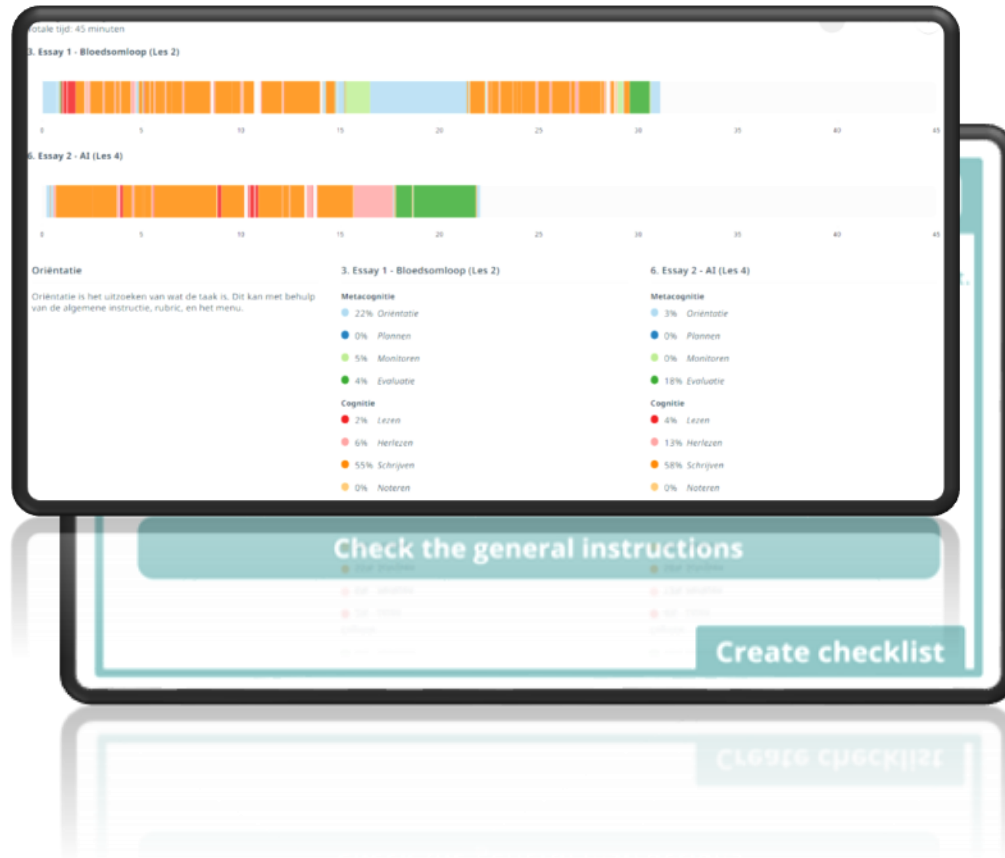
Learner and teacher-faced AI



PART II. SUPPORTING LEARNING AND TEACHING WITH AI

Inform, act, interact

Self-regulated learning during writing

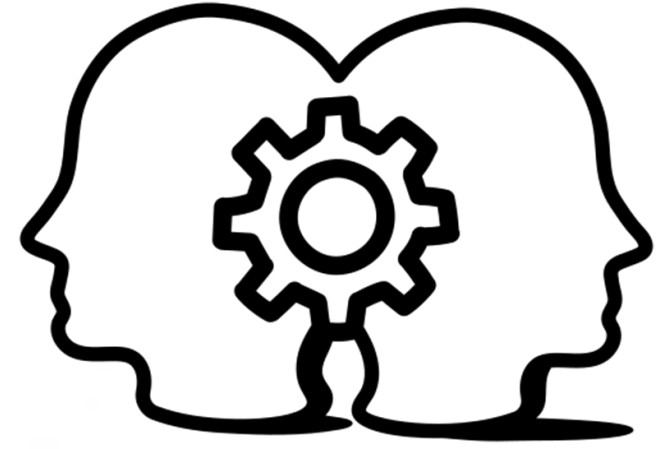


Hmmm, I think I spent too much time writing..

