

How can AI systems help with differentiation in education?

← Pick a reward and exercise: ★ 🏠 🗑️ ?
Next time you will get 4 new exercises.

$8 + X = 25$

Level: ★★★★

Reward: 1 🟡

$X - 1 = -14$

Level: ★★★★

Reward: 2 🟡

$12 + X = 5$

Level: ★★★★

Reward: 1 🟡

$-8 + X = -24$

Level: ★★★★

Reward: 2 🟡

Leerlingprofiel

Week	Profiel
Week 1	Novice
Week 2	Advanced beginner
Week 3	Competent
Week 4	Proficient
Week 5	Expert

De oefeningen die u nu krijgt zijn:

- Oefening 1
- Oefening 2
- Oefening 3
- Oefening 4
- Oefening 5
- Oefening 6
- Oefening 7

How is your new level determined?

Wiki estimates your level and the difficulty of exercises. Both change when solving exercises. Your level remained similar after solving the exercise series. Then, it increased even further because of your feedback.

Expert
Proficient
Competent
Advanced beginner
Novice

Before series After series

[Solve more exercises on this topic](#) [Return to exercise page](#)

Question: Wat is de hoofdstad van de staat Florida?

Answer: Tallahassee

Quality of distractors: ● Good

Similarity scores: ● Distractor Questions

- Miami
- New York
- Los Angeles
- Limburg
- Noorwegen
- Zuidpool

Your mastery of skills in these exercises ↑ Sort

Exercise 1

Exercise 2

Exercise 3

Exercise 4

Solving this exercise will change your mastery as follows in the:

worst case usual case best case

Handle exercises like $x = 3$

Handle exercises like $2x = 3$

Handle exercises like $2x + 4 = 3$

Start

Solve a recommended exercise of the same chapter

Recommended

- Exercise 37
- Exercise 26
- Exercise 21

Why this exercise? Wiki thinks your current level aligns with that of the exercise!
Wiki expects you will need 1 or 2 attempts to solve exercise 21, based on your results and those of your fellow students.

Solve exercise 21

... or pick your next exercise yourself

Go to the exercise overview

🔔 **Novice** I believe this is your level now for the following subject: **Coordinates in space**

What difficulty level would you like for the next exercise series?

Very easy Easy **Novice** Difficult Very difficult

If you finish all exercises correctly, your level will increase:

Expert
Proficient
Competent
Advanced beginner
Novice

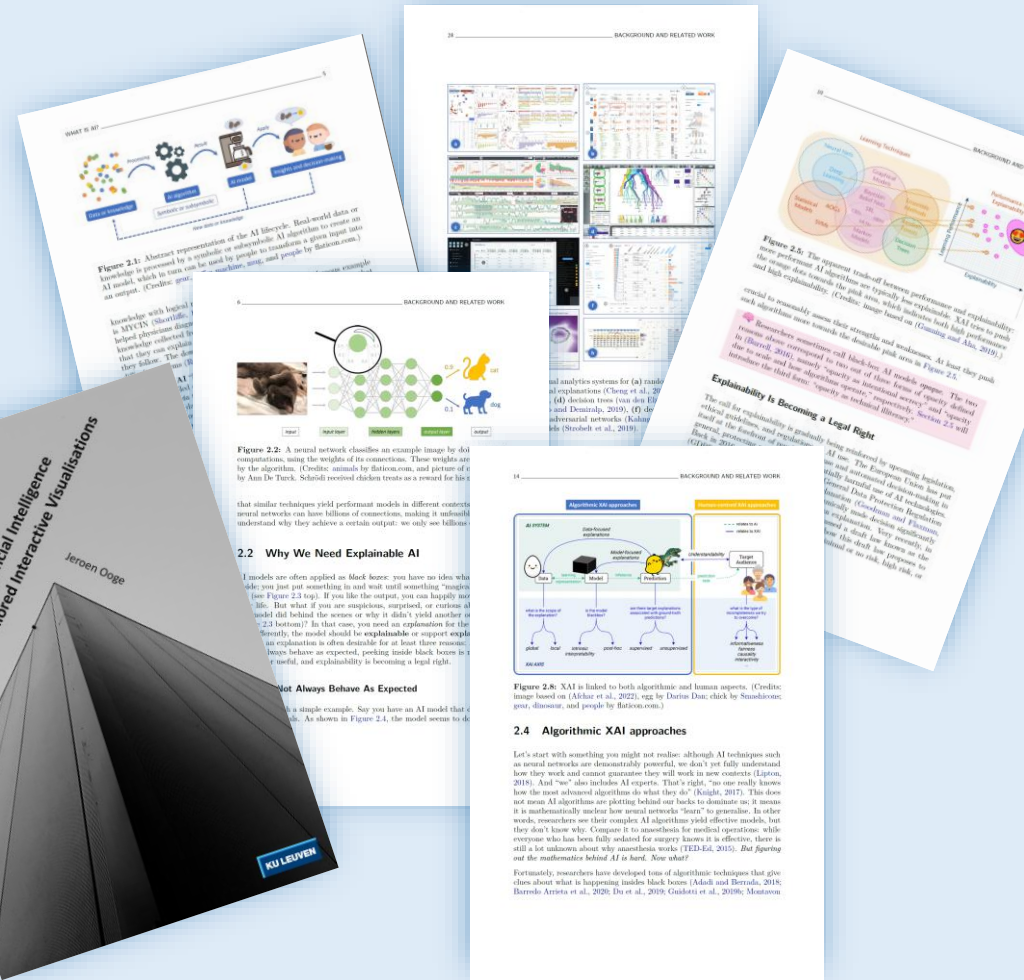
Your level after completion

Jeroen Ooge

jeroenooge.be

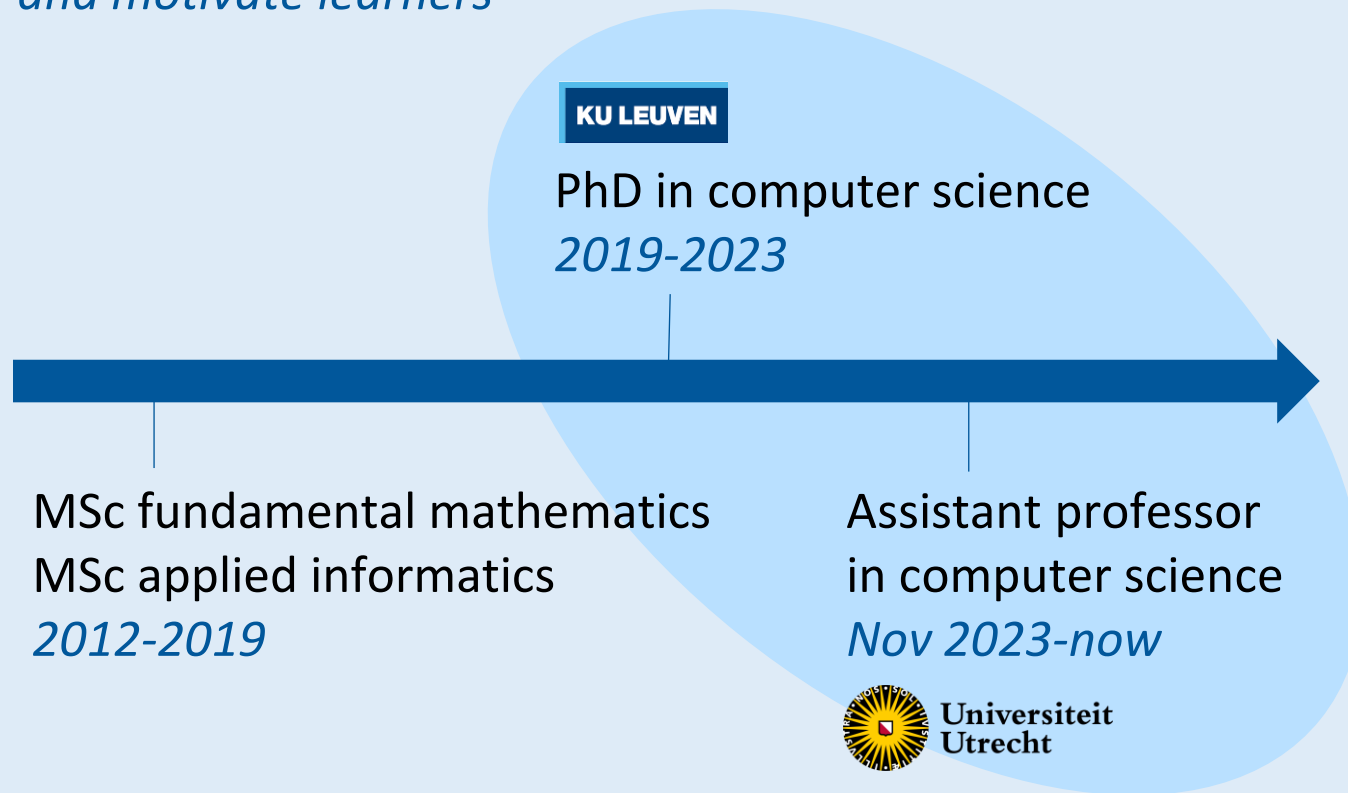
Universiteit Utrecht

About 2 years ago



My (professional) life in 1 slide

Explainable and controllable AI systems to personalise education and motivate learners



Jeroen Ooge
jeroenooge.be

How can AI systems help with **differentiation** in education?

What's that?

← Pick a reward and exercise:
Next time you will get 4 new exercises

$8 + X = 25$ Level: ●●● Reward: 1 ●	$X - 1 = -14$ Level: ●●● Reward: 2 ●●
$12 + X = 5$ Level: ●●● Reward: 1 ●	$-8 + X = -24$ Level: ●●● Reward: 2 ●●

Level: ●●●

Number of solved exercises: ●●●●●

Exercise 1: ●●●●●

Exercise 2: ●●●●●

Exercise 3: ●●●●●

Exercise 4: ●●●●●

How is your new level determined?

Wiski estimates your level and the difficulty of exercises. Both change when solving exercises. Your level remained similar after solving the exercise series. Then, it increased even further because of your feedback.

Level	Before series	After series
Expert	0	0
Proficient	0	0
Competent	0	0
Advanced beginner	0	0
Novice	0	0

[Solve more exercises on this topic](#) [Return to exercise page](#)

Question: Wat is de hoofdstad van de staat Florida?

Difficulty level: ●●●●●

Options: Miami, New York, Los Angeles, Limburg, Noorwegen, Zuidpool

Your mastery of skills in these exercises: ●●●●●

Exercise 1: ●●●●●

Exercise 2: ●●●●●

Exercise 3: ●●●●●

Exercise 4: ●●●●●

Solving this exercise will change your mastery as follows in the:

Worst case: ●●●●●

Usual case: ●●●●●

Best case: ●●●●●

Handle exercises like $x = 3$: ●●●●●

Handle exercises like $2x = 3$: ●●●●●

Handle exercises like $2x + 4 = 3$: ●●●●●

[Start](#)

Solve a recommended exercise of the same chapter

Recommended: ●●●●●

Why this exercise? Wiski thinks your current level might well 'just fit' the exercise!

Wisk expects you will need 1 or 3 attempts to solve exercise 21, based on your results and those of your fellow students.

Exercise 27: ●●●●●

Exercise 28: ●●●●●

Exercise 21: ●●●●●

Number of attempts fellow students needed to solve exercise 21:

Attempts	Number of students
1	10
2	5
3	2
4	1
5	0

[Solve exercise 21](#)

... or pick your next exercise yourself

[Go to the exercise overview](#)

Novice: I believe this is your level now for the following subject: Coördinaten in space

What difficulty level would you like for the next exercise series?

