

Transparent and Controllable Adaptive Systems in Education



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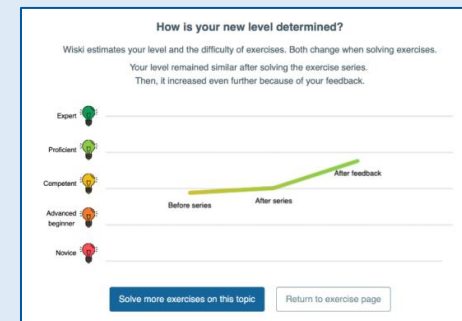
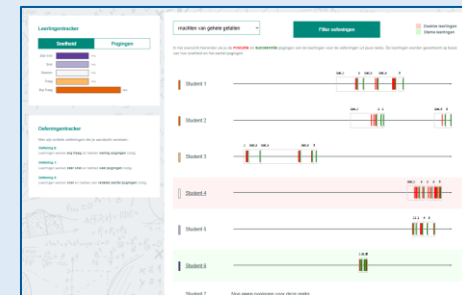
← Pick a reward and exercise:
Next time you will get 4 new exercises.

$8 + X = 25$
 Level: ★★★★
 Reward: 1

$X - 1 = -14$
 Level: ★★★★
 Reward: 2

$12 + X = 5$
 Level: ★★★★
 Reward: 1

$-8 + X = -24$
 Level: ★★★★
 Reward: 2



Question
Wat is de hoofdstad van de staat Florida?

Answer
Tallahassee

Quality of distractors
Good

Similarity scores

Distractors

- 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? 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.

Number of attempts fellow students needed to solve exercise 21

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 **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

Lecture 1 Introduction

Lecture 2 User Modelling



Lecture 3 Context Modelling

Lecture 4 Recommender Systems 1 - Collaborative



Lecture 5 Recommender Systems 2 - Content-based



Lecture 6 Group Recommender Systems

Lecture 7 Adaptive Interfaces and Visualization



Lecture 8 Explanations



Lecture 9 Evaluation - Metrics and Reproducibility

Lecture 10 Evaluation - Layered Evaluation



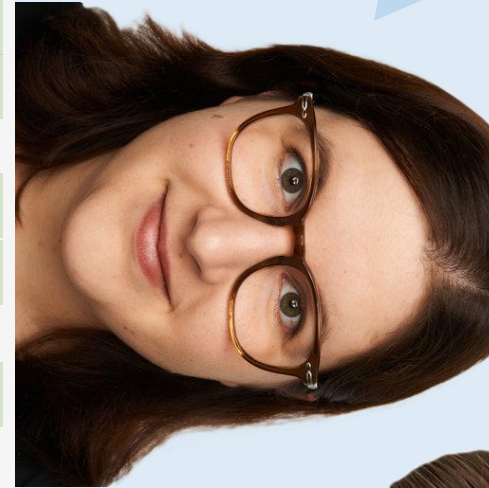
Lecture 11 Impact and Ethics

Lecture 12 - Music Recommender Systems

Lecture 13 Application Area - Intelligent Interactive Health Systems

Lecture 14 ???

I'm looking for a
guest speaker...

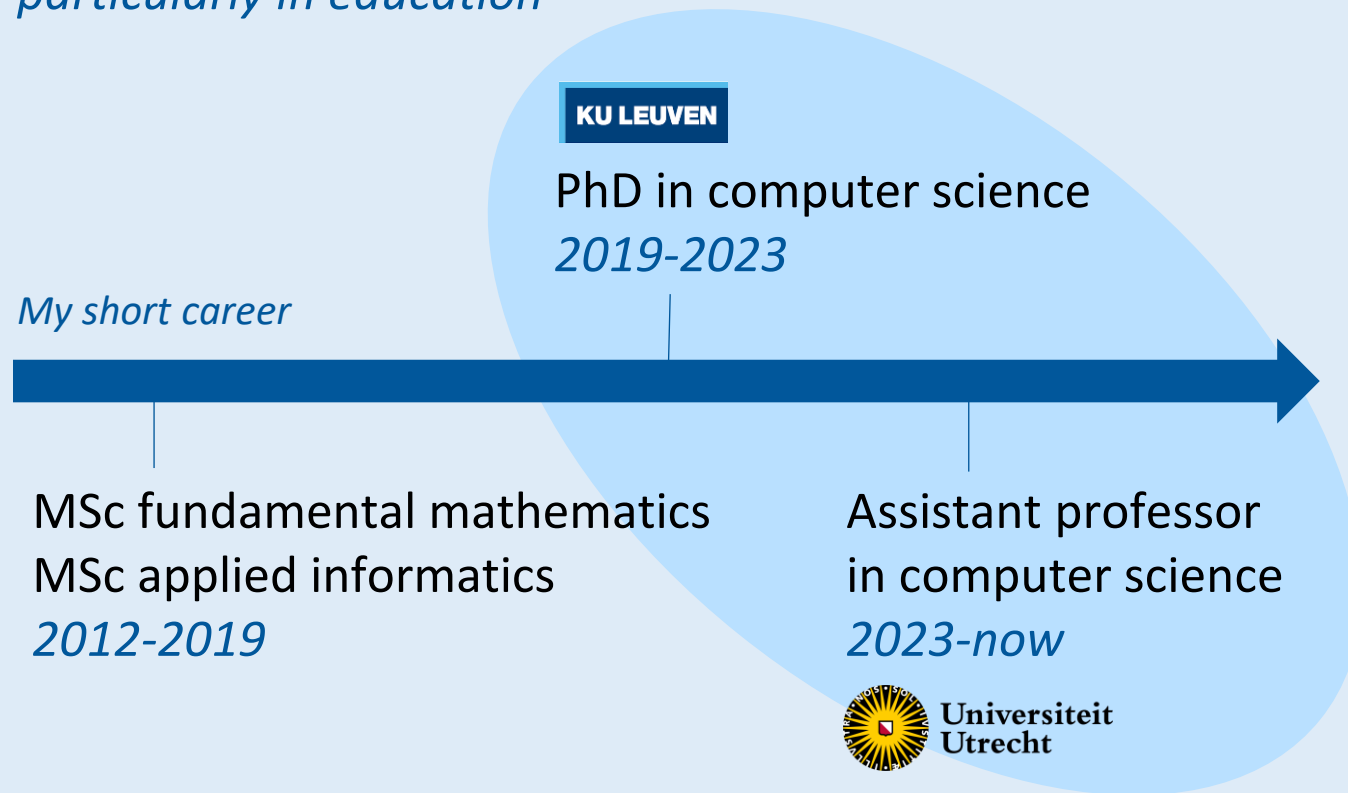


Hmm, I should do it! 💪



About Me

Create AI systems and make them explainable and controllable, particularly in education



Jeroen Ooge
jeroenooge.be

I How to adapt education?