Indeed! Remember, it's not a novel



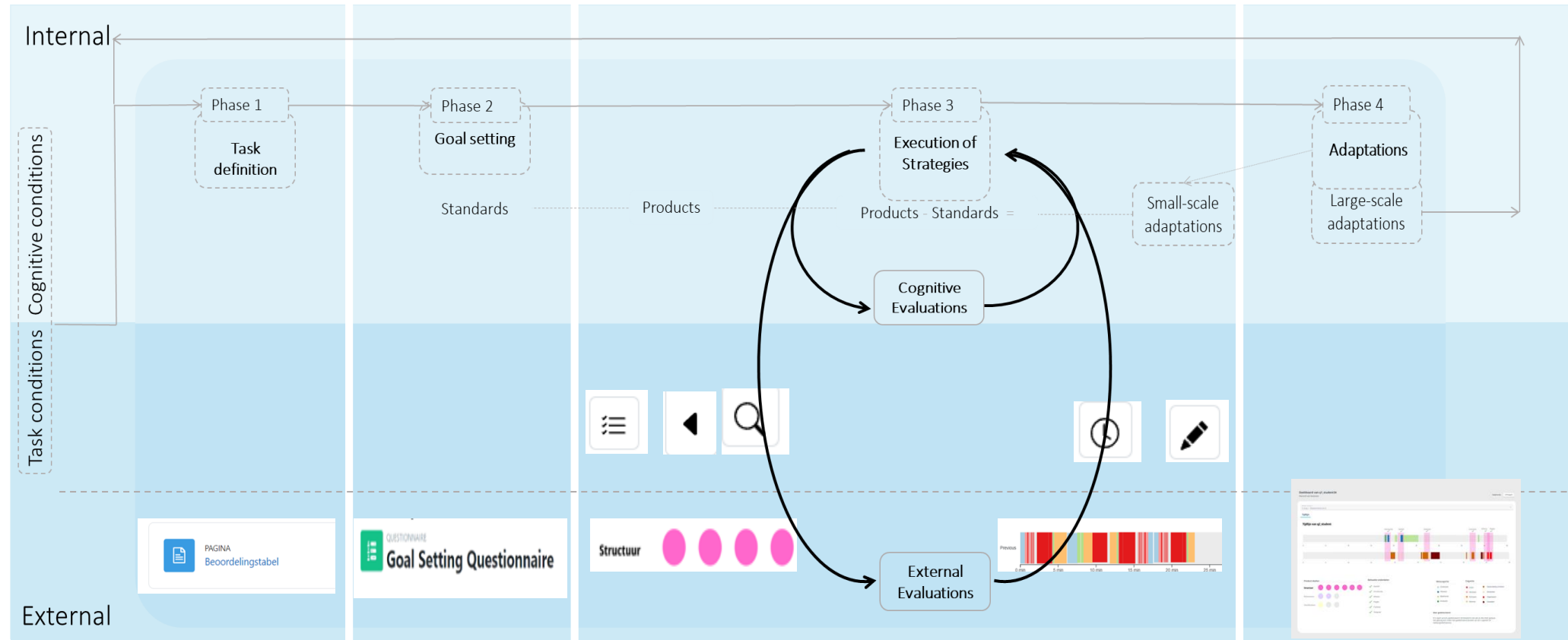
The double role of AI



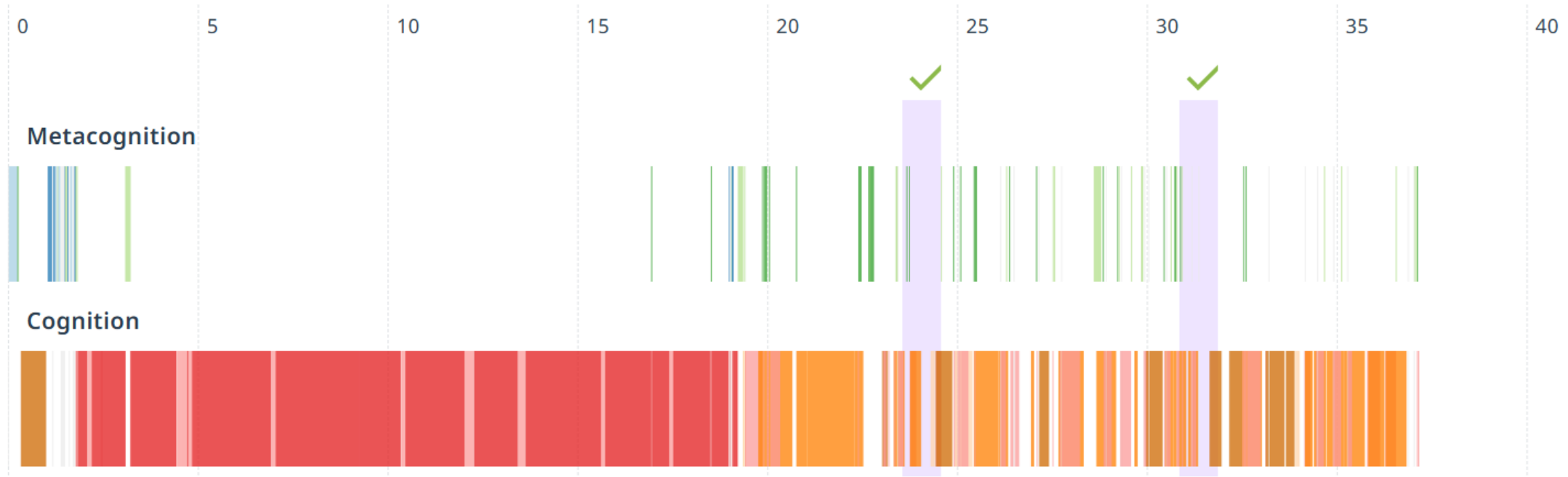
Detect-Diagnose- Act

PART II. SUPPORTING LEARNING AND TEACHING WITH AI

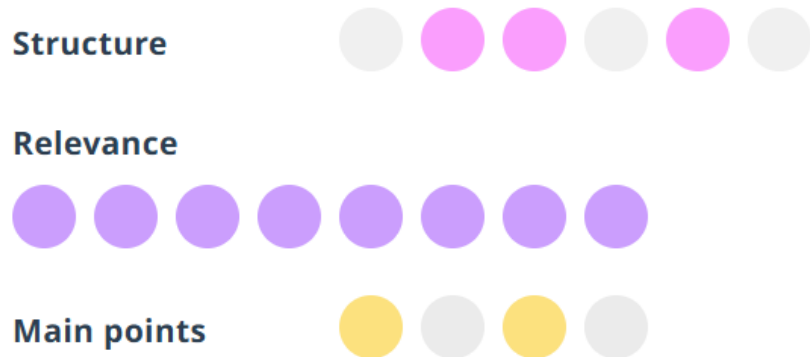
Example FLORA – informing



Schrijfpoddracht 1 - Van wereldoorlog naar Koude Oorlog



Product goals



Completed subgoals

- ✓ Conferentie van Potsdam
- ✗ Het rode gevaar
- ✓ Militaire blokvorming
- ✗ Sovjet-invloedssfeer in Europa