Very easy: ●●●●●

Easy: ●●●●●

Intermediate: ●●●●●

Difficult: ●●●●●

Very difficult: ●●●●●

If you finish all exercises correctly, your level will increase:

Expert: ●●●●●

Proficient: ●●●●●

Competent: ●●●●●

Advanced beginner: ●●●●●

Novice: ●●●●●

[Your level after completion](#)

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Universiteit Utrecht



The non-differentiated (usual?) way



What teachers might expect



teacher



learning content



one-size-fits-all approach works for everyone

Reality



teacher

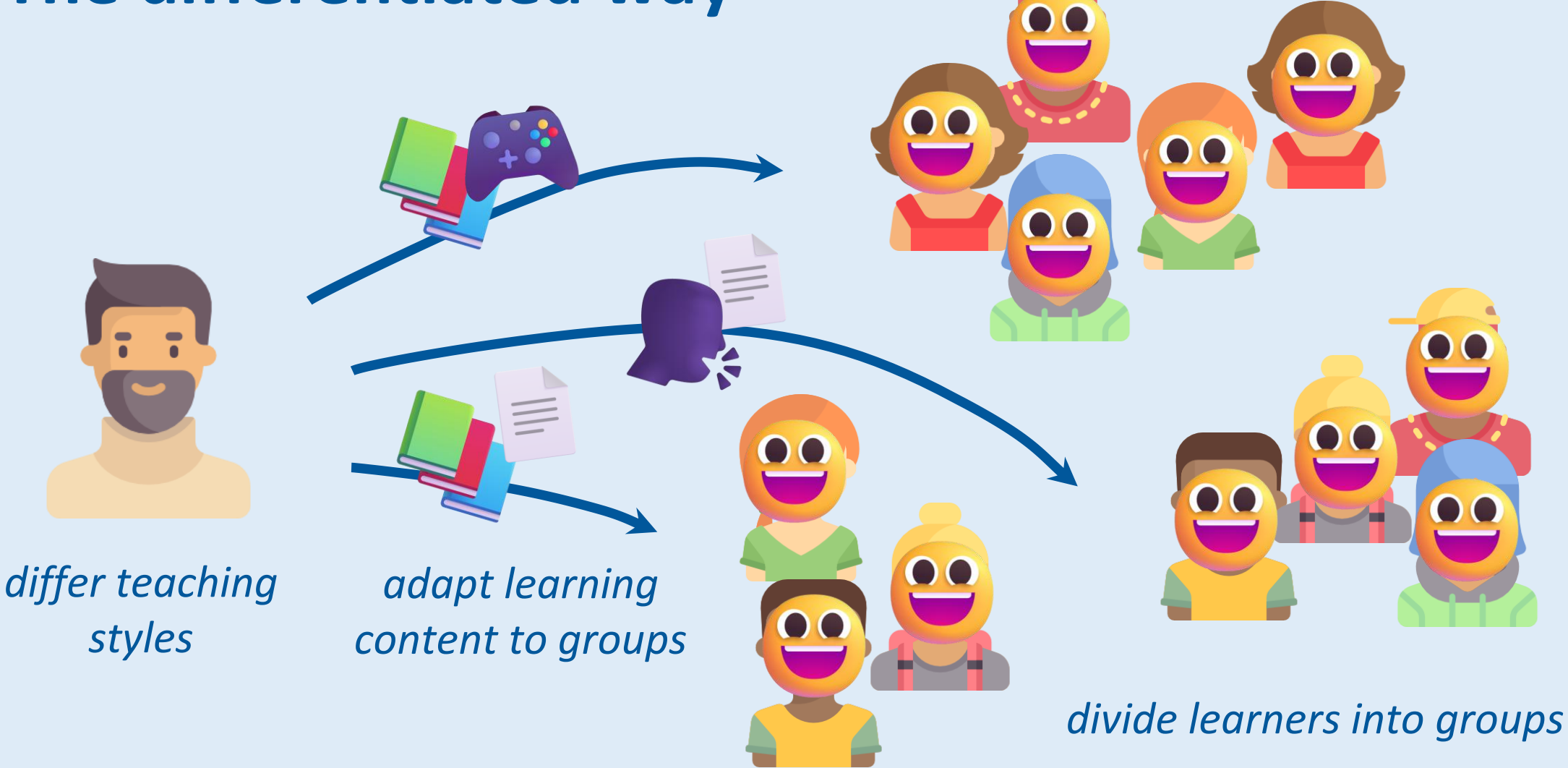


learning content



effectiveness depends on abilities, interests, background...

The differentiated way



How can AI systems help with differentiation* in education?

*in the sense of individualisation/personalisation

Make learning experiences more
1 adaptive, **2** transparent, and **3** motivating



How can AI systems help with differentiation?

1

Adaptation

2

Transparency

3

Motivation

How can AI systems help with differentiation?

1

Adaptation

*About fake whiskey, Elo ratings,
and spying dashboards*

2

Transparency

3

Motivation



Goed gewerkt!

Maak een aangeraden oefening van hetzelfde hoofdstuk

Aangeraden

- Oefening 32
- Oefening 42
- Oefening 3

Waarom deze oefening? Wiski denkt dat jouw huidige niveau past bij dat van deze oefening!
Wiski verwacht dat je 1 of 2 pogingen nodig gaat hebben om oefening 32 juist te maken, gebaseerd op de resultaten van jou en je medeleerlingen.

Aantal pogingen medeleerlingen nodig hadden om oefening 32 juist op te lossen

Maak oefening 32

... of kies zelf je volgende oefening

Naar het oefeningenoverzicht

WISKI Oefenen Helpen Oefeningen overzicht

Selecteer een Badge om te tonen aan jouw klasgenoten

1/5
2/5
2/5
1/5

gevorderde beginner Volg mij is dit nu je level voor het onderwerp Hoofdbewerkingen

Welke moeilijkheidsgraad wil je voor de volgende oefeningreeks?

Heer makkelijk Makkelijk Gewoon Moeilijk Heer moeilijk

Als je alle oefeningen in de reeks juist oplost, dan stijgt je level:

- Expert
- Bedreven
- Competent
- Gevorderde beginner
- Beginner

Start de reeks

Op volgende van Hoog naar laag

Verwachte moeilijkheidsgraad voor jou

Makkelijk
Moeilijk
Makkelijk
Moeilijk
Makkelijk
Makkelijk
Makkelijk
Makkelijk

WISKI

Schakel hier technieken in die jou motiveren om Wiski te gebruiken. Schakel de andere uit

Punten

Verdien punten voor juist opgeloste oefeningen en verlies punten voor fout opgeloste oefeningen. Jij en anderen zien je puntentotaal op je profiel.

Puntenklassement

Vergelijk je puntentotaal met dat van anderen op een klassenmentpagina. Er zijn twee klassenmenten: 'deze week' en 'aller tijden'.

Oefeningenklassement

Vergelijk je aantal juist opgeloste oefeningen met dat van anderen op een klassenmentpagina. Er zijn twee klassenmenten: 'deze week' en 'aller tijden'.

Day streak

WISKI

personalised maths practice with AI

How good do you think you are at mathematics?

There is no right or wrong answer. Wiski uses your answer to find suitable exercises for you.

- Expert: mathematics holds no secrets for you.
- Proficient: you score better than average on mathematics.
- Competent: you score average on mathematics.
- Advanced beginner: basic exercises are not a problem for you.
- Novice: you often have a hard time understanding mathematics.

Submit

Gefeliciteerd Pri(s)ma resultaat!

Maak een oefening correct en ontbloot je voor een volgende poging

Volgzaam

WISKI Oefenen

Kies het onderwerp waarover je wilt oefenen. Er start dan een reeks met 3 oefeningen over dat onderwerp.

Natuurlijke getallen

Hoofdbewerkingen
Volgde van bewerkingen

Gehele getallen

Volgde van bewerkingen
Eigenschappen van de hoofdbewerkingen
Eerstegraadsvergelijkingen
Rekenen met lettervormen
Machten

Basisbegrippen meetkunde

Coördinaten in de ruimte
Hoeken
Omrek en oppervlakte van vlakke figuren

WISKI Oefenen Helpen Oefeningen overzicht

Badge Vooruitgang

Challenge Badges

0 0 1

Badge Overzicht

Delen van oplossingen (2/4)

Mededudenten helpen (1/2)

Hang te behouden badges

Reeds behaalde badges

0/5
2/5
0/5

How is your new level determined?

Wiski estimates your level and the difficulty of exercises. Both change when solving exercises. Your level remained similar after solving the exercise series. Then, it increased even further because of your feedback.

Expert

Proficient

Competent

Advanced beginner

Novice

Before series After series

Volgorde van bewerkingen



$6 \cdot (-12) + 36 \cdot 2 = \dots$ Bereken en tik de juiste oplossing aan.

- 0
- 144
- 72
- 144



Correct

Top-zl

Over slaan

Volgend



expert

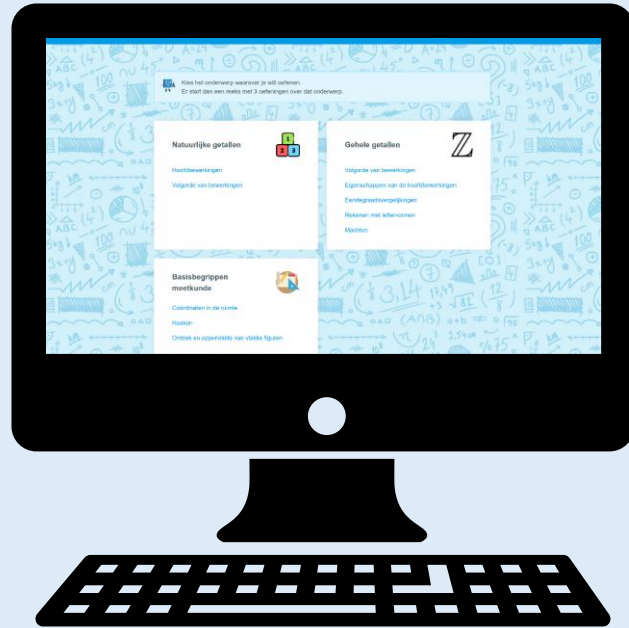


competent

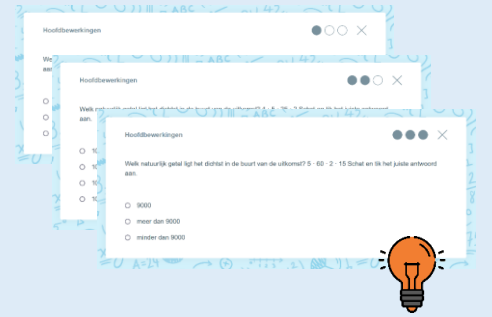
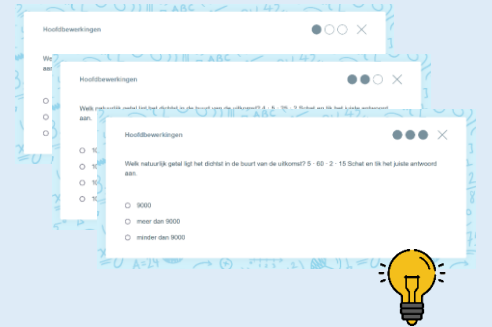
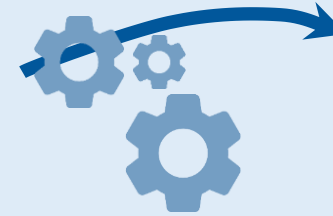