Examples of adaptation in education

II What is my research about?

Transparent and controllable

AI systems for education

III How can you contribute?

Exercise & ideas for master's theses

AI can help make education adaptive in many ways

Teaching

- Teaching-aid
- Teaching quality
- Pedagogical agents
- Training of teachers
- Personalised teaching
- Improving teaching



Student performance

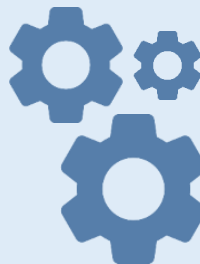
- Dropout prediction
- Assessment
- Cognitive diagnosis
- Achievements
- Grading
- Reading ability
- Creativity
- Engagement
- Feedback
- Argumentation



“AI” consists of algorithms with specific tasks



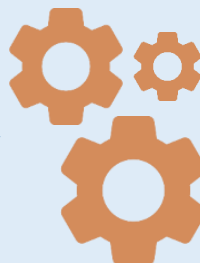
Available exercises



Recommended exercise



Learner profile



Predicted progress/risk

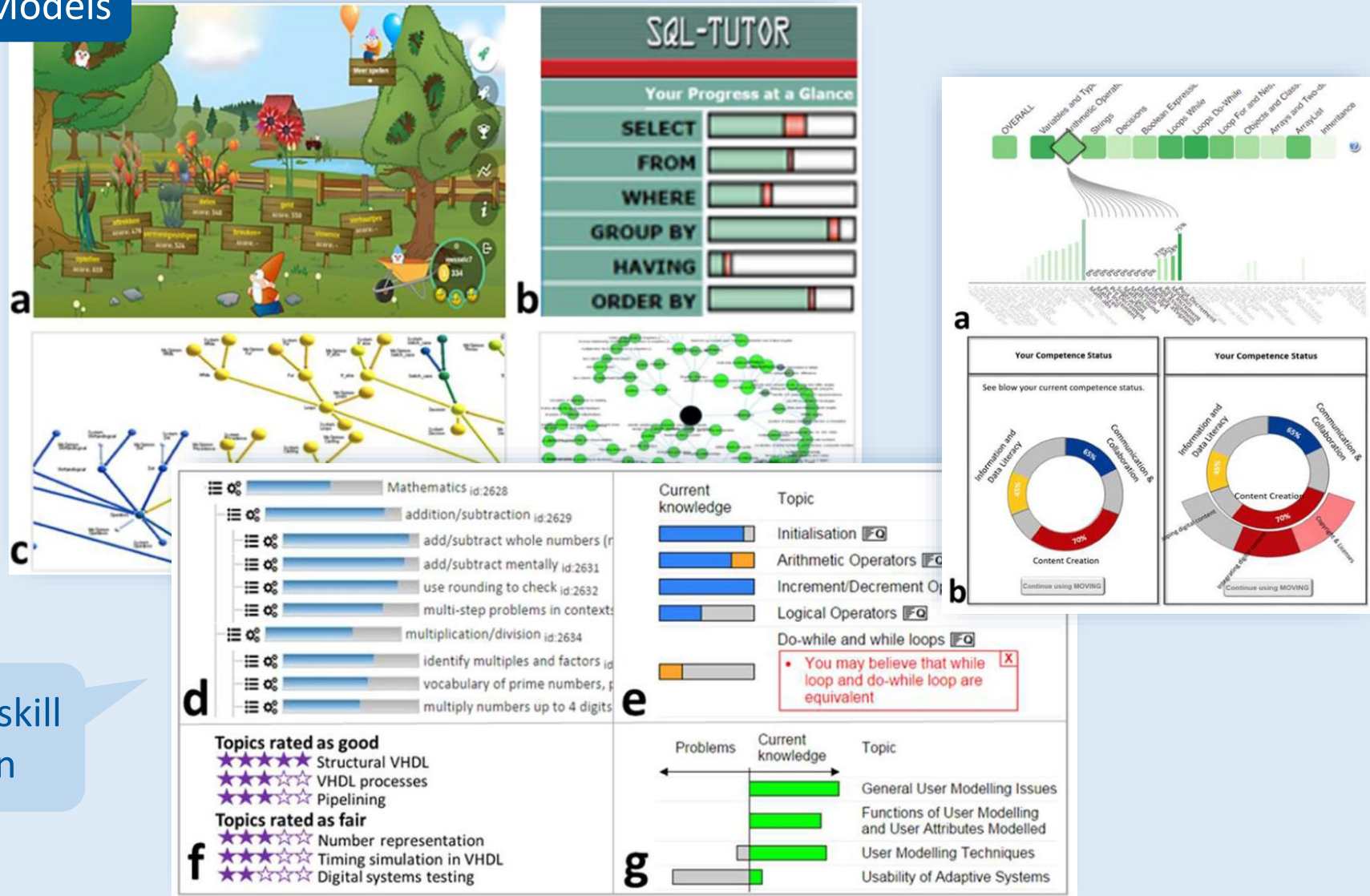
AaI

Textual prompt



Exam question

Open Learner Models



Algorithmic skill estimation

Goed gewerkt!

Maak een aangeraden oefening van hetzelfde hoofdstuk

Waarom deze oefening? Wisk! denkt dat jouw huidige niveau past bij dit van deze oefening!

Wisk! 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.

Aangeraden

 **Oefening 32**

 **Oefening 42**

 **Oefening 3**

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



pogingen nodig	aantal leerlingen
1	10
2	2
3	1
> 4	2

Maak oefening 32

... of kies zelf je volgende oefening

Naar het oefeningsoverzicht

[illegible]

WISKO

personalised maths practice with AI

WISKI

Schakel hier technieken in die jou verderom en Wiski te gebruiken. Schakel die 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 klassamentpagina. Er zijn twee klassamenten: 'deze week' en 'aller tijden'.



Oefeningenklassement

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



How good do you

There is no right or wrong answer. V

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



[Cursussen](#)



Kies het onderwerp waarvoor je wilt oefenen.

Er start dan een reeks met 3 oefeningen over dat onderwerp.