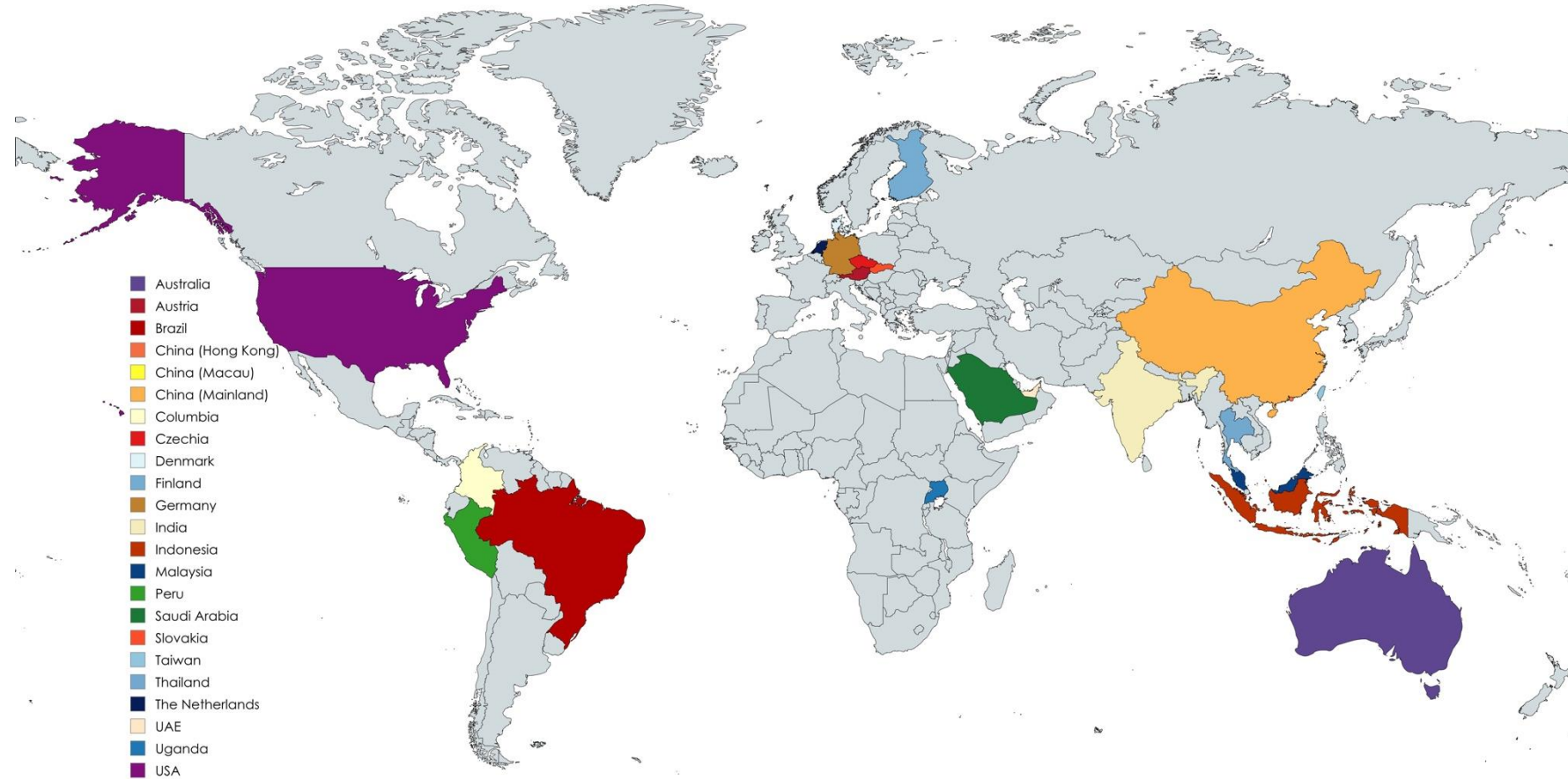
Metacognition

- *Orientation*
- *Planning*
- *Evaluation*
- *Monitoring*

Cognition

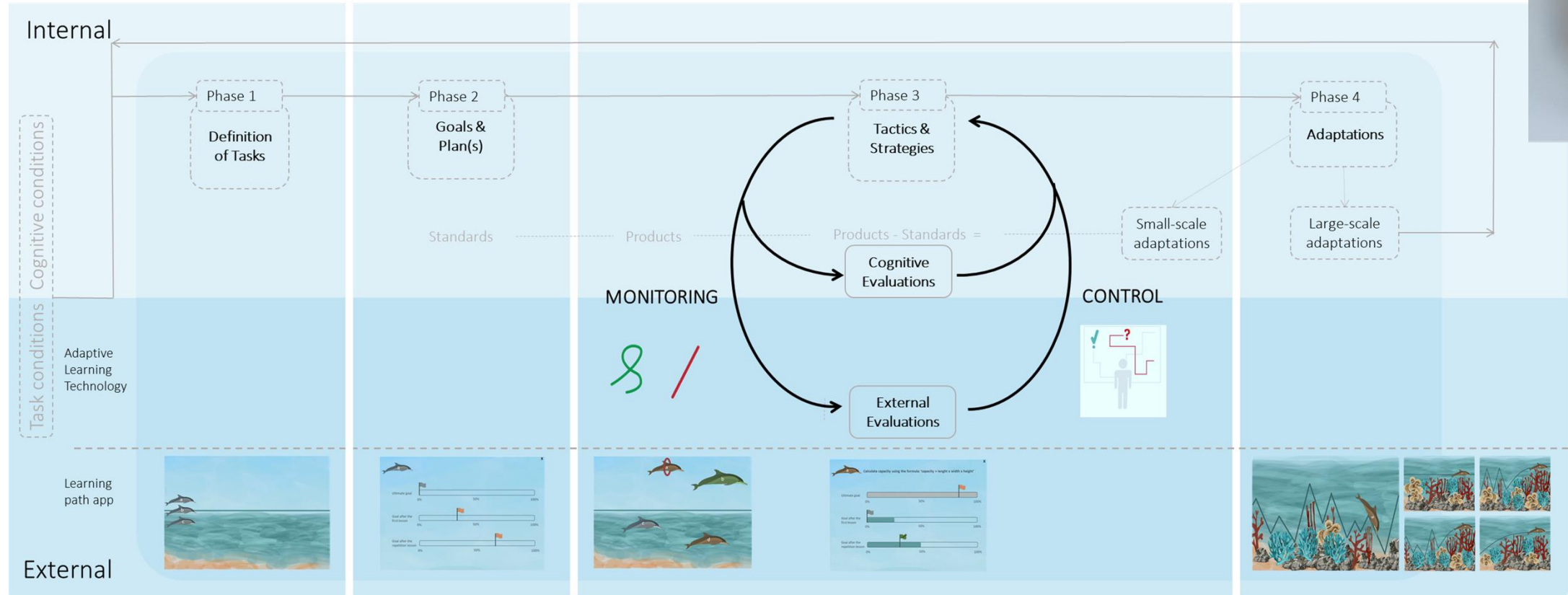
- *Reading*
- *Rereading*
- *Note-taking*
- *Copying*

Who has joined?



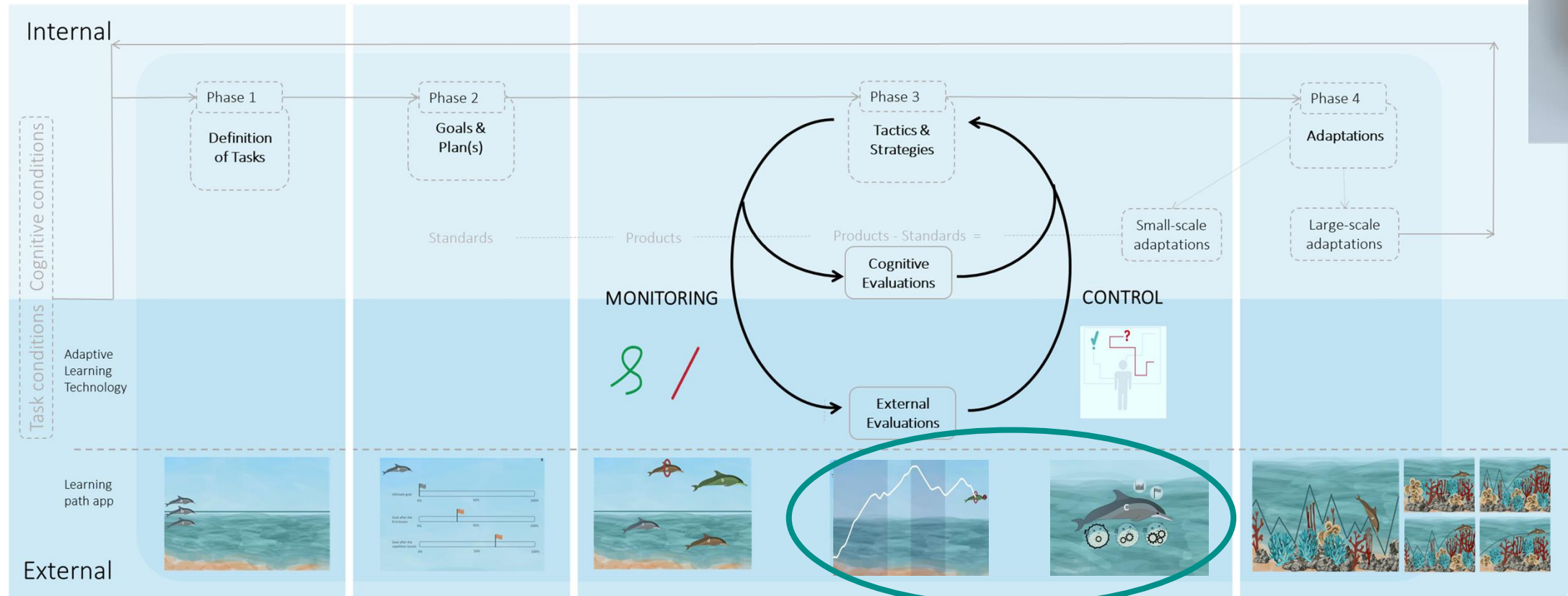
PART II. SUPPORTING LEARNING AND TEACHING WITH AI