beginner

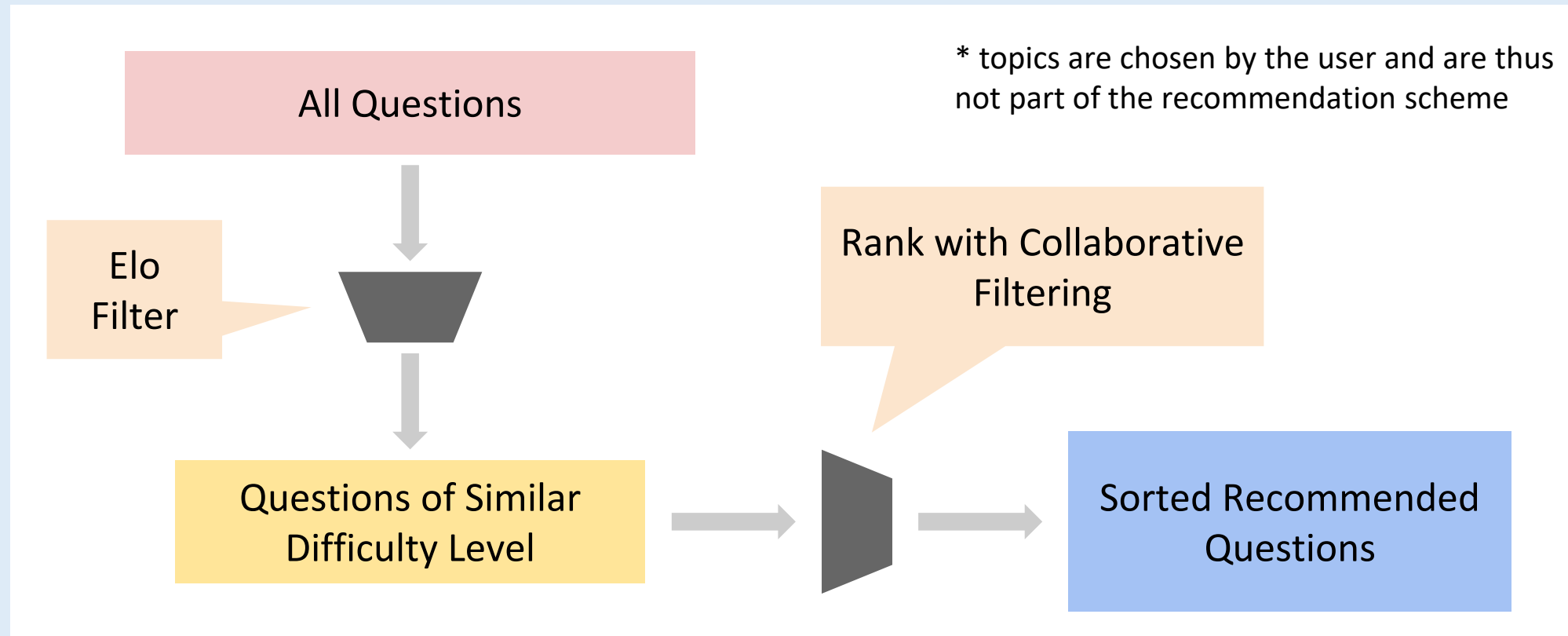
$$\sqrt{x} + \int dx + \pi$$



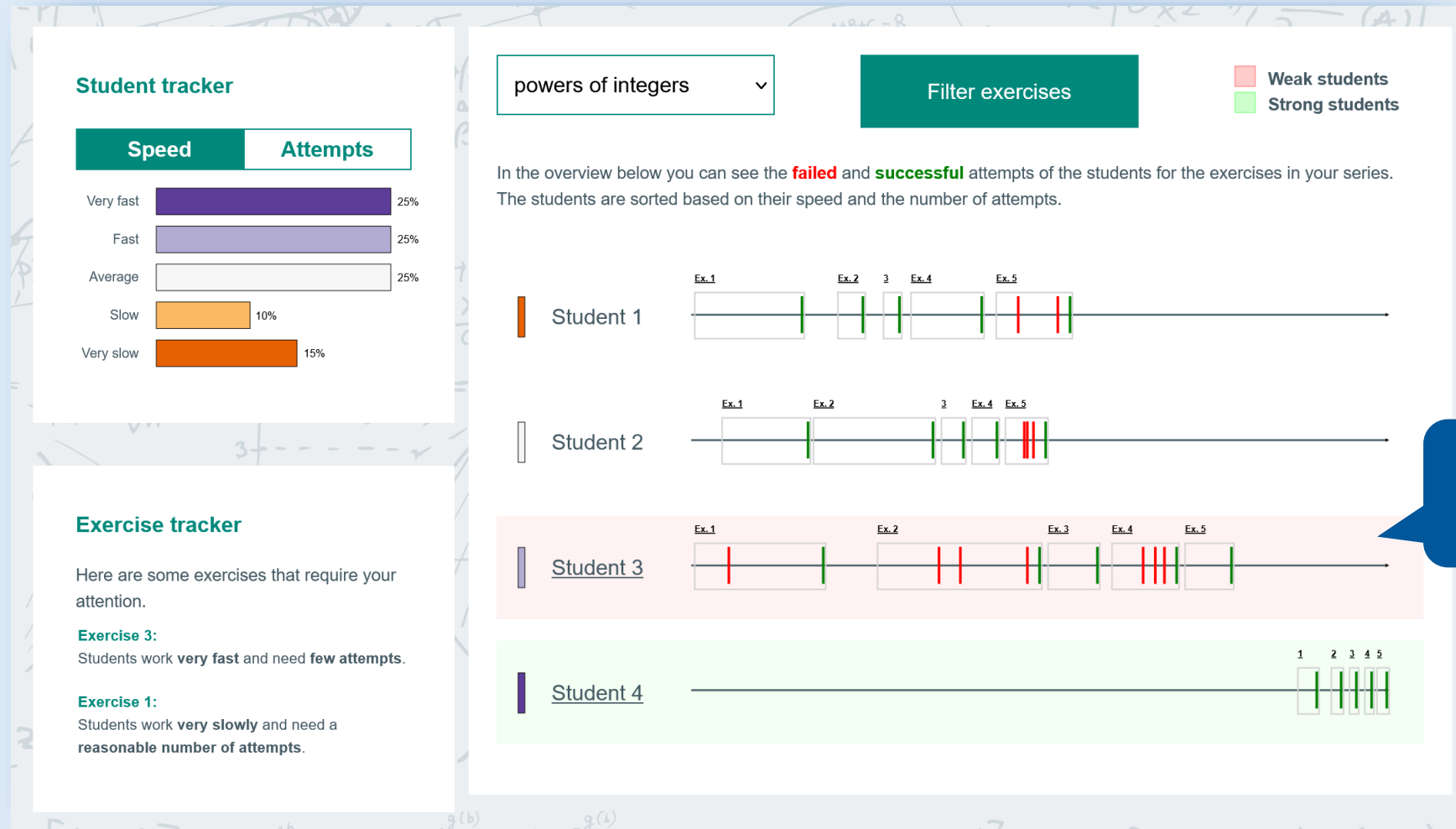
Recommender system



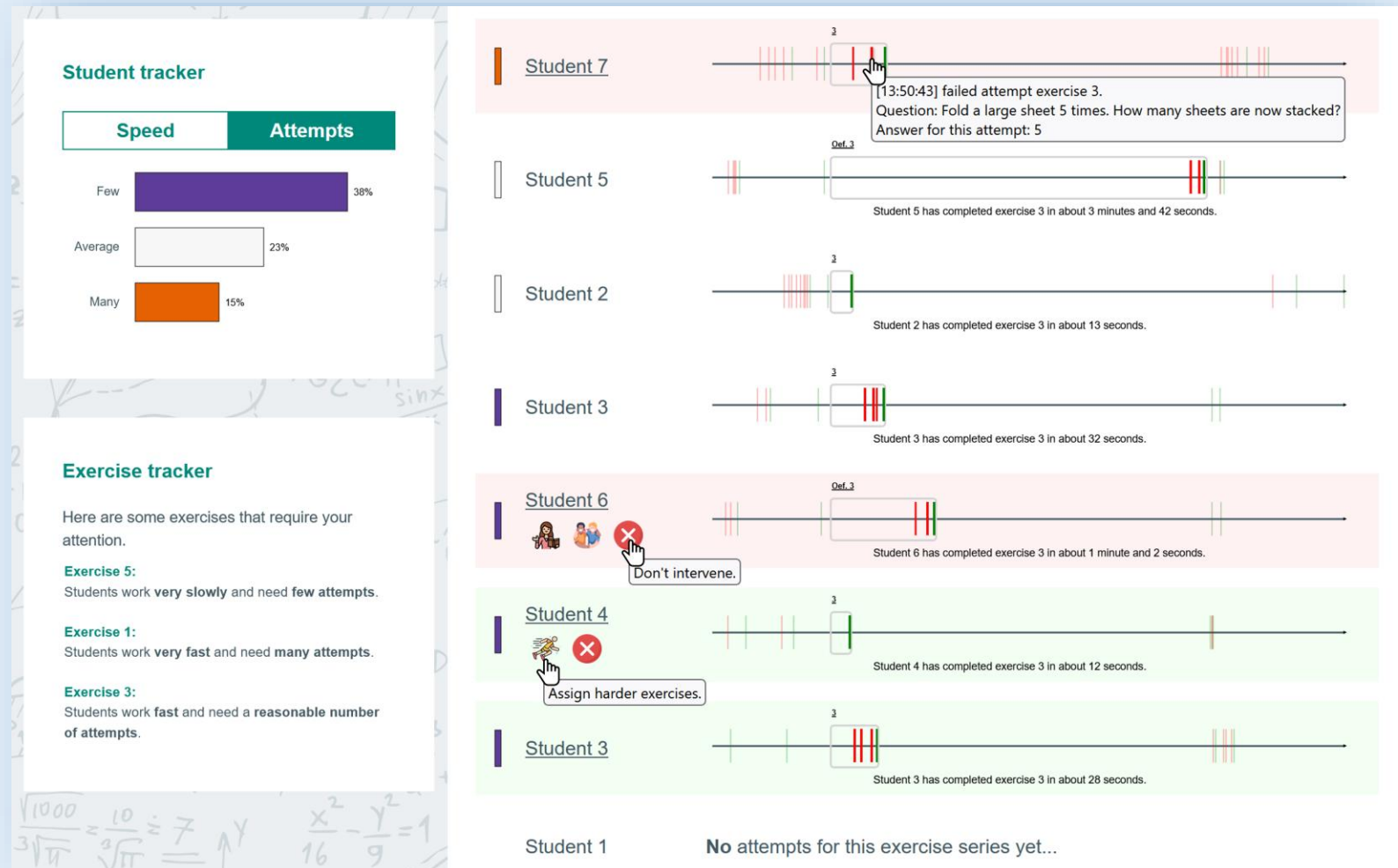
Recommending with Elo and collaborative filtering



Monitoring dashboard for teachers



Monitoring dashboard for teachers



Ongoing project: adaptive planning

The screenshot displays a project planning interface with a 7-week timeline. The interface is divided into two main sections: 'Outside class' and 'In class'. The 'Outside class' section is further divided into 'Offline', 'Online asynchronous', and 'Online synchronous' activities. The 'In class' section is divided into 'Individually' and 'Group work' activities. The 'Learning Goals' section on the right lists several goals related to understanding UE and UX, and the 'Activities' section lists various activities like 'Guest lecture', 'Watch knowledge clip', 'Listen to podcast', 'E-learning', 'Read literature', and 'Instruction'. The 'Group work' section includes activities like 'Reward', 'Conduct research', 'Peer feedback', 'Feedback', and 'Case study'.