1

2

3

Natuurlijke getallen

Hoofdbewerkingen

Volgorde van bewerkingen



Gehele getallen

Volgorde van bewerkingen

Eigenschappen van de hoofdbewerkingen

Eerstegraadsvergelijkingen

Rekenen met lettervormen

Machten



Basisbegrippen meetkunde

Coördinaten in de ruimte

Hoeken

Omtrek en oppervlakte van vlakke figuren

The screenshot displays the 'Wiskol' website interface. At the top, there are navigation links: 'Definieren', 'Helpen', and 'Oefeningen overzicht'. The main content area is divided into two sections. The left section, titled 'Badge Vooruitgang', shows a progress bar with five segments. The first three segments are highlighted in yellow and labeled '1', '2', and '3'. The fourth segment is labeled '4' and the fifth '5'. A large arrow points from the progress bar to the right section, titled 'Challenge Badges'. This section shows three challenge badges: a red one labeled '0', a silver one labeled '0', and a gold one labeled '1'. Below the progress bar, there is a section titled 'Badges Overzicht' which lists 'Delen van oplossingen (2/4)' and 'Medestudenten helpen (1/2)'. Below this, there is a section titled 'Bijdrage aan de oplossing' which shows a progress bar with a green segment labeled '3/5' and a red segment labeled '0/5'. Below this, there is a section titled 'Mede bijdrage aan de oplossing' which shows a progress bar with a green segment labeled '2/5' and a red segment labeled '0/5'. At the bottom, there is a section titled 'Hoe is uw nieuwe level bepaald?' which explains that the level and difficulty of exercises change when solving exercises, and that the level remains similar after solving the exercise series, but it increased even further because of your feedback.

Volgorde van bewerkingen



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

- ☒ 0
- ☐ -144
- ☐ 72
- ☐ 144

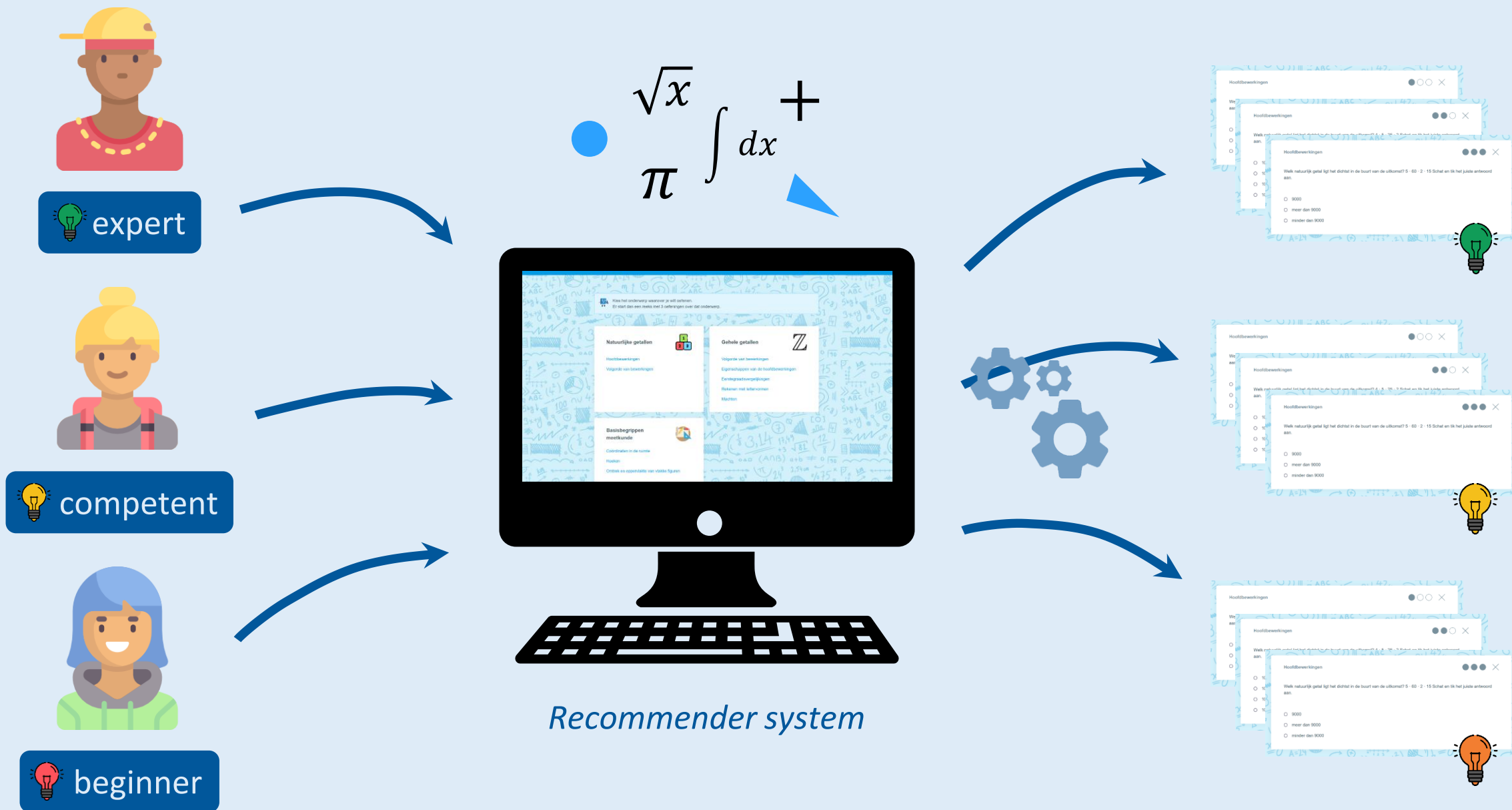


Correct

Top-21

Overslaan

Volgende



Estimating mastery and difficulty with Elo ratings

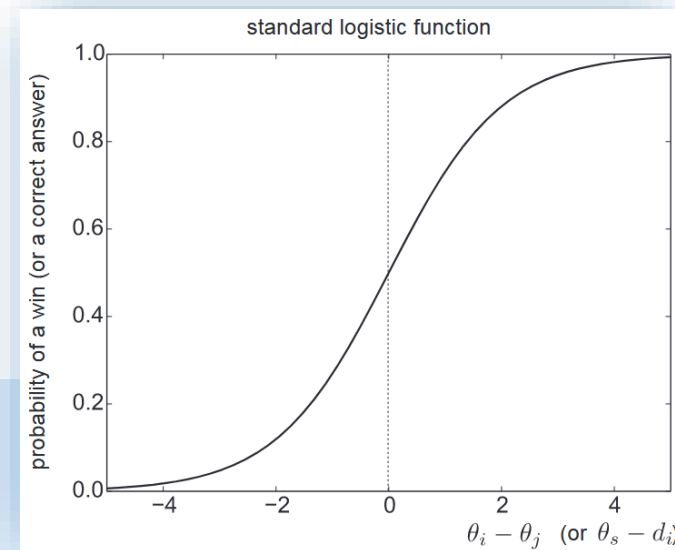
2.2. The Elo rating system in an educational setting