Example HHAIR – informing and acting AI

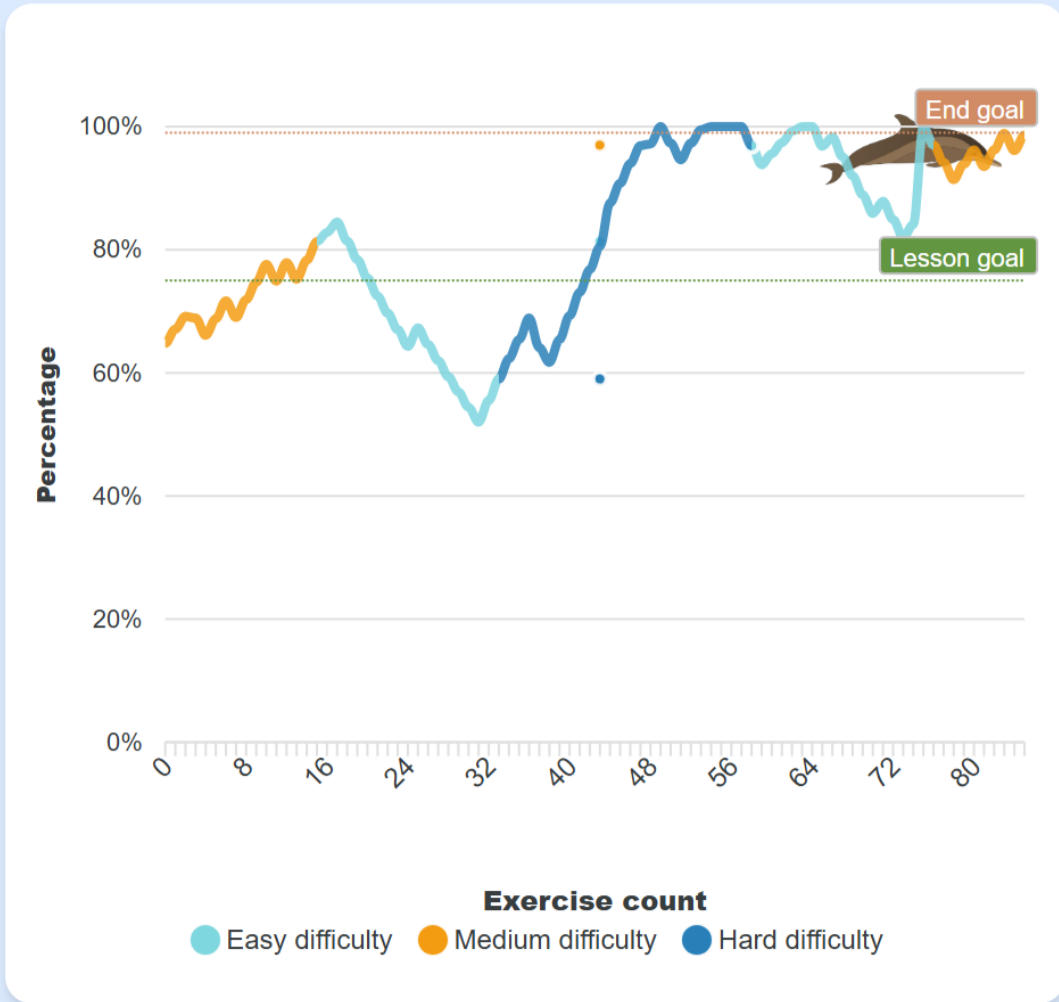















PART II. SUPPORTING LEARNING AND TEACHING WITH AI

Example HHAIR – informing, combined acting

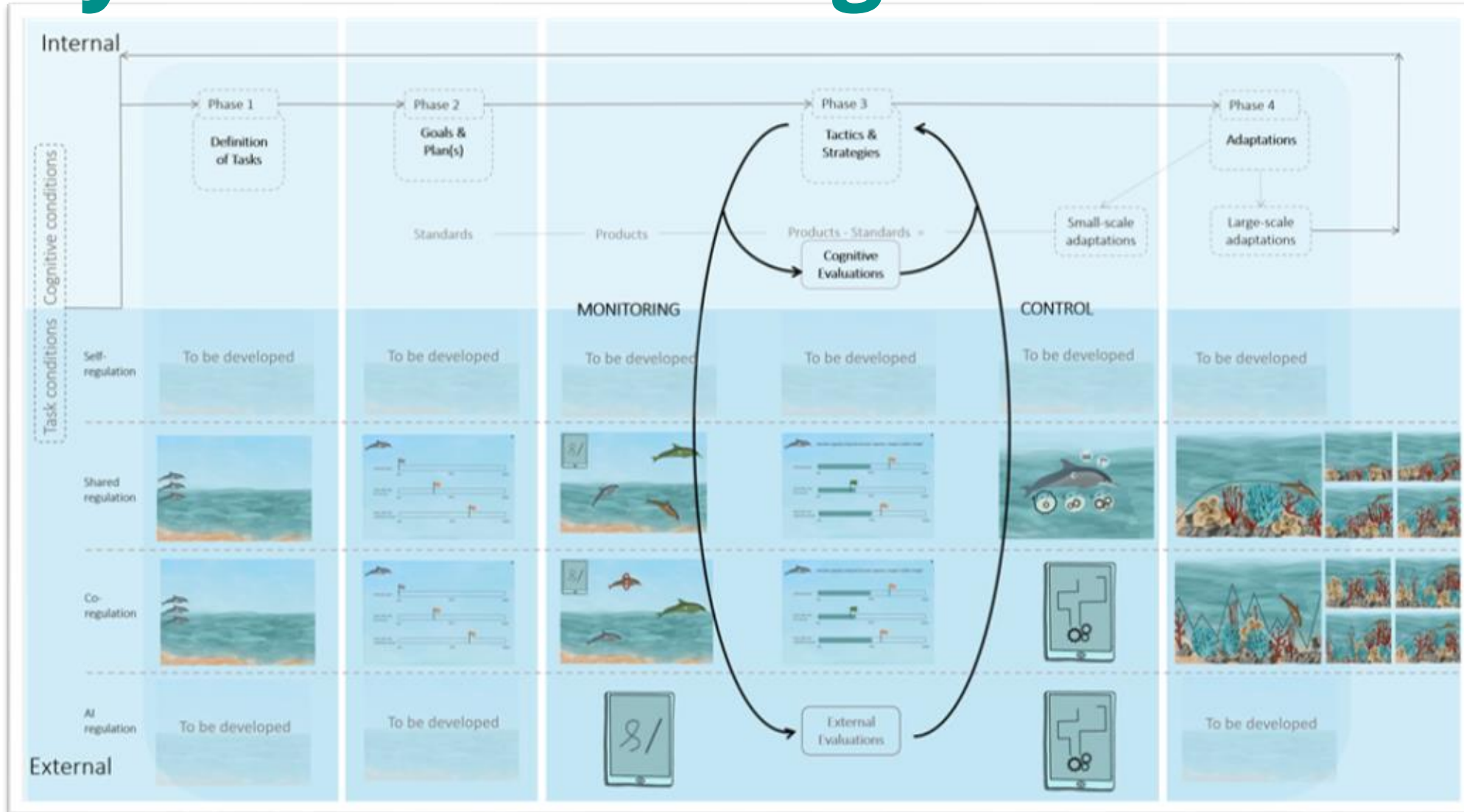


How am I growing towards my goals?

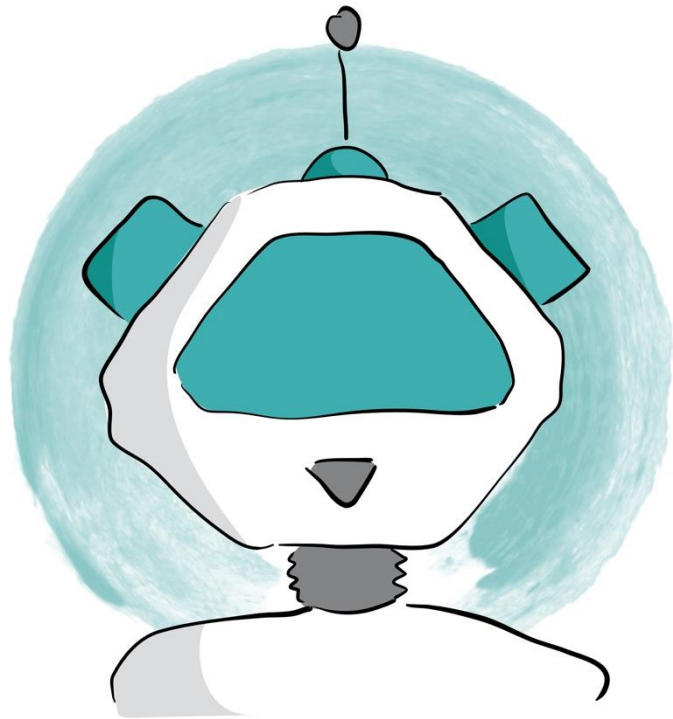


	  
<p>What happened?</p> <p>10  </p> <p>4  </p>	 <input checked="" type="checkbox"/> Take more time
<p>What will happen?</p> <p>...  </p> <p>...  </p>	<input type="checkbox"/> Ask for help <input type="checkbox"/> Use scratchpad <input type="checkbox"/> Take more time <input checked="" type="checkbox"/> Work faster <input type="checkbox"/> Check answer <input checked="" type="checkbox"/> Keep attention