	Week 1 Mon 01/09 - Sun 07/09	Week 2 Mon 08/09 - Sun 14/09	Week 3 Mon 15/09 - Sun 21/09	Week 4 Mon 22/09 - Sun 28/09	Week 5 Mon 29/09 - Sun 05/10	Week 6 Mon 06/10 - Sun 12/10	Week 7 Mon 13/10 - Sun 19/10
Outside class							
Offline		Conduct research Opdracht 1	Self-reflection Opdracht 1	Conduct research Opdracht 1	Self-reflection Opdracht 1		
Online asynchronous					Create a video Rapportering opdracht 1		
Online synchronous							
In class							
Individually							Play a game Eye-tracking practicum
Group work	Reward Geen werkcollege	Conduct research Opdracht 1 TAs en Robin	Peer feedback Opdracht 1 TAs en Robin	Feedback Opdracht 1 TAs en Robin	Feedback Opdracht 1 TAs en Robin	Conduct research Opdracht 2	

Learning Goals

- Aan het einde van de cursus kunnen studenten...
- ... uitleggen wat UE, UX en verwante disciplines inhouden
- ... geschikte ontwerp- en evaluatiemethodes voor UE en UX selecteren op basis van hun sterktes en beperkingen
- ... individueel en in groep onderzoek rond UE en UX formuleren
- ... in groep onderzoek rond UE en UX uitvoeren en onderzoeksresultaten analyseren, interpreteren en presenteren

Activities

Gathering Knowledge

- Guest lecture
- Watch knowledge clip
- Listen to podcast
- E-learning
- Read literature
- Instruction

Learning from Each Other

- Consultation
- Discussion
- Role play
- Knowledge exchange

Add explainable recommendations based on blended learning theory to a planner tool

e.g., can teachers more efficiently plan blended courses?



TIME FOR

QUESTIONS



How can AI systems help with differentiation?

1

Adaptation

*About fake whiskey, Elo ratings,
and spying dashboards*

2

Transparency

3

Motivation



How can AI systems help with differentiation?

1

Adaptation

2

Transparency

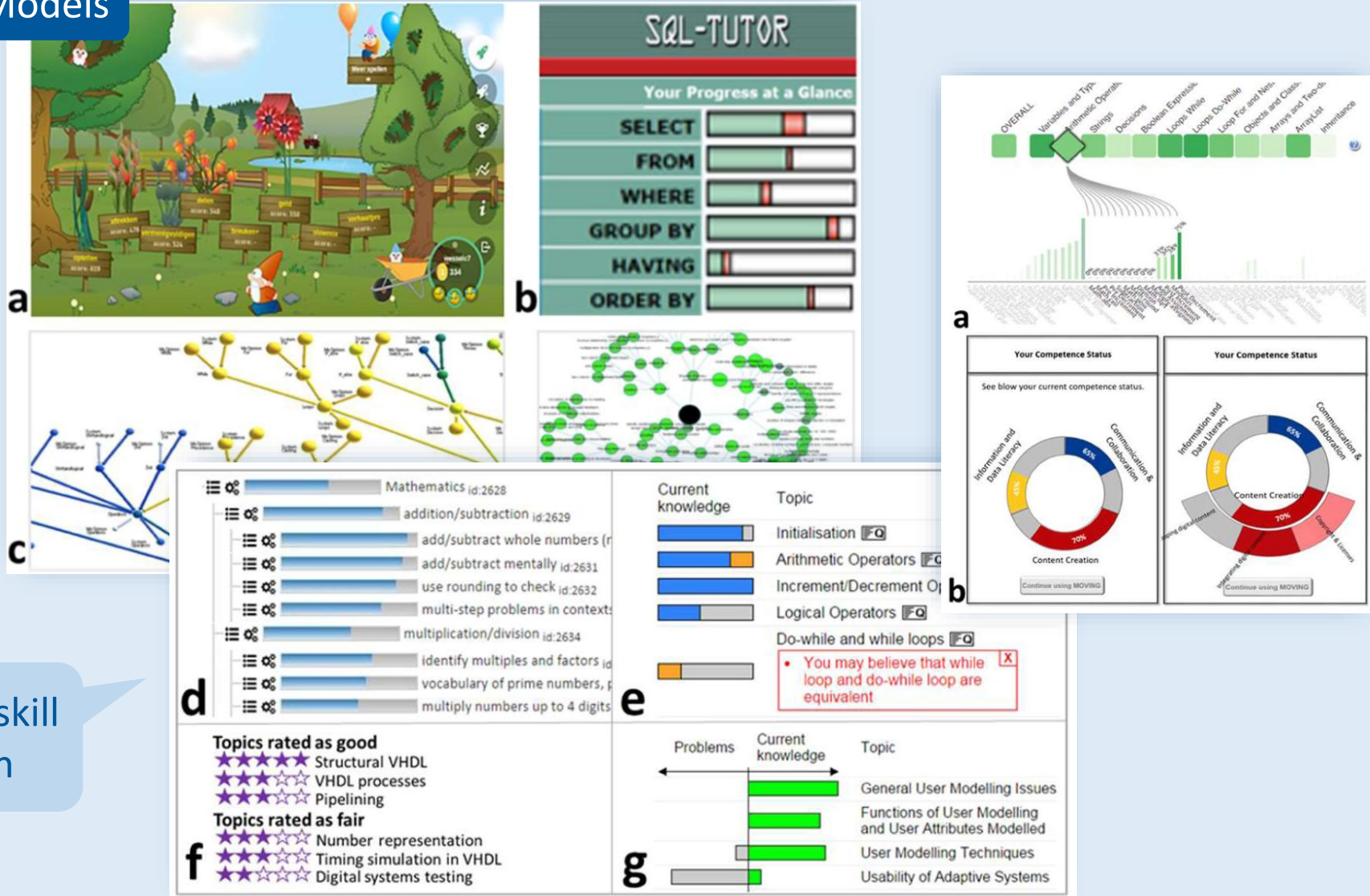
3

Motivation

*About seeing what you master,
explaining AI decisions, and control*



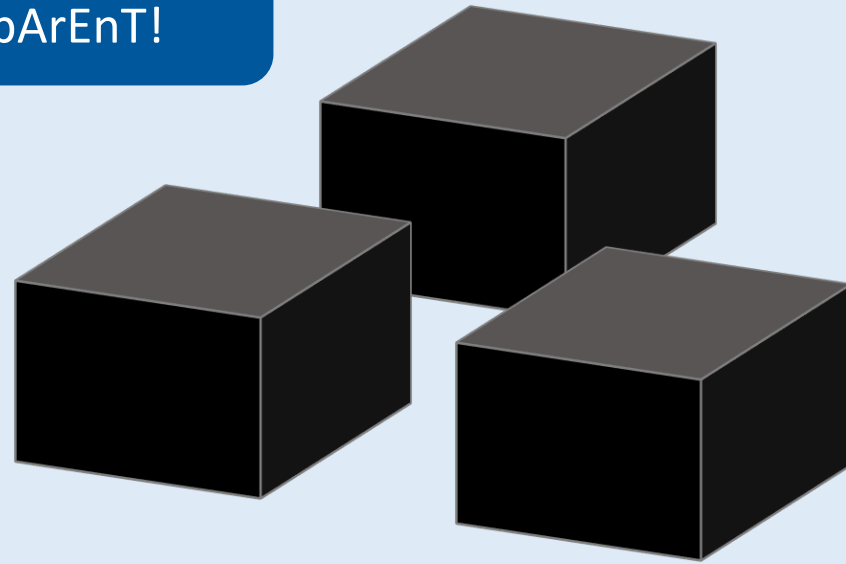
Open Learner Models



Algorithmic skill estimation



We need to make AI black boxes TrAnSpArEnT!



Explanations

+

Control

+

Human-Centred



Explanations

+

Control

+

Human-Centred

Design explanations and control mechanisms for/with a specific audience and **evaluate** how they affect behaviours
(e.g., trust, understanding, motivation, learning)

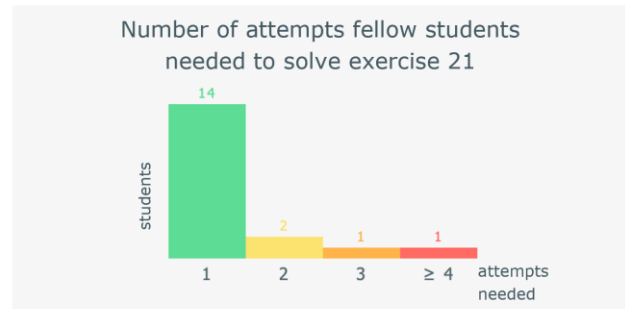
Solve a recommended exercise of the same chapter

Recommended

-  Exercise 37
-  Exercise 26
-  Exercise 21

Why this exercise? Wiski thinks your current level aligns with that of the exercise!

Wiski expects you will need **1 or 2 attempts** to solve exercise 21, based on your results and those of your fellow students.



Solve exercise 21

... or pick your next exercise yourself

Go to the exercise overview

Textual explanation

Visual explanation

Explanations: *why* explanations for recommendations

Control: choose next exercises

Goed gewerkt!

Maak een aangeraden oefening van hetzelfde hoofdstuk

Aangeraden

- Oefening 4**
- Oefening 11**
- Oefening 7**

Waarom deze oefening? Wiski denkt dat jouw huidig niveau past bij dat van deze oefening!

Wiski verwacht dat je **1 of 2 pogingen** nodig gaat hebben om oefening 4 juist te maken, gebaseerd op de resultaten van jou en je medeleerlingen.

Aantal pogingen medeleerlingen nodig hadden om oefening 4 juist op te lossen

pogingen nodig	leerlingen
1	17
2	4
3	2
≥ 4	0

Maak oefening 4

... of kies zelf je volgende oefening

Naar het oefeningenoverzicht

Explanations: *why* explanations for recommendations

Control: choose next exercises

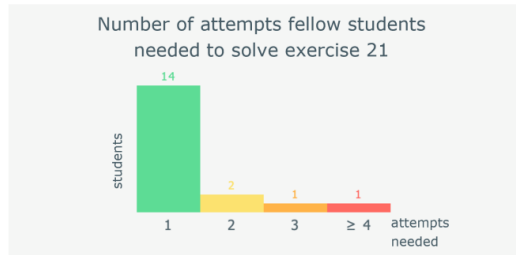
Solve a recommended exercise of the same chapter

Recommended

- Exercise 37
- Exercise 26
- Exercise 21

Why this exercise? Wiski thinks your current level aligns with that of the exercise!

Wiski expects you will need **1 or 2 attempts** to solve exercise 21, based on your results and those of your fellow students.



Solve exercise 21

... or pick your next exercise yourself

Go to the exercise overview

Real explanation

How was trust in the platform affected?

Solve a recommended exercise of the same chapter

Recommended

- Exercise 37
- Exercise 26
- Exercise 21

Why this exercise?
Exercise 21 is recommended because Wiski's algorithm computed it this way



Solve exercise 21

... or pick your next exercise yourself

Go to the exercise overview

Placebo explanation

Solve a recommended exercise of the same chapter

Recommended

- Exercise 37
- Exercise 26
- Exercise 21

Wiski recommends this next exercise



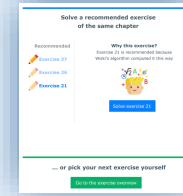
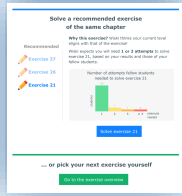
Solve exercise 21

... or pick your next exercise yourself

Go to the exercise overview

No explanation

How was trust in the platform affected?