To apply the Elo rating system in the context of educational systems, we interpret a student's answer to an item as a match between the student and the item. In this context it is natural to slightly change the notation while keeping the basic principle the same. We denote skill of a student s as θ_s , difficulty of an item i as d_i , and the correctness of an answer of a student s on an item i as $\text{correct}_{si} \in \{0,1\}$. The probability of a correct answer is given by the logistic function with respect to the difference between skill and difficulty (Fig. 1 left):

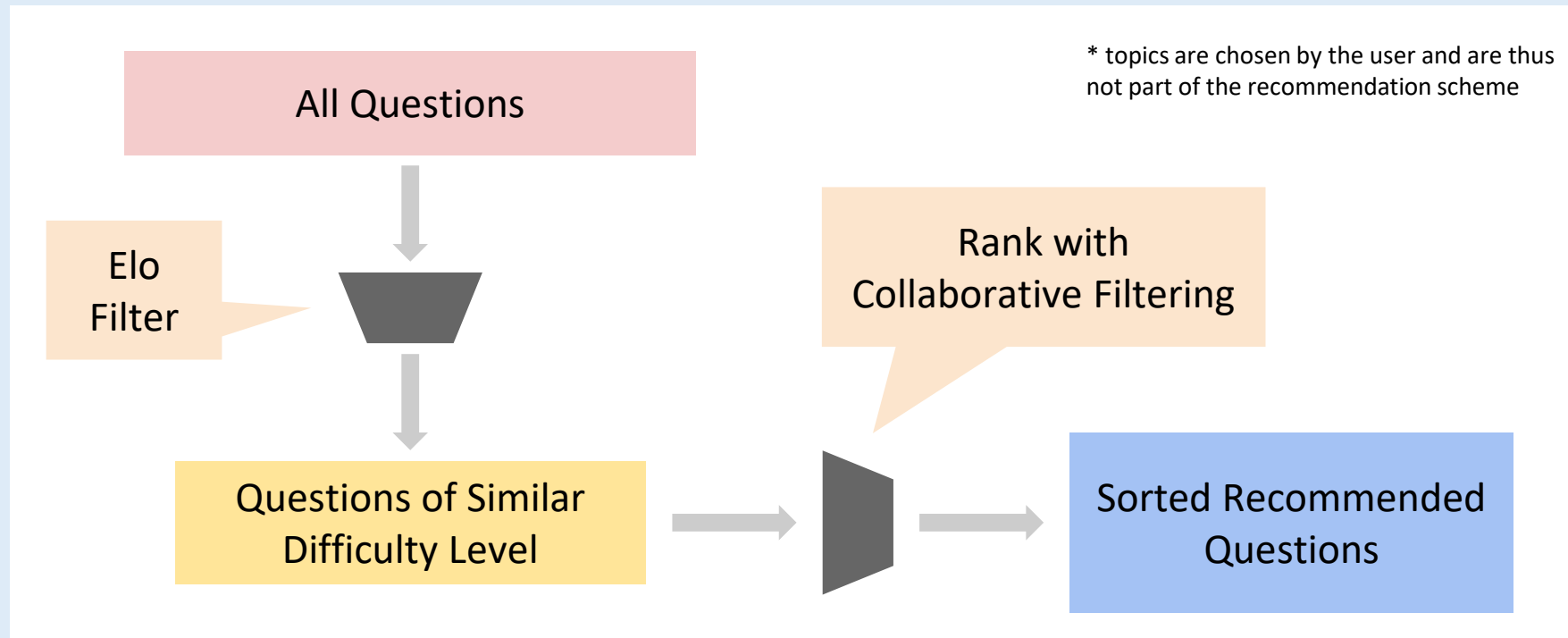
$$P(\text{correct}_{si} = 1) = 1 / (1 + e^{-(\theta_s - d_i)})$$

The skill and difficulty estimates are updated as follows:

$$\begin{aligned}\theta_s &:= \theta_s + K \cdot (\text{correct}_{si} - P(\text{correct}_{si} = 1)) \\ d_i &:= d_i + K \cdot (P(\text{correct}_{si} = 1) - \text{correct}_{si})\end{aligned}$$



Recommending with Elo and collaborative filtering





I How to adapt education?

Examples of adaptation in education

II What is my research about?

Transparent and controllable

adaptive ~~AI~~ systems for education

Call it *adaptive* systems

III How can you contribute?

Exercise & ideas for master's theses





Available exercises



Recommended exercise



Learner profile



Predicted progress/risk



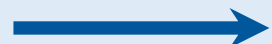
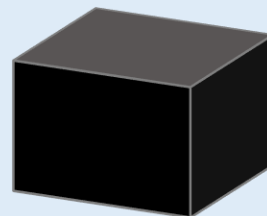
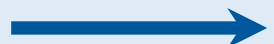
Textual prompt



Exam question



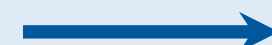
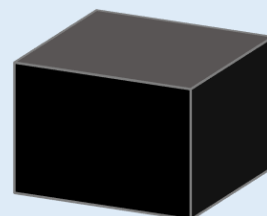
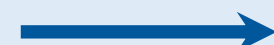
Available exercises



Recommended exercise



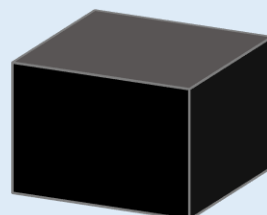
Learner profile



Predicted progress/risk



Textual prompt



Exam question



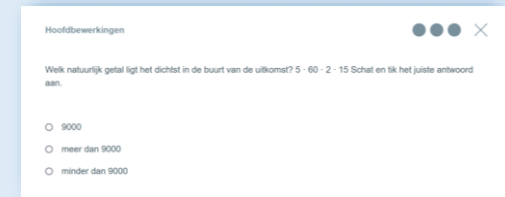
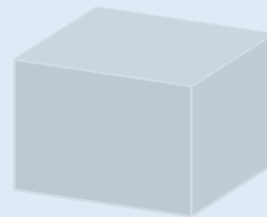
Available exercises

We need to “explain” these AI black boxes!

We should be able to control AI!