Hybrid human-AI Regulation



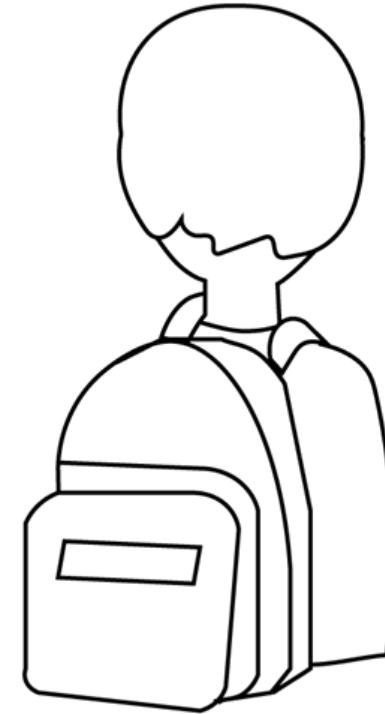
Learner – AI collaboration



Functioning of the AI

Informing role AI

Acting role AI

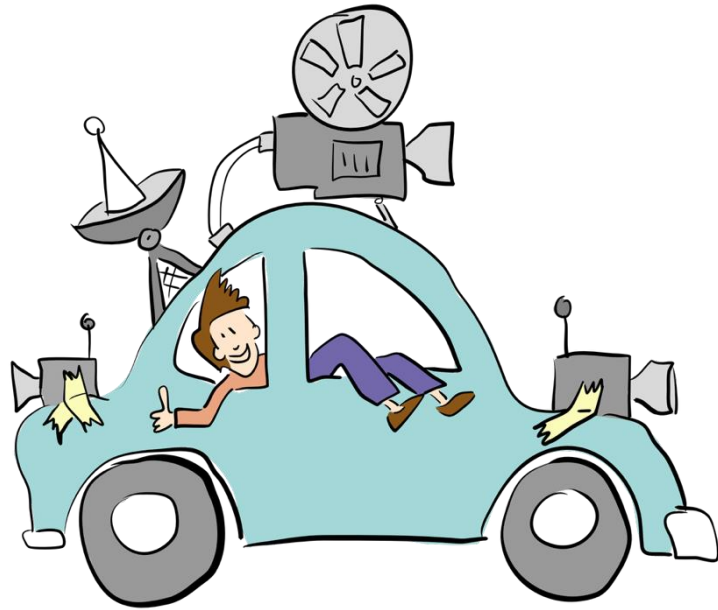


TEACHERS & AI

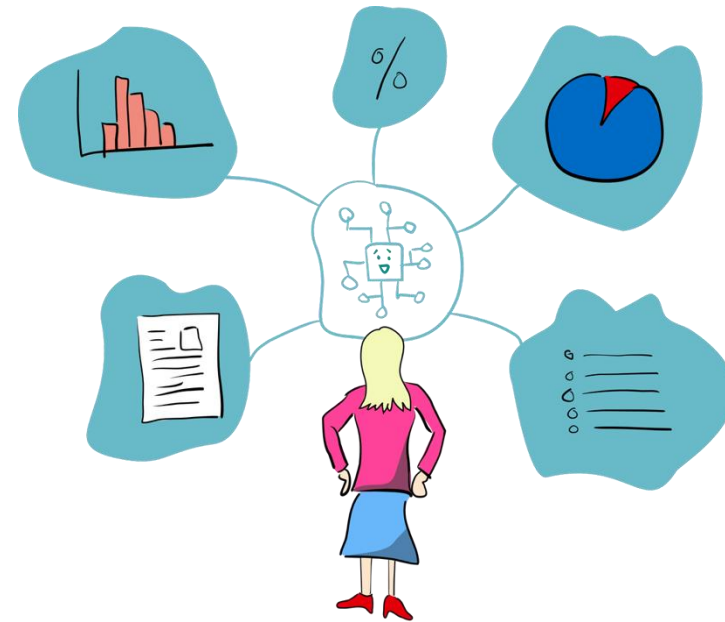
on task changes

TEACHERS & AI

The role of AI



Replacement perspective



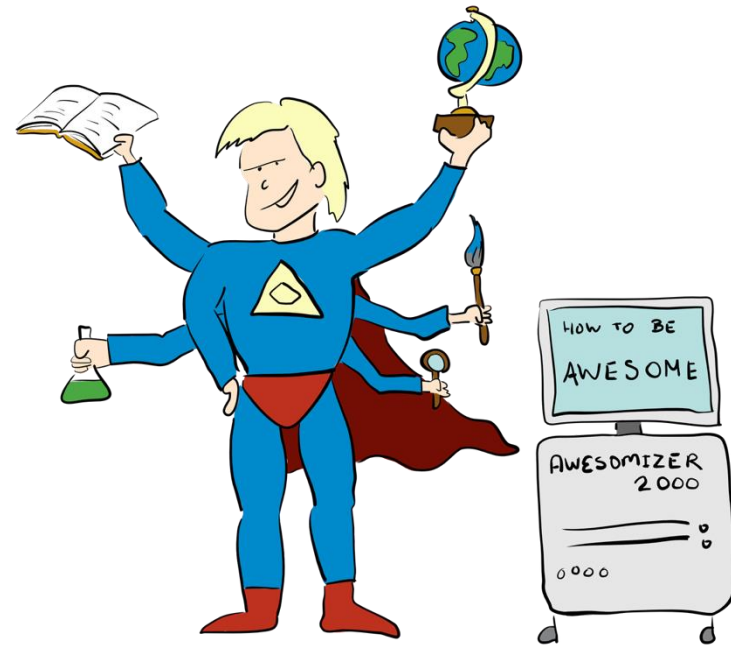
Augmentation perspective

TEACHERS & AI

Teacher's call!