Real vs no explanation

Placebo vs no explanation

trust increased

trust increased

trust unchanged

trust unchanged

trust decreased

trust decreased

Novice I believe this is your level now for the following subject:
Coordinates in space.

What difficulty level would you like for the next exercise series?

Very easy Easy Normal Difficult Very difficult

If you finish all exercises correctly, your level will increase:

Expert
Proficient
Competent
Advanced beginner
Novice

Your level after completion
Your level now

Start exercises

Control: choose difficulty of recommended exercises series

Explanations: real-time *what-if* explanations (“how does my level change if I solve this series correctly?”)

gevorderde beginner Volgens mij is dit nu je level voor het onderwerp *Volgorde van bewerkingen*

Welke moeilijkheidsgraad wil je voor de volgende oefeningenreeks?

Heel makkelijk Makkelijk Gewoon Moeilijk Heel moeilijk

Als je alle oefeningen in de reeks juist oplost, dan stijgt je level:

- Expert
- Bedreven
- Competent
- Gevorderde beginner
- Beginner

Je level na de reeks

Je level nu

Start de reeks

Control: choose difficulty of recommended exercises series

Explanations: real-time *what-if* explanations (“how does my level change if I solve this series correctly?”)

What-if explanations

Best Case



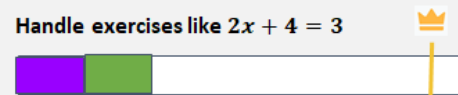
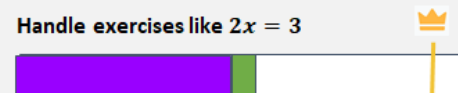
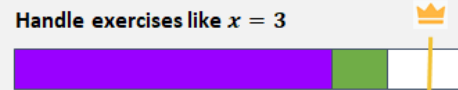
Based on your mastery levels, I selected an exercise about these skills:

Show your mastery changes in the

worst case

usual case

best case



Start

Usual Case



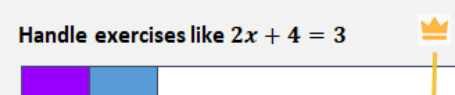
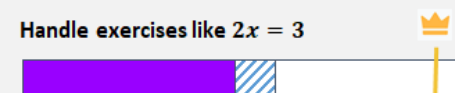
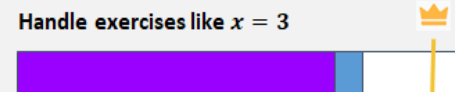
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Show your mastery changes in the

worst case

usual case

best case



Start

Worst Case



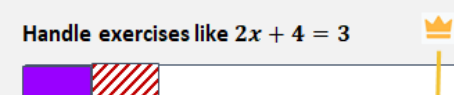
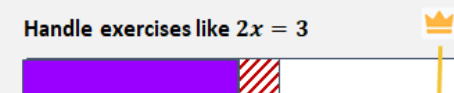
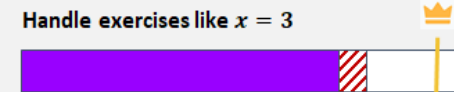
Based on your mastery levels, I selected an exercise about these skills:

Show your mastery changes in the

worst case

usual case

best case

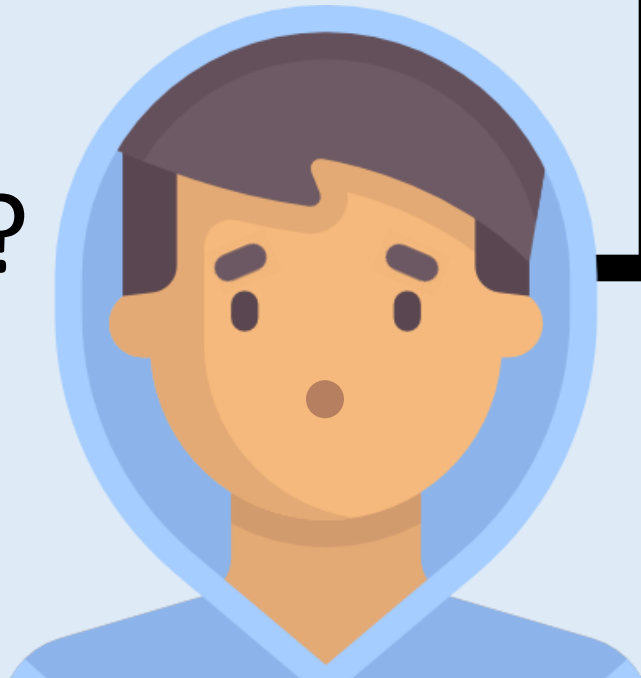


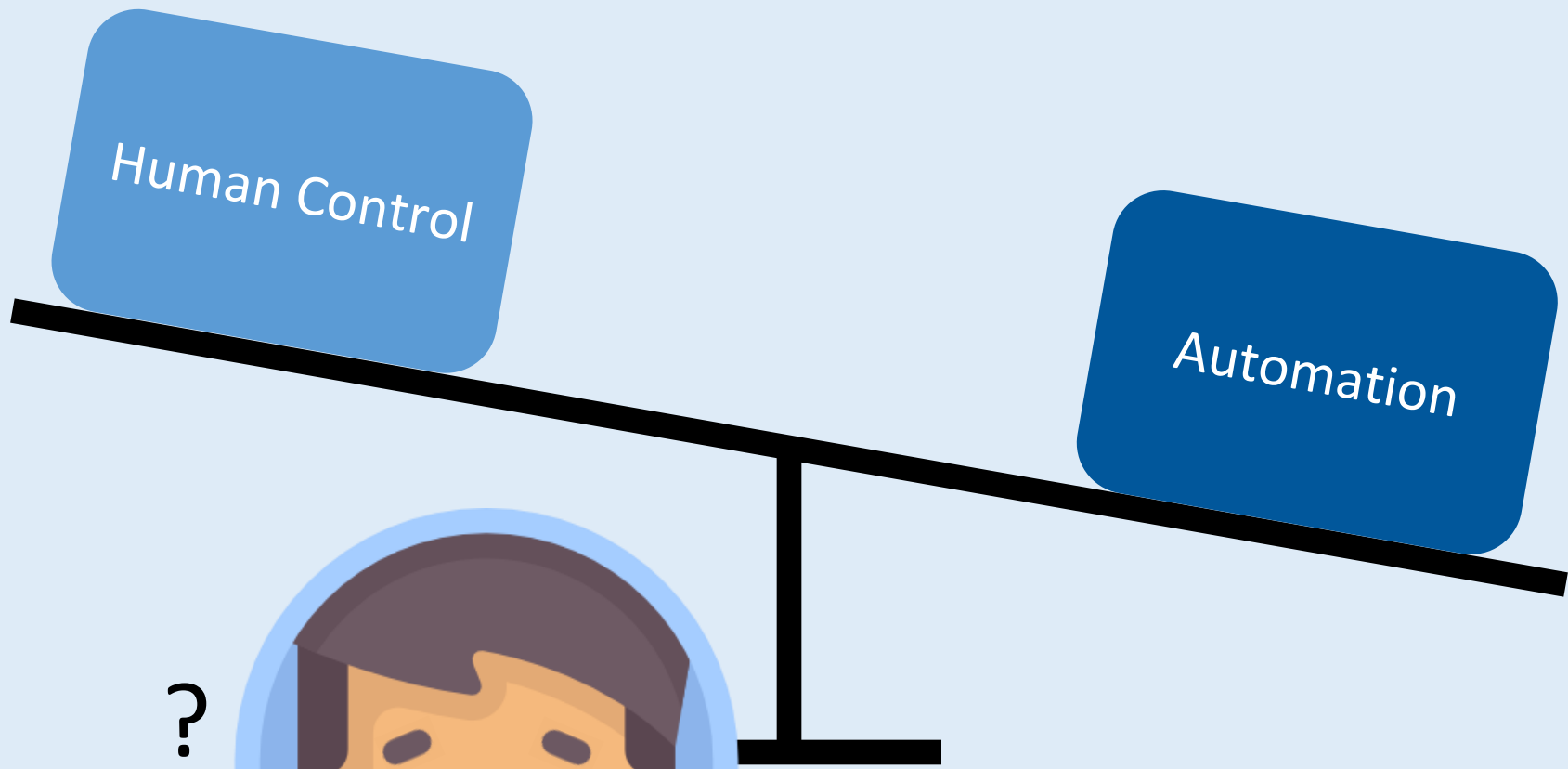
Start

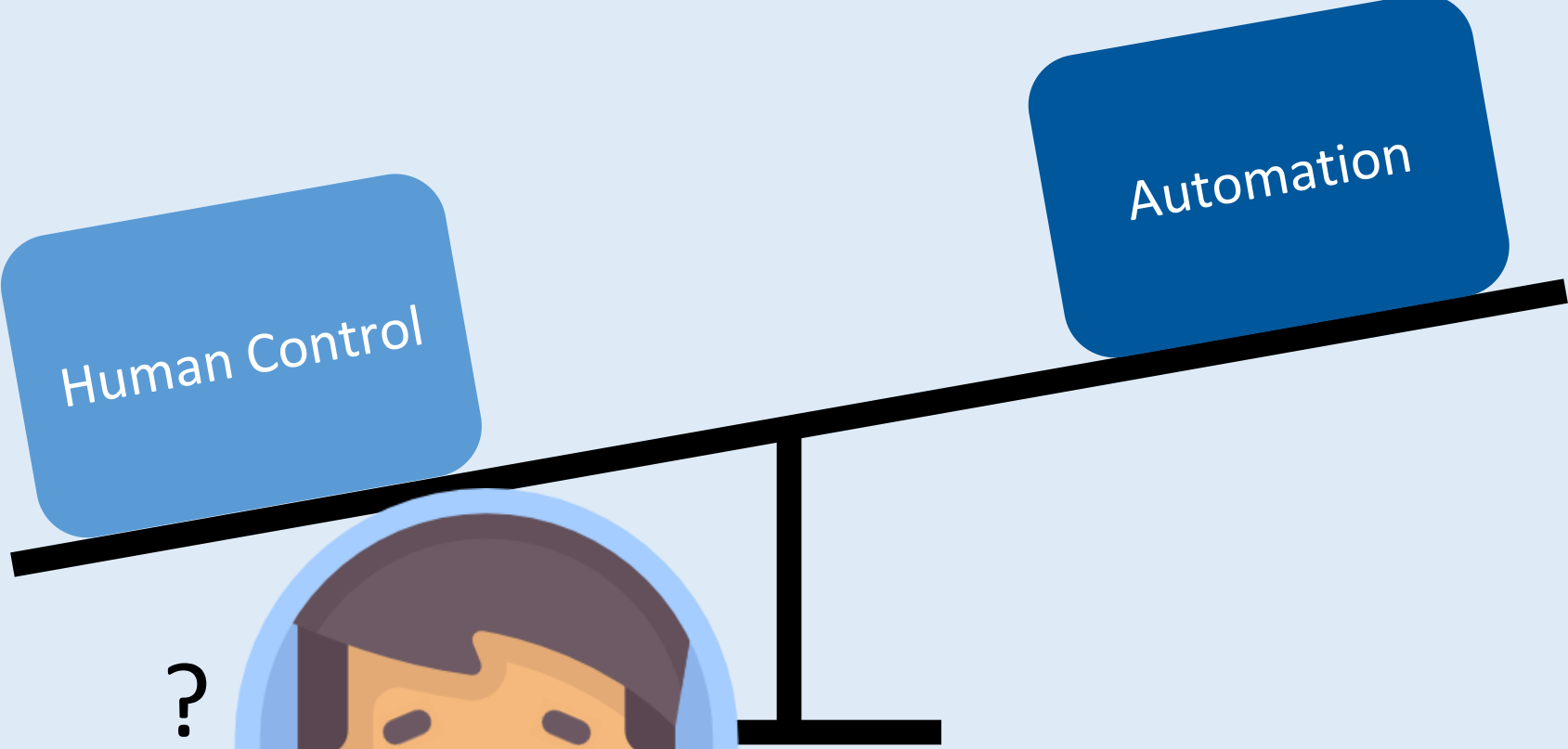
Human Control

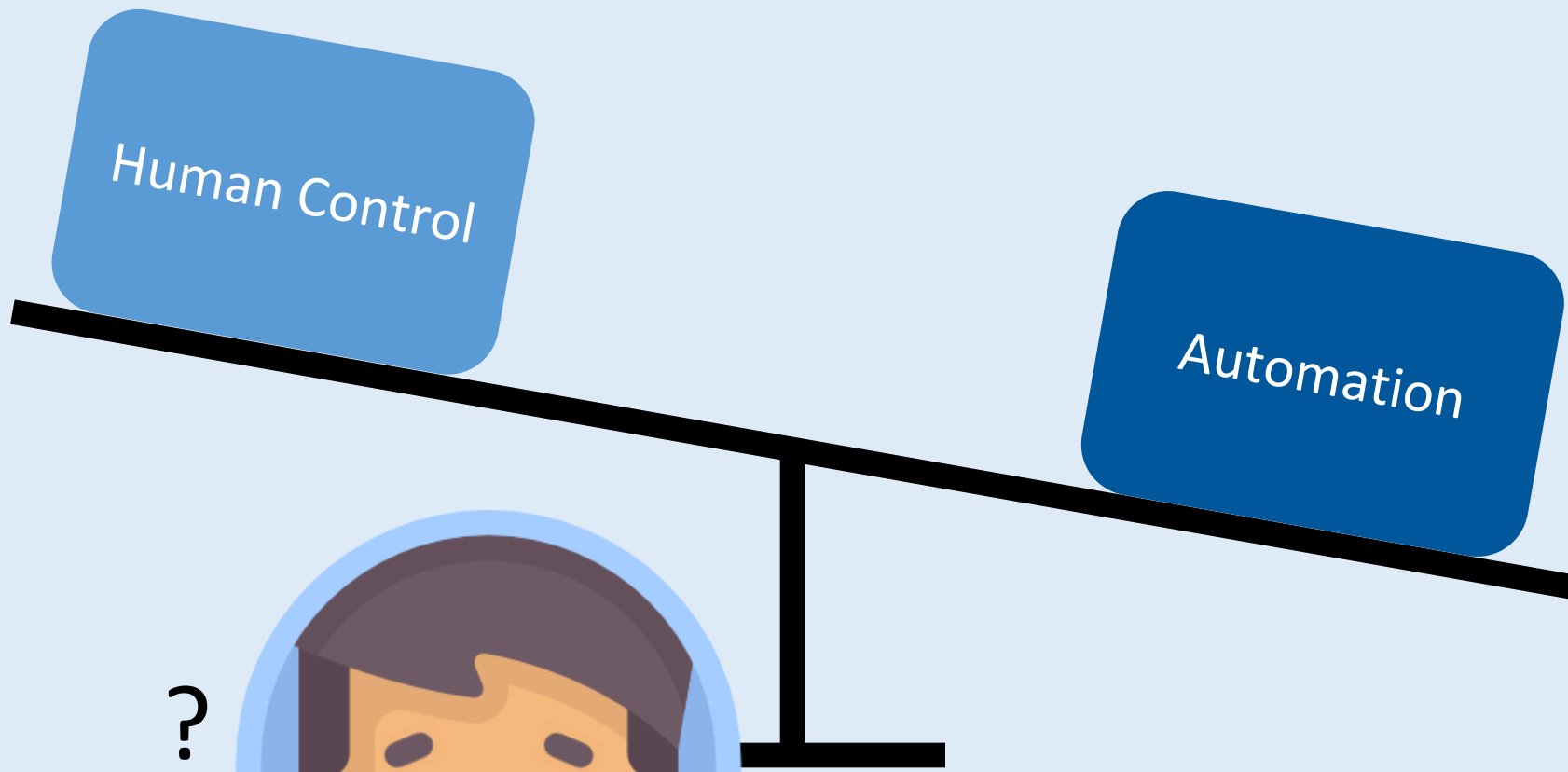
Automation

?



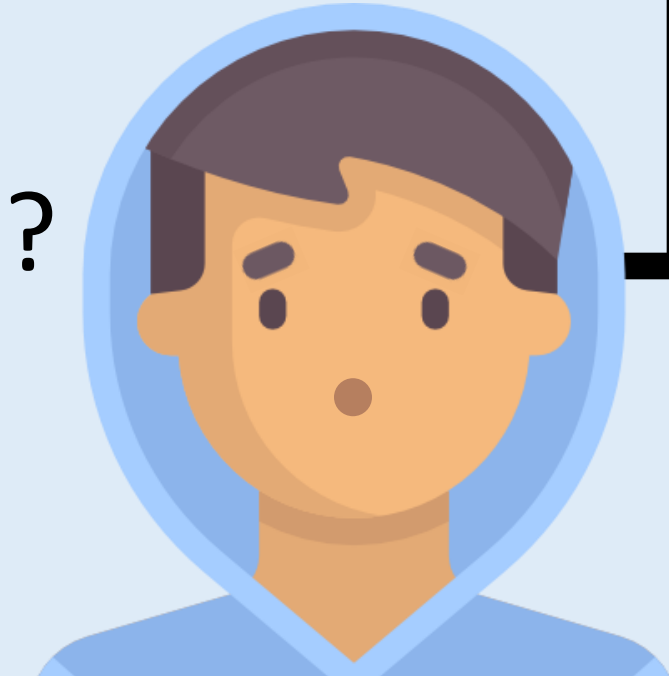


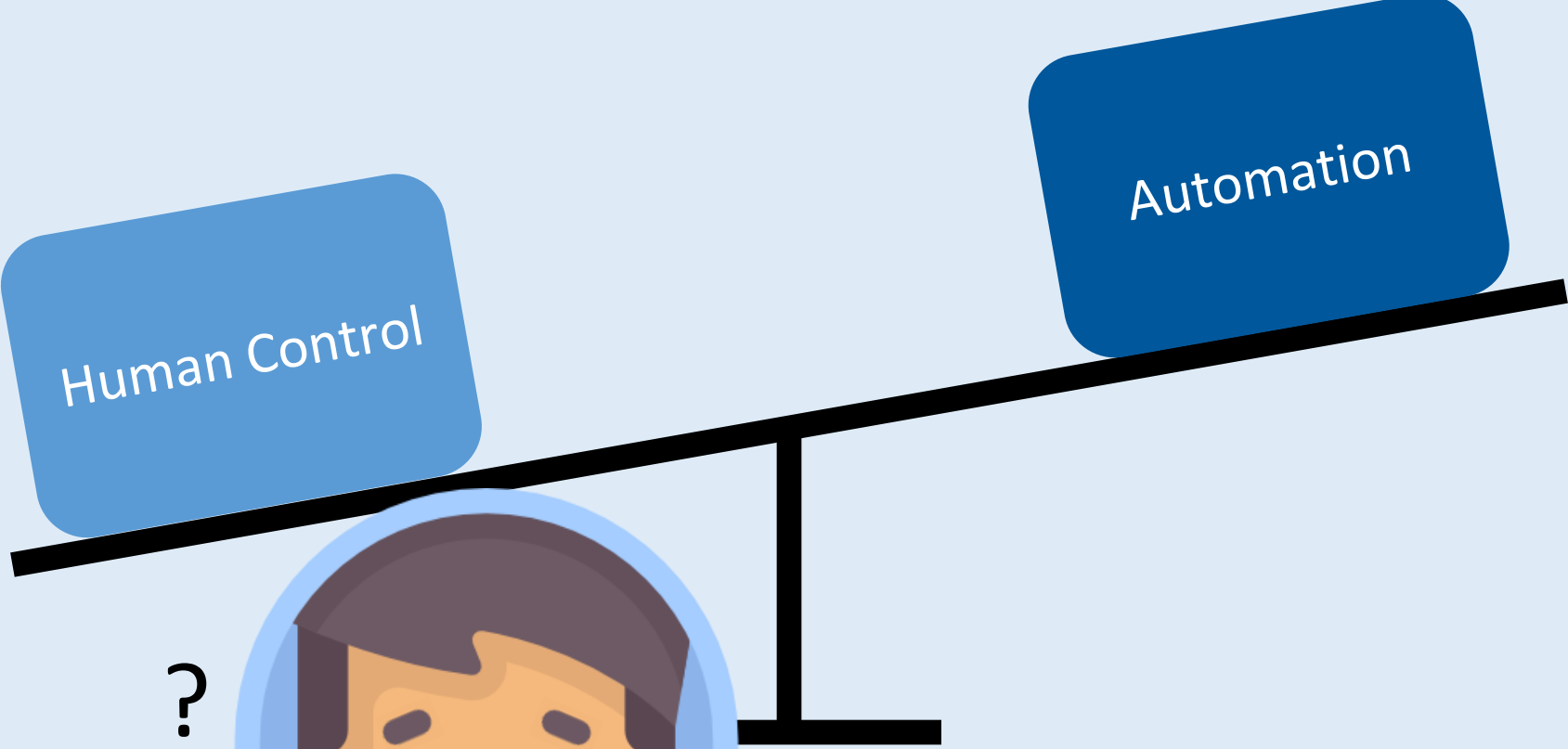




Human Control

Automation

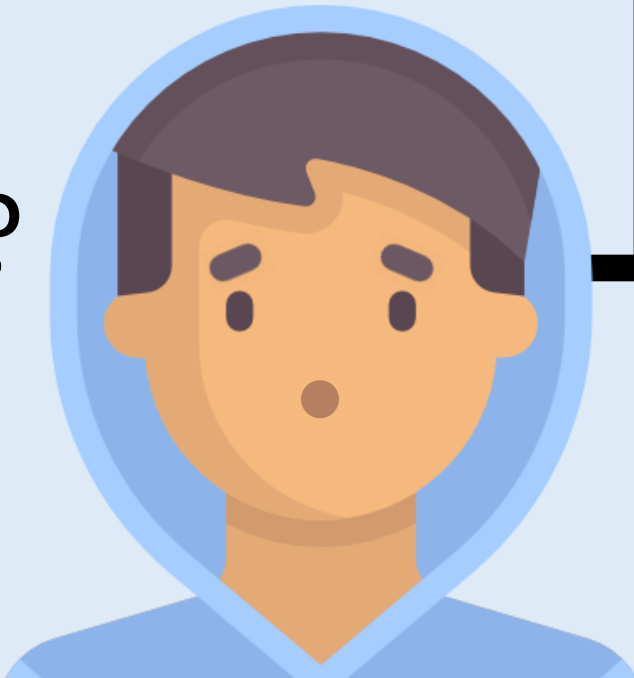




Human Control

Automation

?