Textual prompt



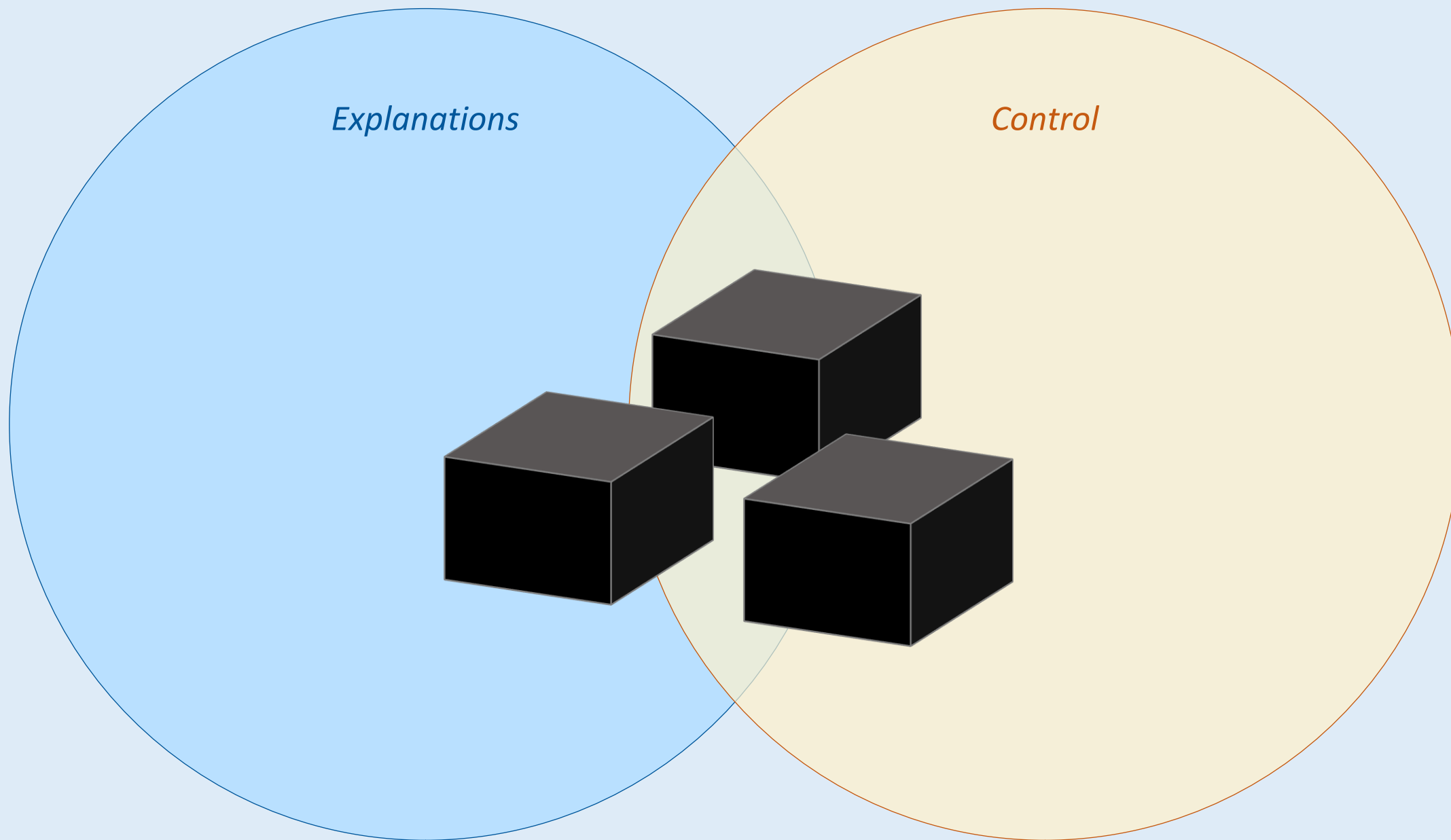
Recommended exercise

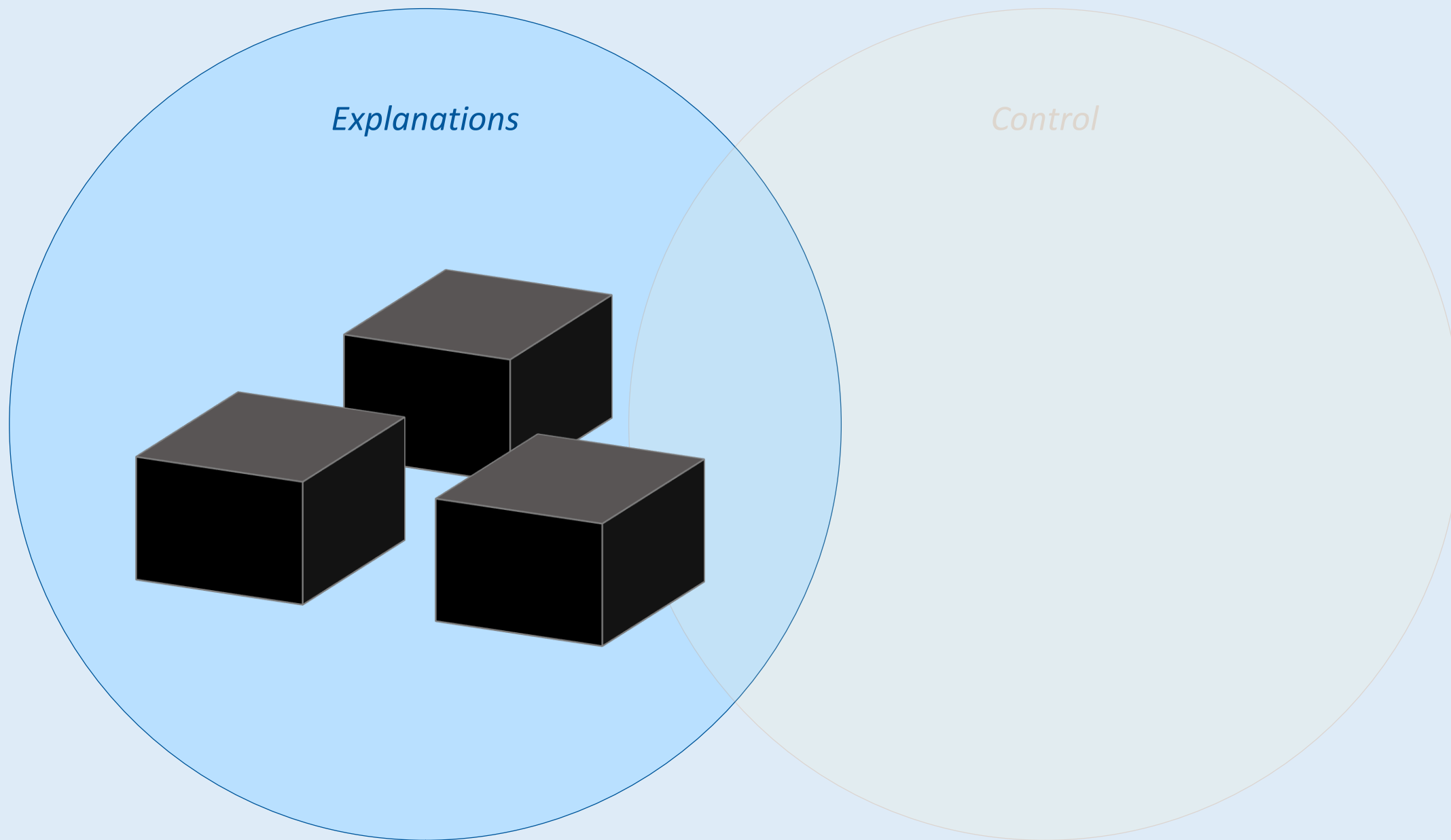


Predicted progress/risk