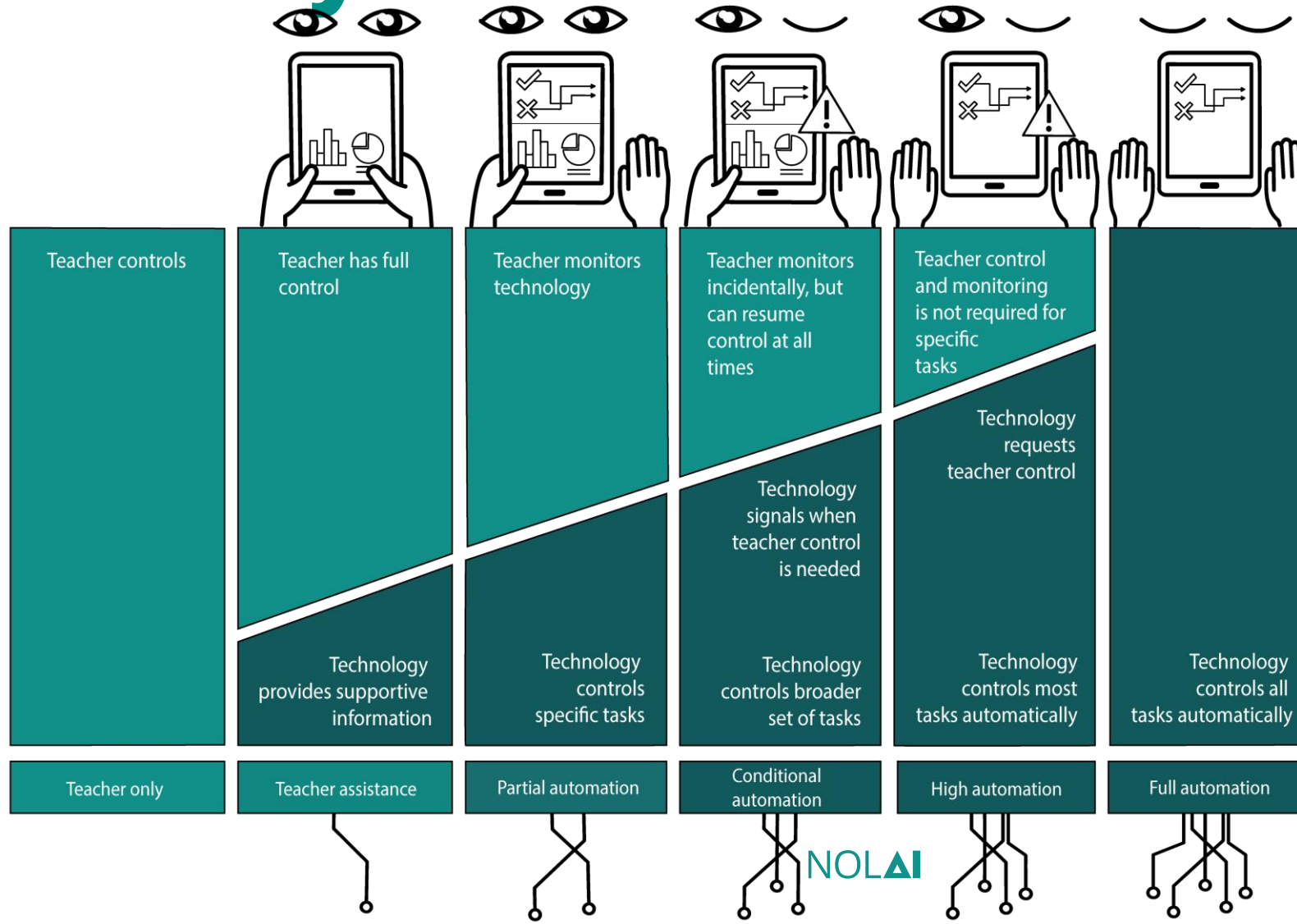


Replacement & augmentation



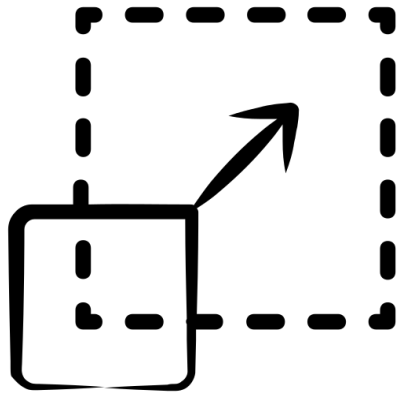
Agency

The 6 layers of automation model



TEACHERS & AI

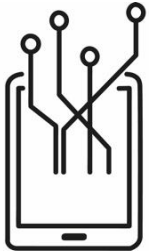
Informing teachers



Complement



Level 2
teacher assistance



Co-creation project
Technical Reading with ASR

NOLA**AI**

TEACHERS & AI

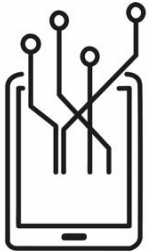
Informing & acting teachers



Augment



**Level 3
Partial
Automation**



Co-creation project
Technical Reading with ASR

NOLA**AI**

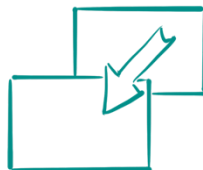
Changing tasks

Teacher-AI collaboration

AI replaces the teacher

AI provides learners with feedback based on knowledge on adaptive learning technologies.

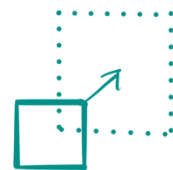
#workloadreduction



AI complements the teacher

AI provides insights for teachers and/or learners into progress, based on learning data.

#educationalimprovement



NOLA Δ I

AI augments the teacher

AI provides teachers with suggestions to optimise learning and the curriculum.

#educationalinnovation



In practice

Checking open questions with the help of AI

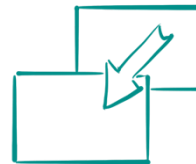
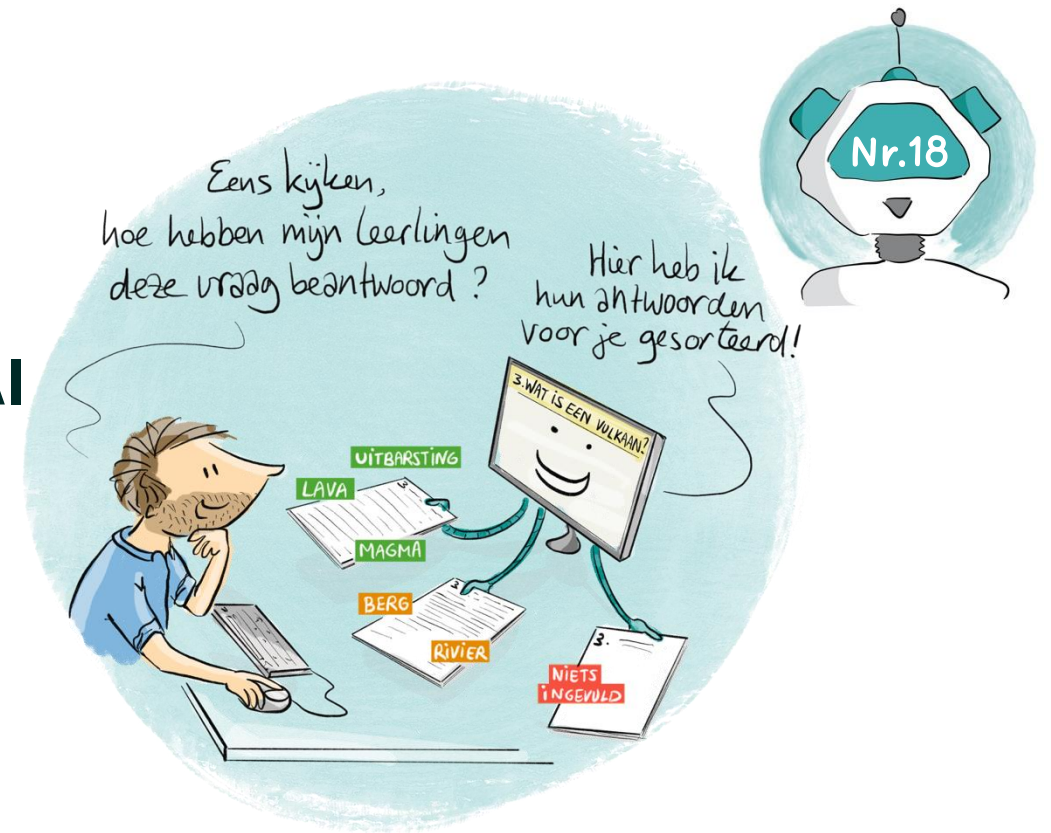
Semi-automation level of support