Sharing control with recommender systems

Full AI Control

Based on your mastery levels, I selected an exercise about these skills:

Show your mastery changes in the

worst case usual case best case

Handle exercises like $x = 3$

Handle exercises like $2x = 3$

Handle exercises like $2x + 4 = 3$

Start

Shared Control

Select the skill(s) you want to practice next

Handle exercises like $2x = 3$

Handle exercises like $x = 3$

Handle exercises like $2x + 4 = 3$

I found an exercise. The bars show how your mastery would change in the

worst case usual case best case

Start

Full Learner Control

Select the exercise you want to solve next

Your mastery of skills in these exercises ↑ Sort

Exercise 1

Exercise 2

Exercise 3

Exercise 4

Solving this exercise will change your mastery as follows in the:

worst case usual case best case

Handle exercises like $x = 3$

Handle exercises like $2x = 3$

Handle exercises like $2x + 4 = 3$

Start

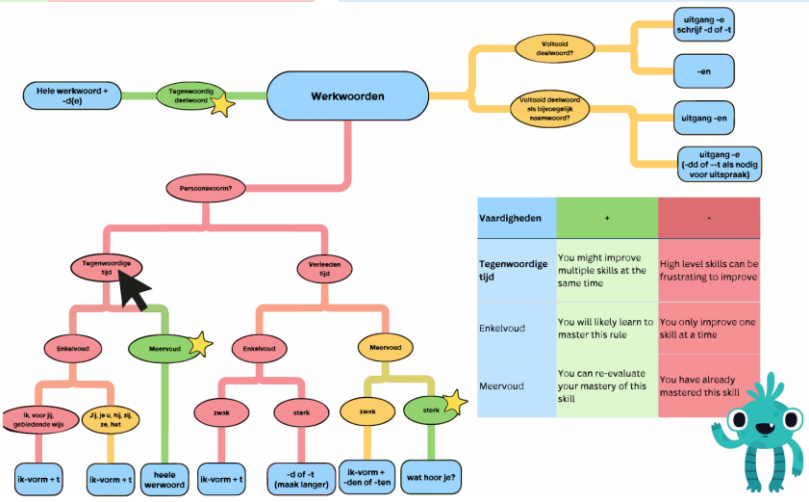
Ongoing project: evaluative AI



AI detection support in texts for teachers

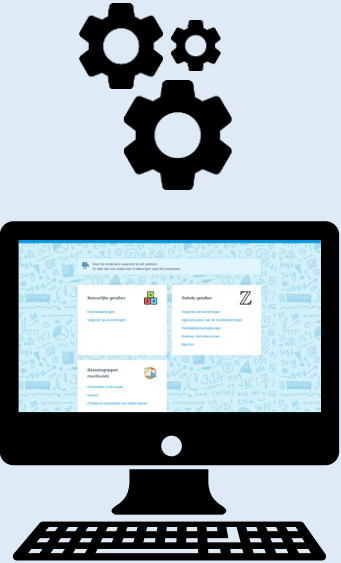


Control for students over learning path

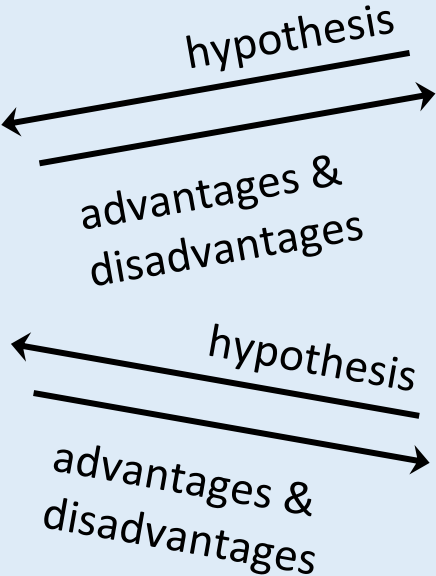


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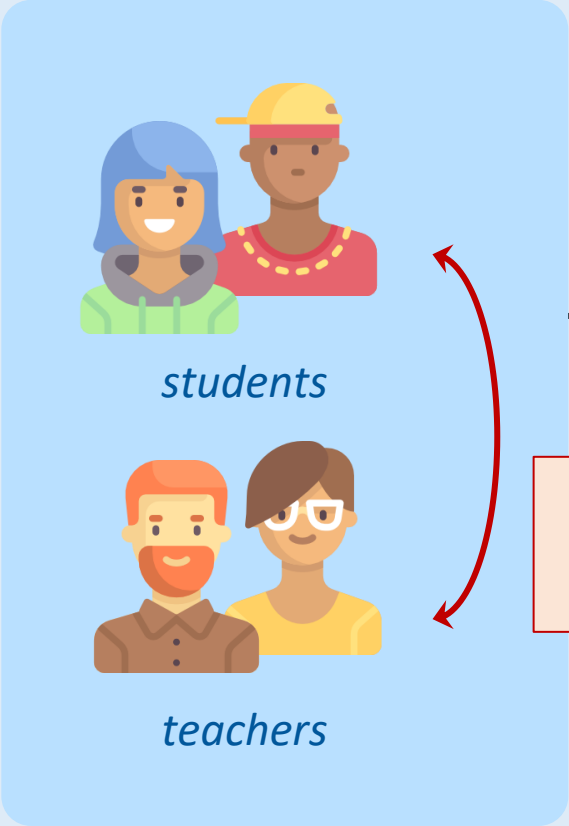
Ongoing project: multi-stakeholder evaluative AI



educational AI system



educational stakeholders (decision makers)



students



teachers

improved decision-making, motivation, and learning?

aligning shared decision-making



TIME FOR

QUESTIONS



How can AI systems help with differentiation?

1

Adaptation

2

Transparency

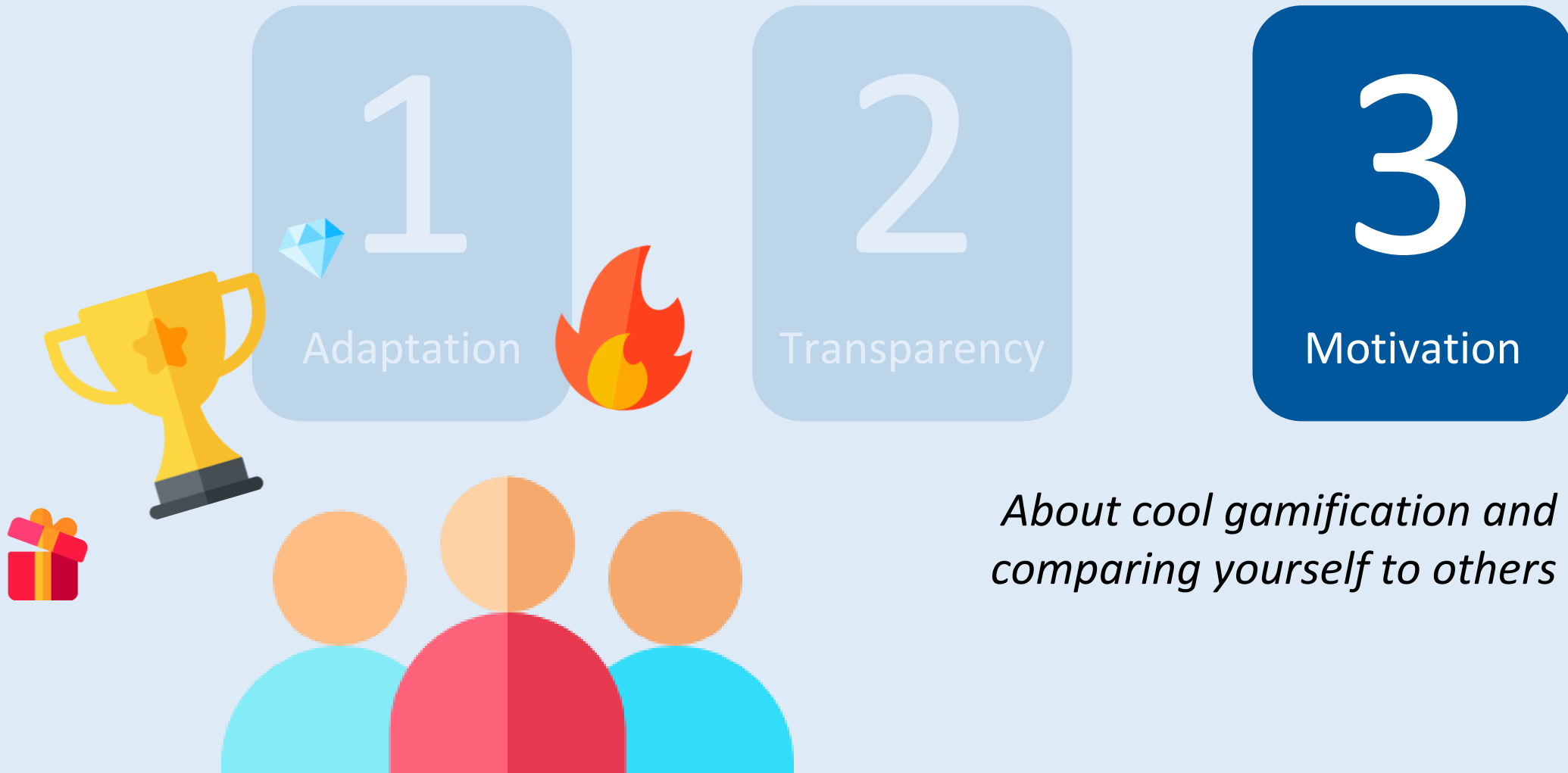
3

Motivation

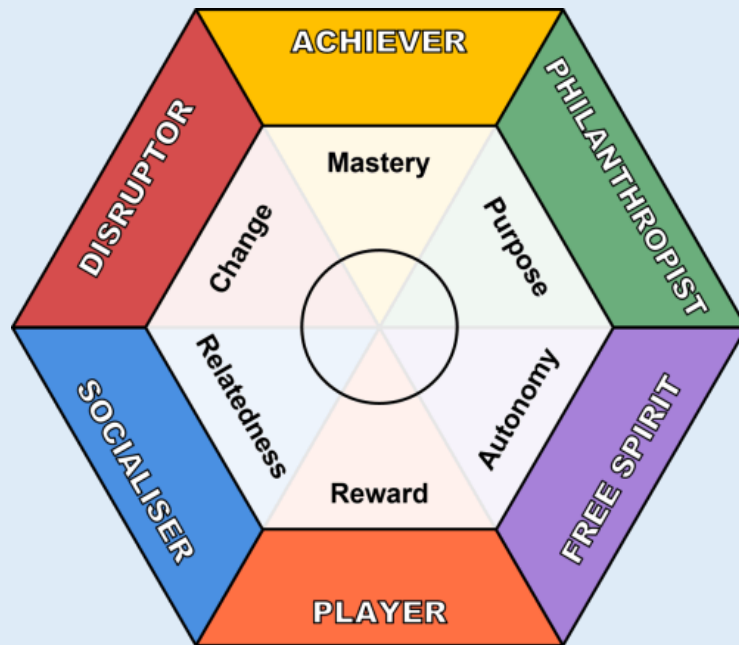
*About seeing what you master
and explaining AI decisions*



How can AI systems help with differentiation?