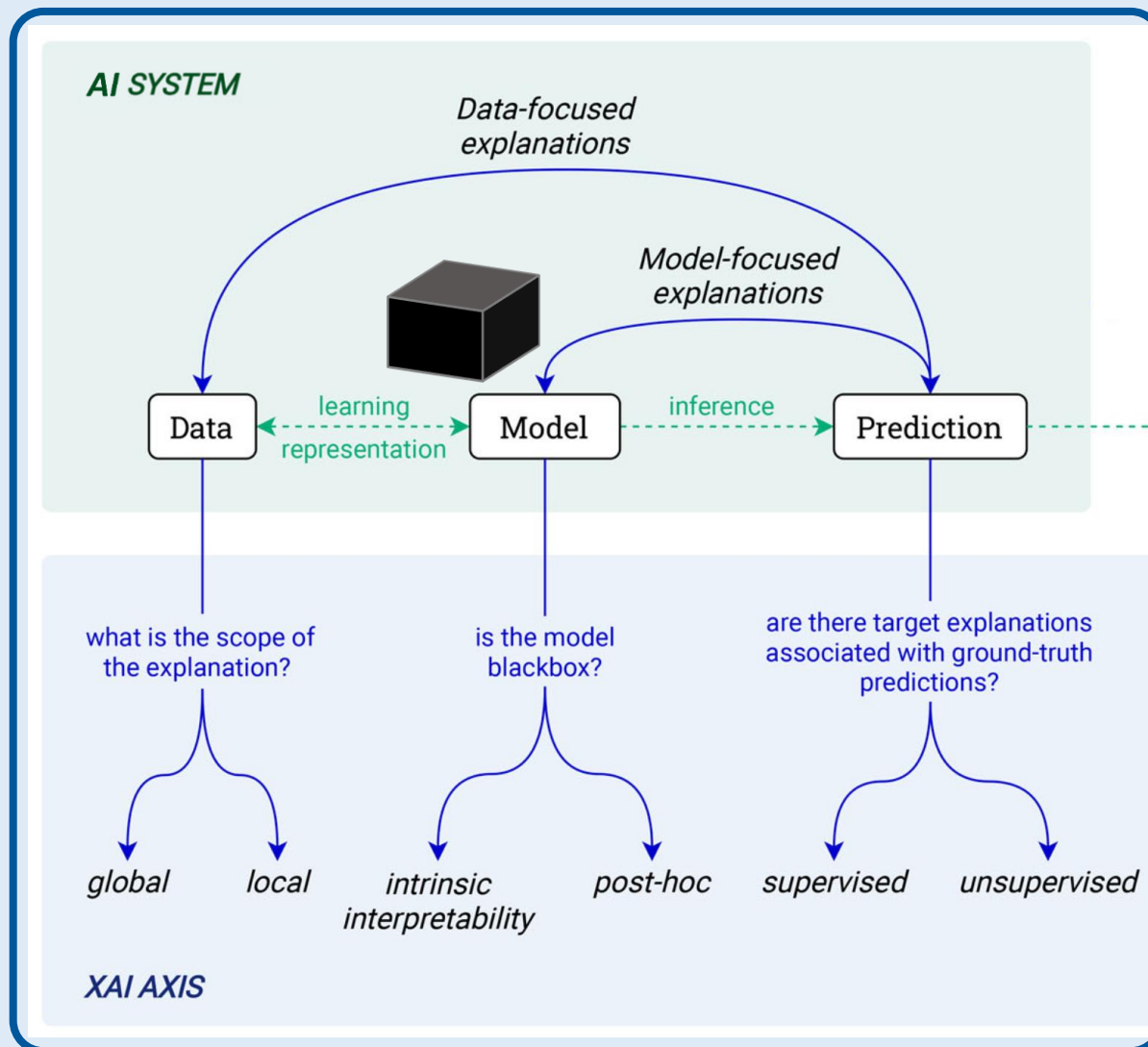


Exam question

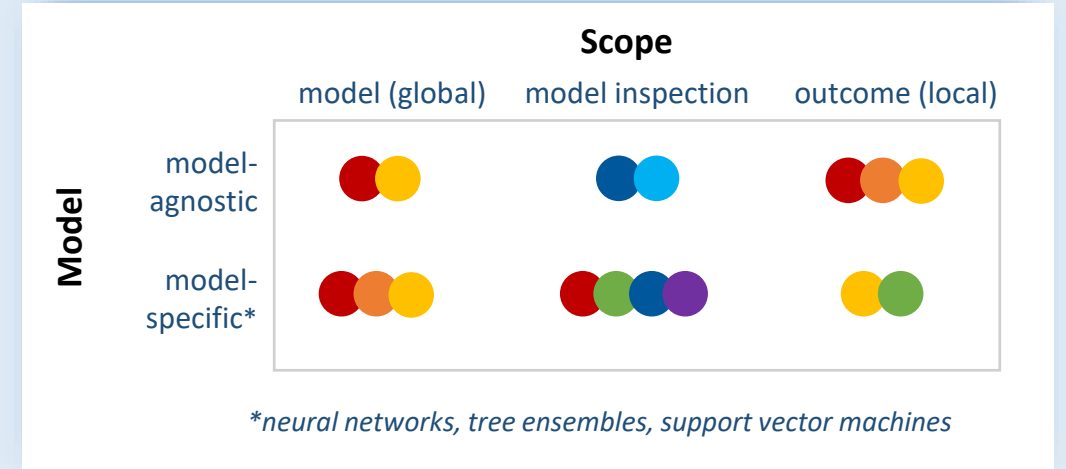
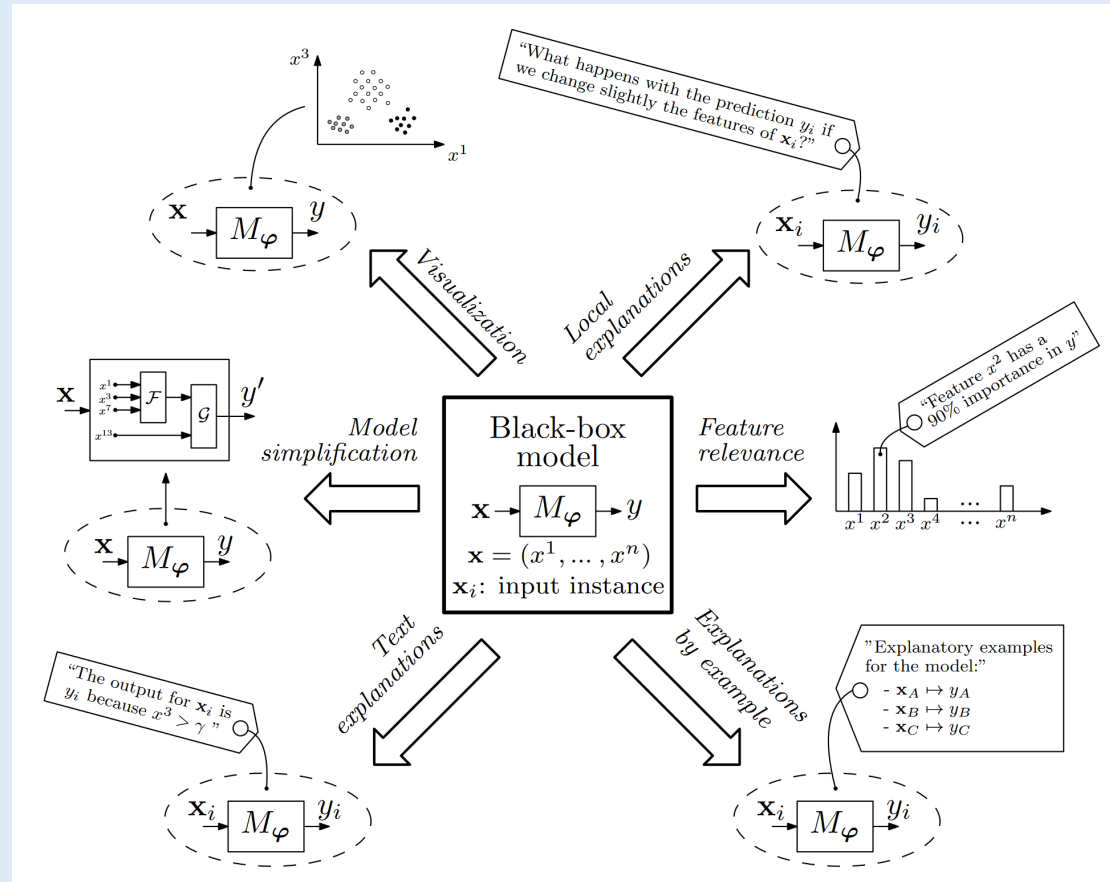