Before

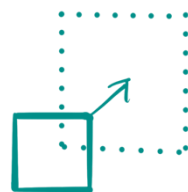
- Developing test questions
- Creating an answermodel
- Scoring answers
- Toets scoren

After

- Developing test questions
- Adjusting answermodel
- Reviewing suggested score



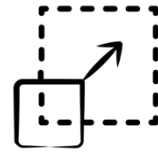
Partial replacement:
comparing answers



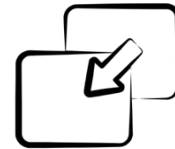
Complementation: overview most frequent mistakes & variety in answers

Task analysis of human-AI collaboration

1. Activate prior knowledge
2. Discuss learning goals
3. Provide instruction
4. Guided practice
5. Individual practice
6. Closing



Complement



Partial replacement



Augment

➔ Understanding Useful Combinations of human & AI



TEACHERS & AI

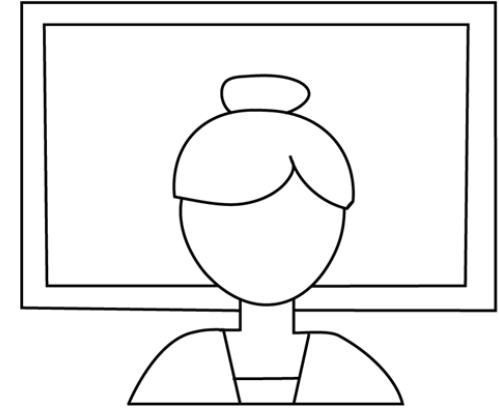
Human & AI co-evolve



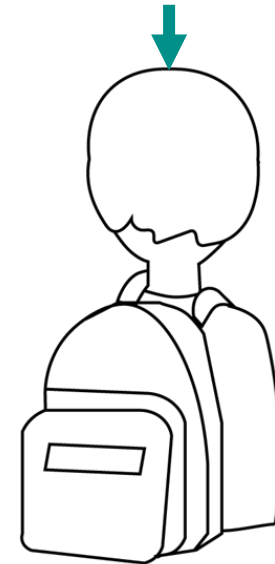
Functioning of the AI

Informing role AI

Acting role AI

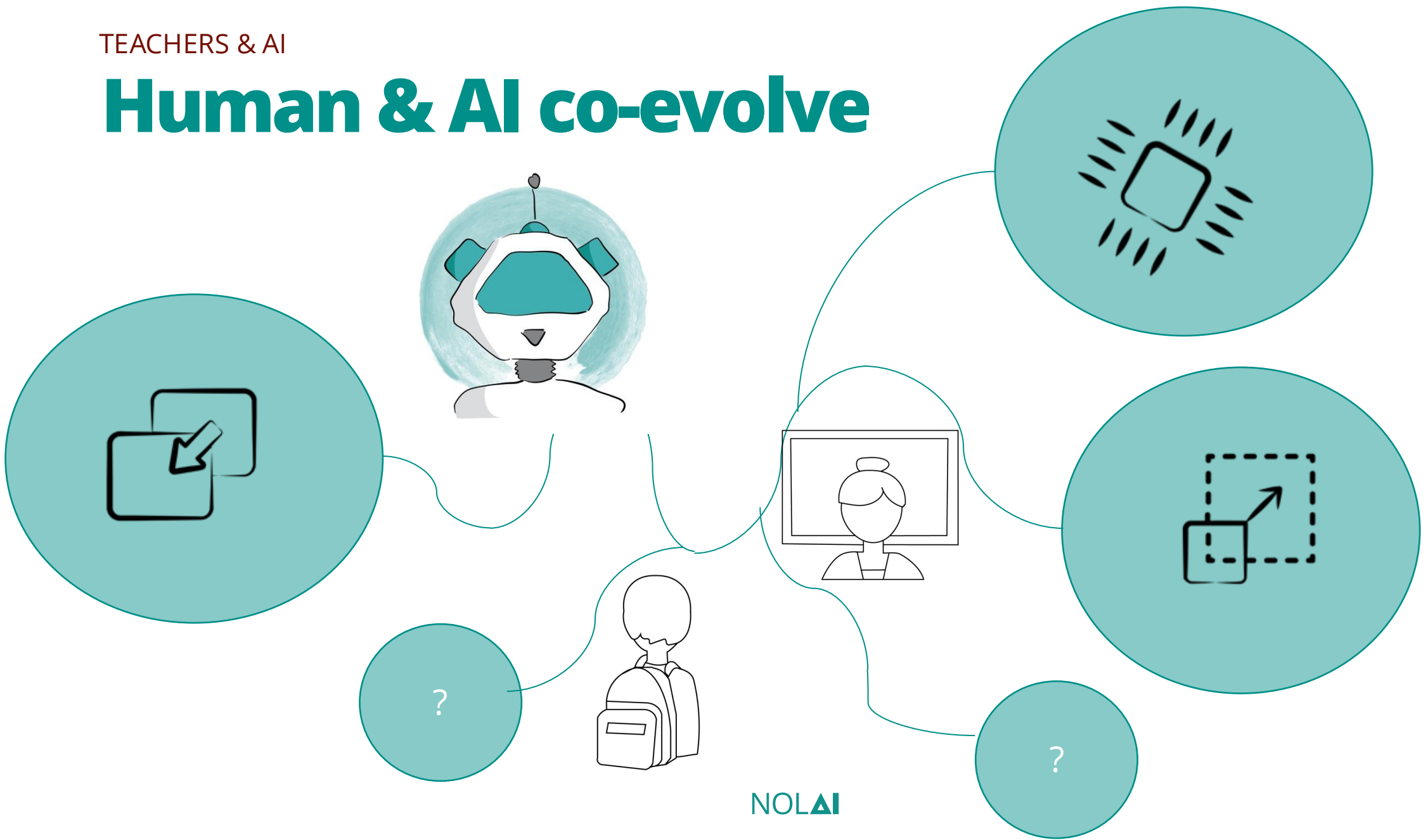


Pedagogical & instructional
Practices teacher

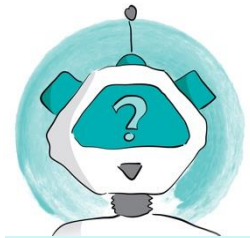


TEACHERS & AI

Human & AI co-evolve

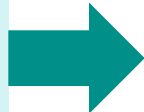


The hybrid future



AI

- Algorithm
- Models
- Interface
- Usability
- EDU-AI



Changing tasks

- Replacement of recurring tasks
- Complementation of existing tasks
- Augmentation of complex tasks

Changing skills

- Reduce
- Intensify
- Innovate / update

Changing job profile

- Higher quality
- Sustainable employability
- Less workload, more job satisfaction

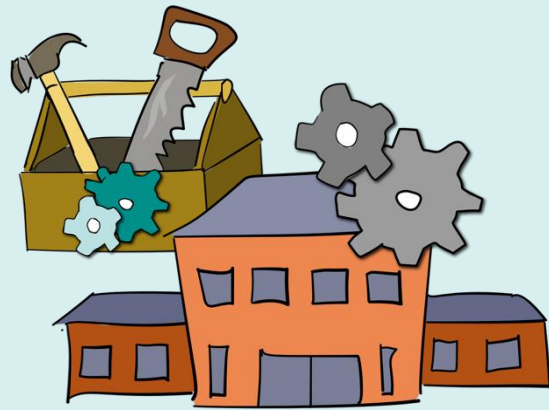


TEACHER

- Pedagogical-didactical knowledge and skills
- technical knowledge
- Beliefs / Principles
- working method