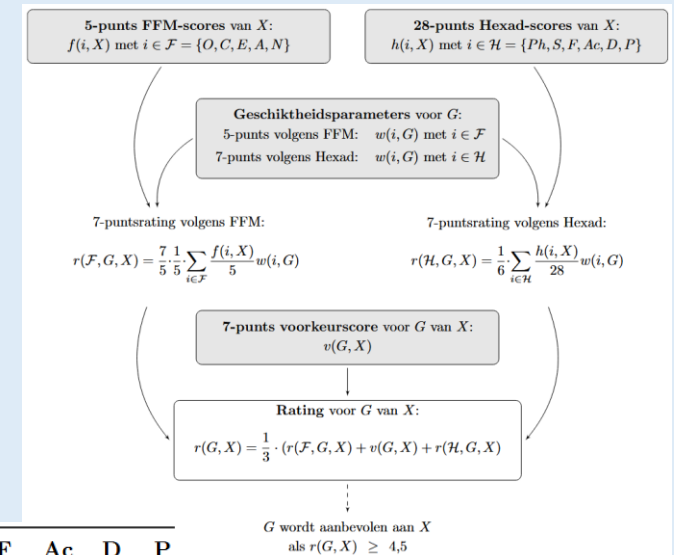


Gamification needs to be personalised



Hexad gamification user types

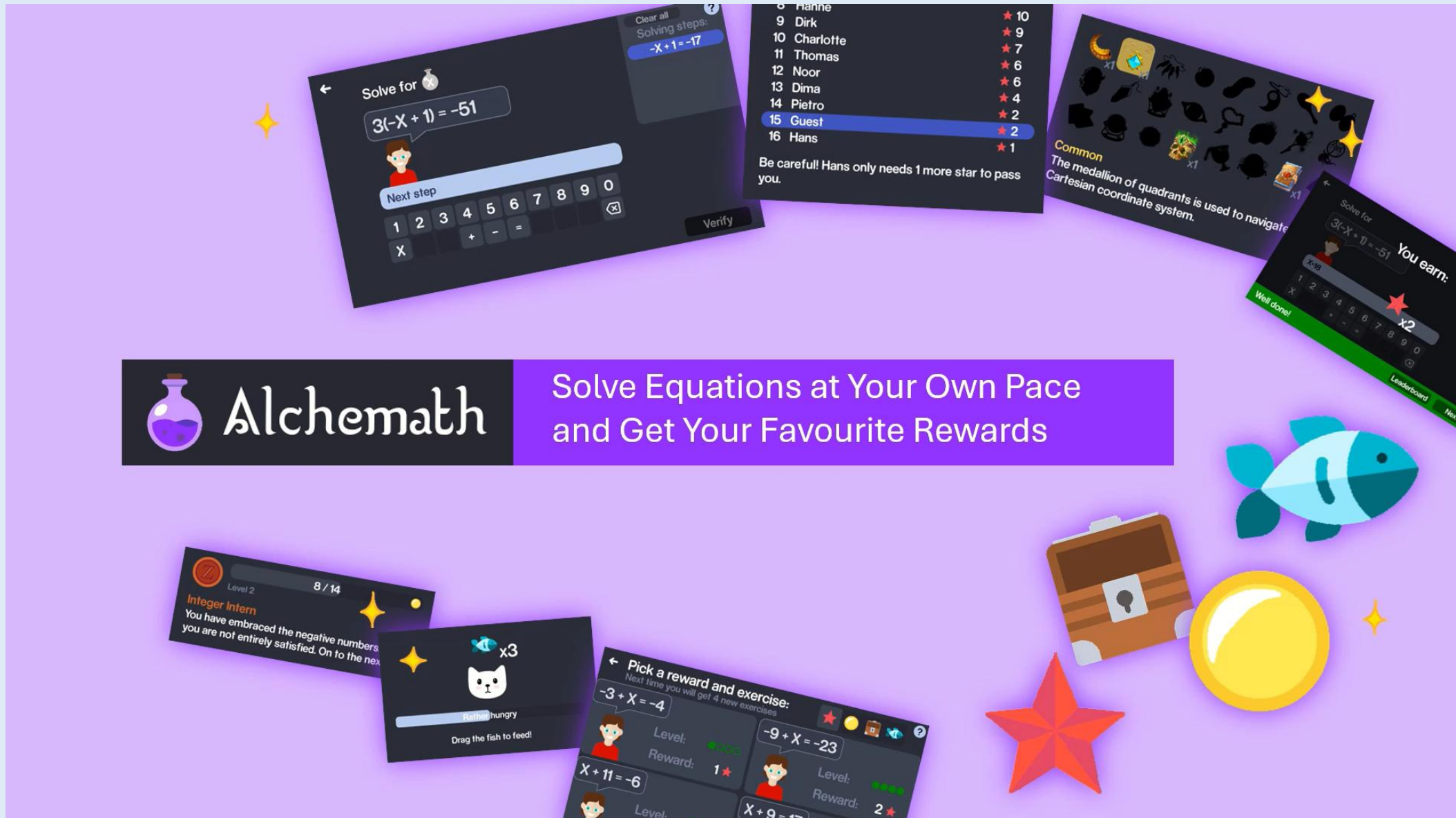
Adapt gamification based on personality, Hexad profile, and preferences



	O	C	E	A	N	Ph	S	F	Ac	D	P
Punten	5a	3	4c	3	4c	4	6e	5b	5b	5e	7a
Puntenklassement	3	4c	5a	4c	3	4	7a	5b	6a	6b	6a
Oefeningeklassement	3	4c	5a	4c	3	4	7a	5b	6a	6b	6a
Day streak	3	4c	3	3	5c	5a	5b	5b	5c	4	6b
Helpen	3	4c	4a	5c	3	7a	6a	5b	6a	5b	6b
Verrassingen	4c	4c	4c	3	5c	5a	5b	7a	7a	5a	7a
Uitdagingen	4c	4c	3	4c	2c	5b	4	7b	7a	5a	6a
Motiverende feedback	5a	3	4d	3	3	4	4	5b	4	5b	5b





Maximilian Altmeyer, Gustavo F. Tondello, Antonio Krüger, and Lennart E. Nacke. 2020. HexArcade: Predicting Hexad User Types By Using Gameful Applications. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play (CHI PLAY '20)*, 219–230. <https://doi.org/10.1145/3410404.3414232>

Jeroen Ooge. 2019. Het personaliseren van motivationele strategieën en gamificationstechnieken m.b.v. recommendersystemen. Master's thesis, KU Leuven. <https://jeroenooge.be/research/masters-thesis-personalising-motivational-strategies-and-gamification-techniques>



← Pick a reward and exercise:
Next time you will get 4 new exercises

★ ● 📁 🐟 ?

$8 + X = 25$  Level: ●○○○ Reward: 1 ●	$X - 1 = -14$  Level: ●●●● Reward: 2 ●
$12 + X = 5$  Level: ●●○○ Reward: 1 ●	$-8 + X = -24$  Level: ●●●○ Reward: 2 ●

Difficulty for the learner

Reward for a correct answer ✨

Transparency: difficulty labels

Control: choose next exercise while being nudged

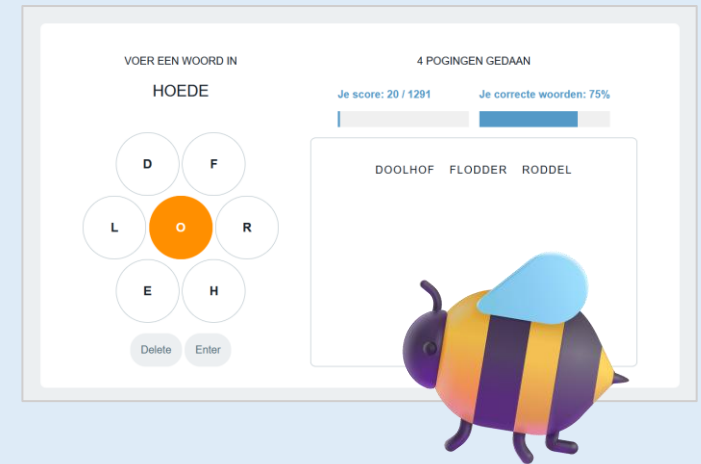
Ongoing project: social comparison



*seeing yourself below
average = 😞*



*seeing yourself
above average = 😊*



People have many reasons to compare themselves



TIME FOR

QUESTIONS



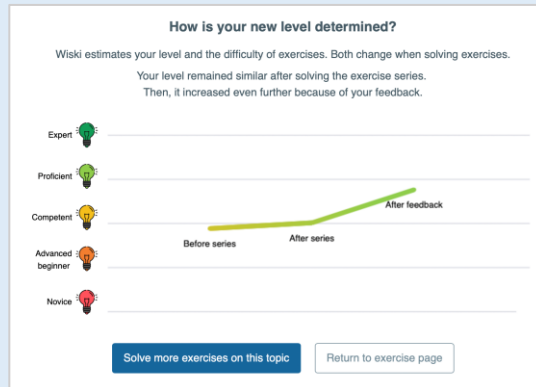
How can AI systems help with differentiation* in education?

*in the sense of individualisation/personalisation

Make learning experiences more
1 adaptive, **2** transparent, and **3** motivating



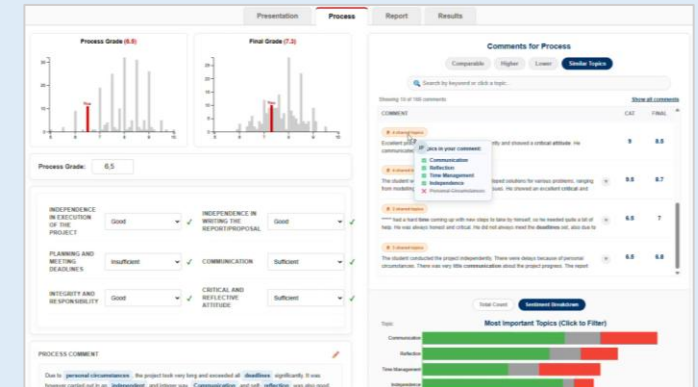
I did and do much more research



Trust effects of steering recommended exercises

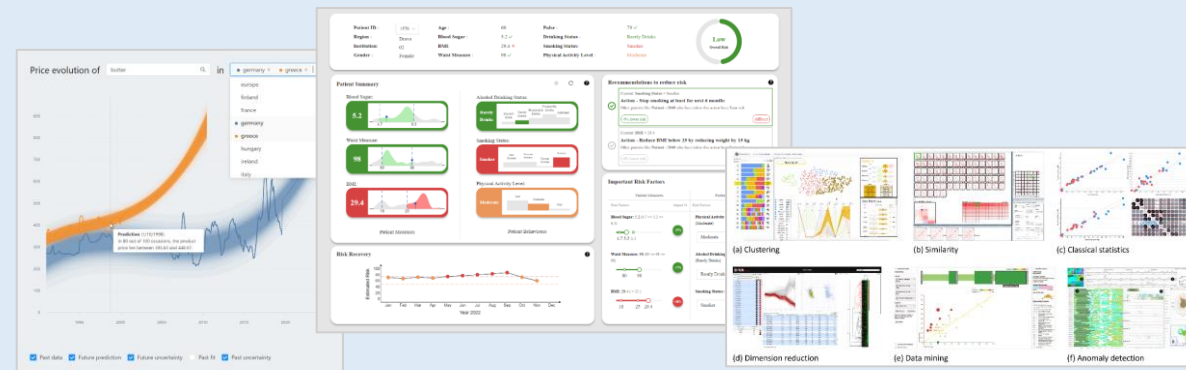
<https://doi.org/10.1145/3581641.3584046>

Visual analytics to support grading (ongoing)



Help teachers create new content

<https://doi.org/10.1145/3636555.3636933>



XAI-related work in other domains

<https://doi.org/10.1145/3636555.3636933>, <https://doi.org/10.1002/widm.1427>

Check out jeroenooge.be and reach out for projects together!



<https://jeroenooge.be/thesis>