Algorithmic Explainability



Algorithmic Explainability

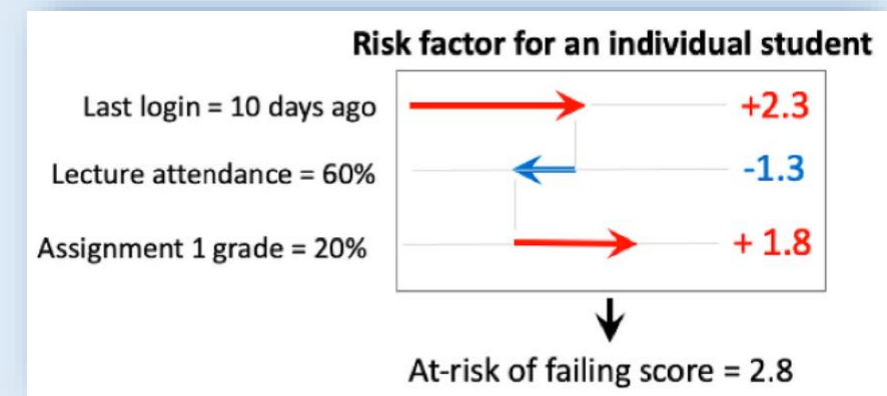
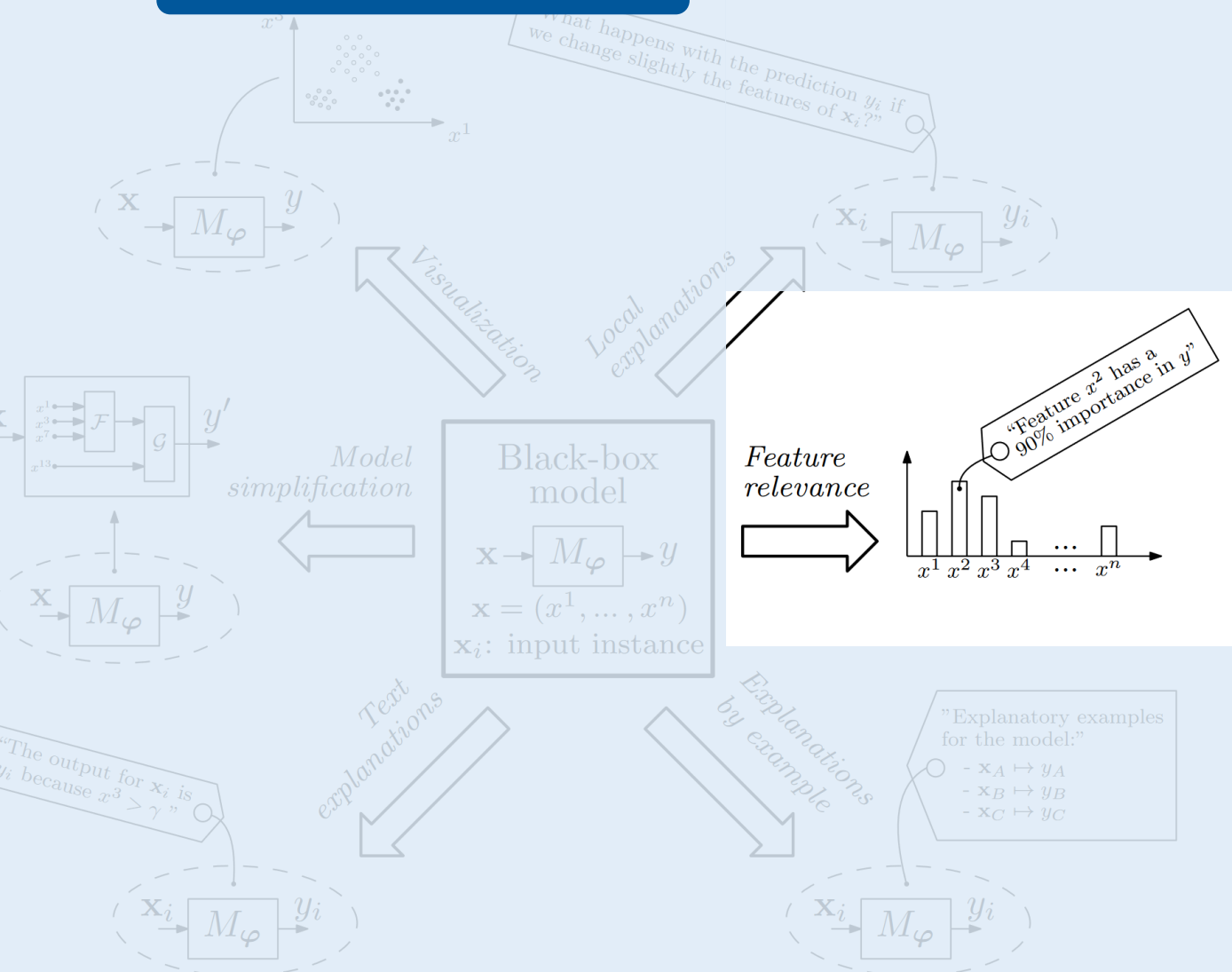