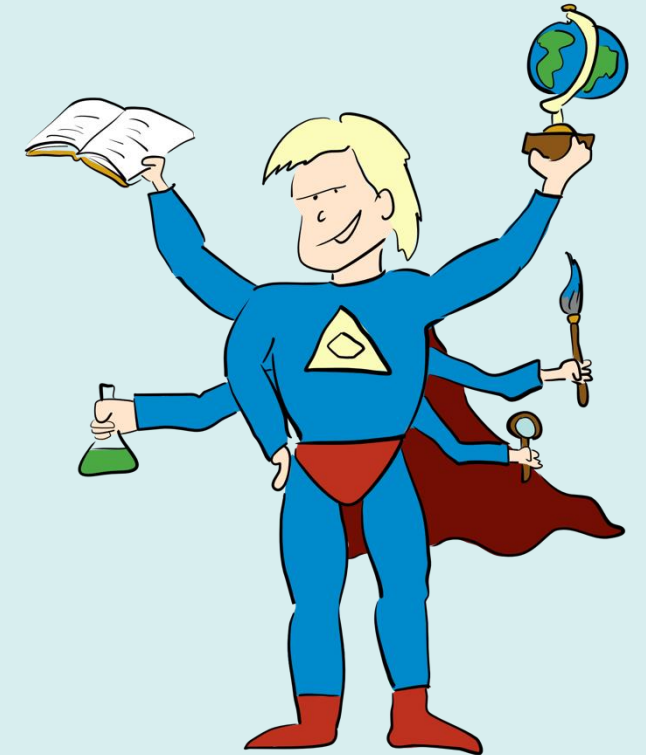
CONCLUSION



Educational AI



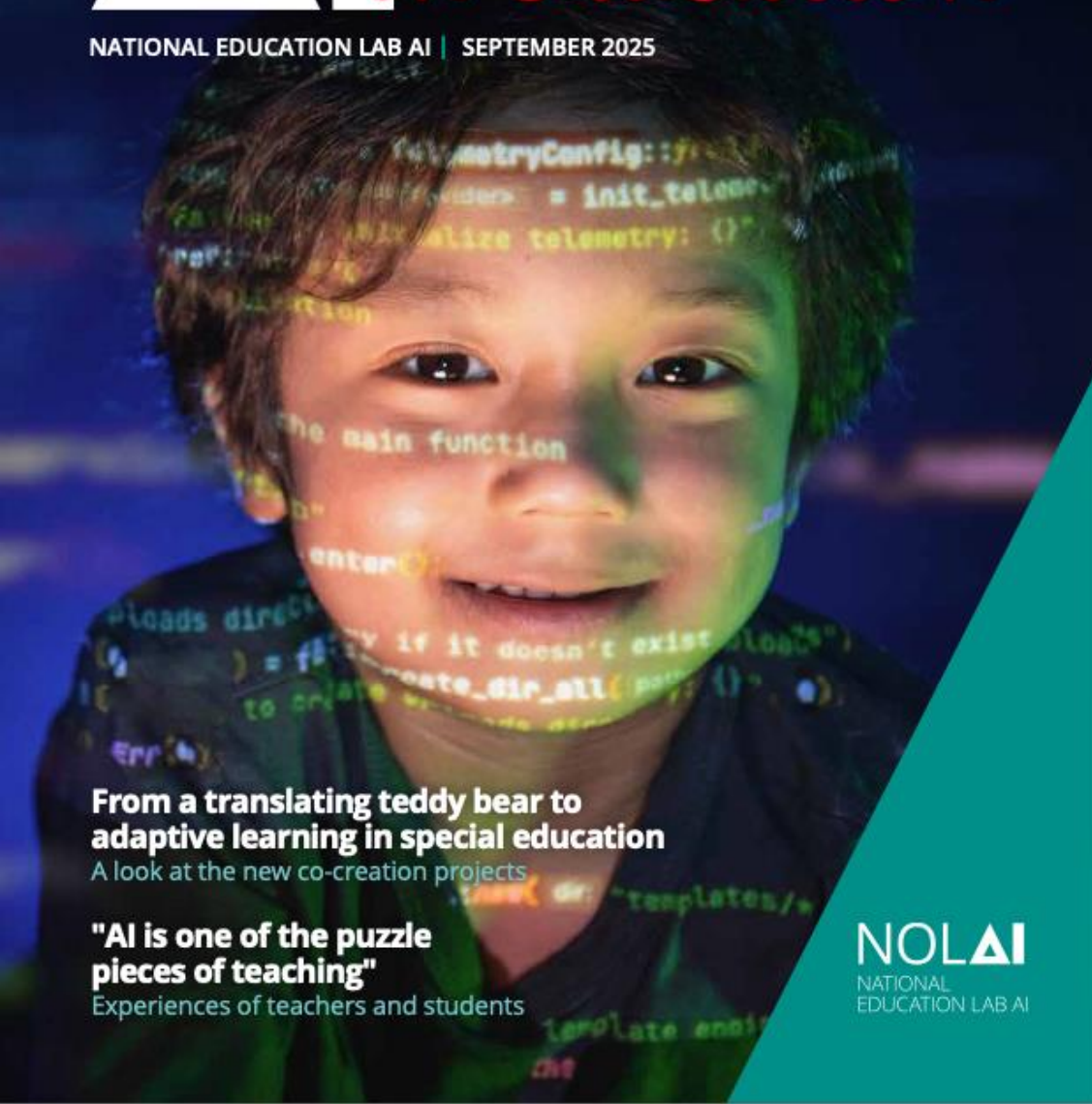
Larning-performance balance



Teacher-AI collaboration

AI *in education*

NATIONAL EDUCATION LAB AI | SEPTEMBER 2025



From a translating teddy bear to adaptive learning in special education

A look at the new co-creation projects

"AI is one of the puzzle pieces of teaching"

Experiences of teachers and students

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our magazine!

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cella

Centre for Learning and Living with AI

- 1. The importance of SRL in an AI era**
- 2. Emphasizing learner and teacher agency**
- 3. Towards AI that augments human learning and teaching**



References

- Molenaar, I. (2022). **Towards hybrid human-AI learning technologies**, *European Journal of Education*.
<https://doi.org/10.1111/ejed.12527>
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<https://doi.org/10.1016/j.caeai.2022.100070>
- Molenaar, I. (2021). **Personalization of learning: Towards hybrid human-AI learning technologies**.
In *OECD digital education outlook 2021: Pushing the frontiers with AI, blockchain, and robots* (pp. 57-77). OECD Publishing
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- Molenaar, I. and P. Slegers (2023), "**Multi-stakeholder collaboration and co-creation: towards responsible application of AI in education**", in *OECD Digital Education Outlook 2023: Towards an Effective Digital Education Ecosystem*, OECD Publishing, Paris, <https://doi.org/10.1787/75b34acc-en>.
- Molenaar, I. (2024). **Human-AI collaboration in education: The hybrid future** . Inaugural address RU (2024, September 26). Nijmegen: Radboud University
- www.ru.nl/nolai/eng



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Radboud Universiteit



NOLA

Behavioural Science Institute