- Decision tree
- Decision rules
- Feature importance
- Saliency mask
- Partial dependence plot
- Sensitivity analysis
- Activation maximisation

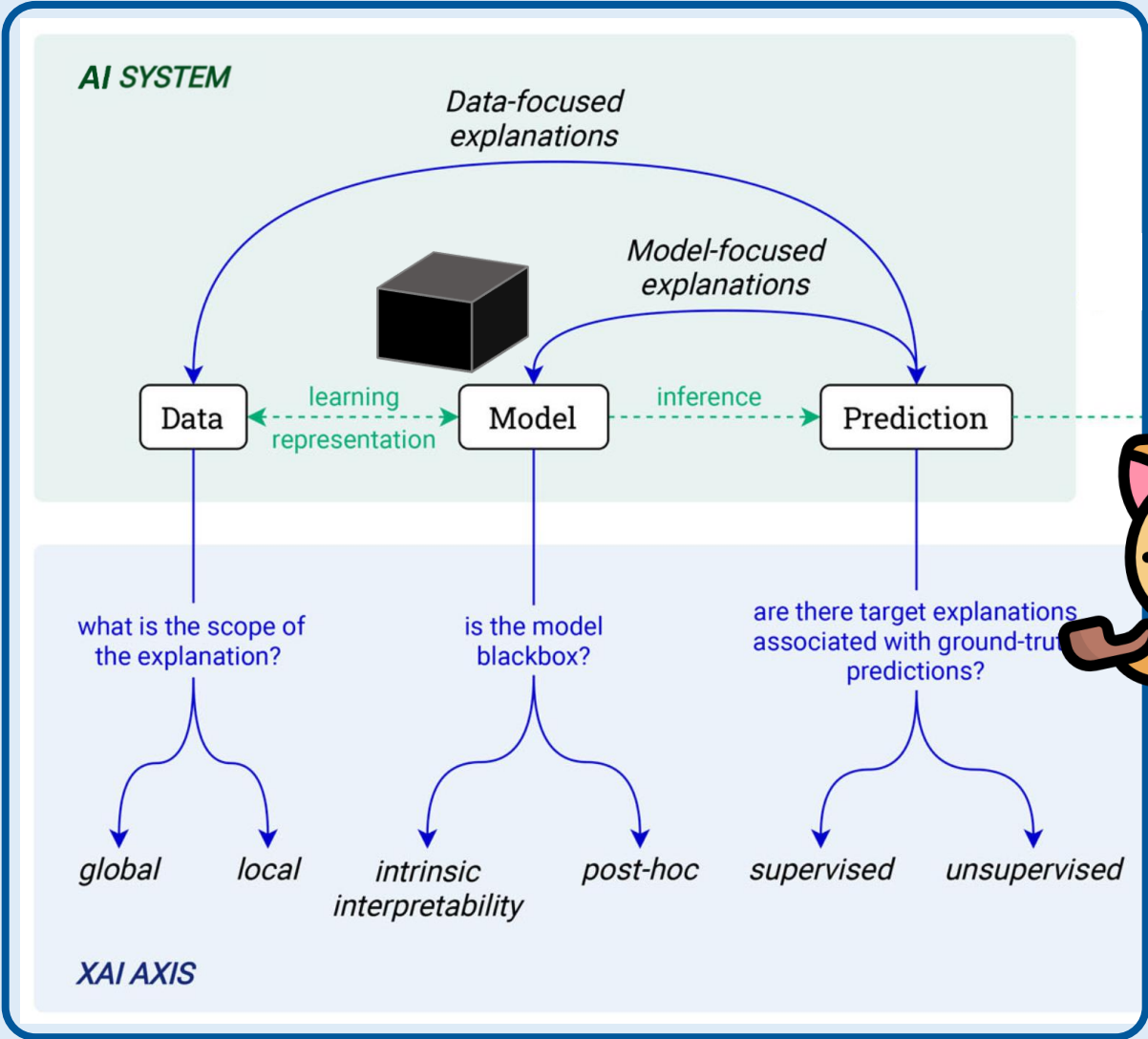
Alejandro Barredo Arrieta et al. 2020. Explainable Artificial Intelligence (XAI): Concepts, taxonomies, opportunities and challenges toward responsible AI. Information Fusion 58: 82–115. <https://doi.org/10.1016/j.inffus.2019.12.012>

Riccardo Guidotti, Anna Monreale, Salvatore Ruggieri, Franco Turini, Fosca Giannotti, and Dino Pedreschi. 2019. A Survey of Methods for Explaining Black Box Models. ACM Computing Surveys 51, 5: 1–42. <https://doi.org/10.1145/3236009>

Algorithmic Explainability



Algorithmic Explainability

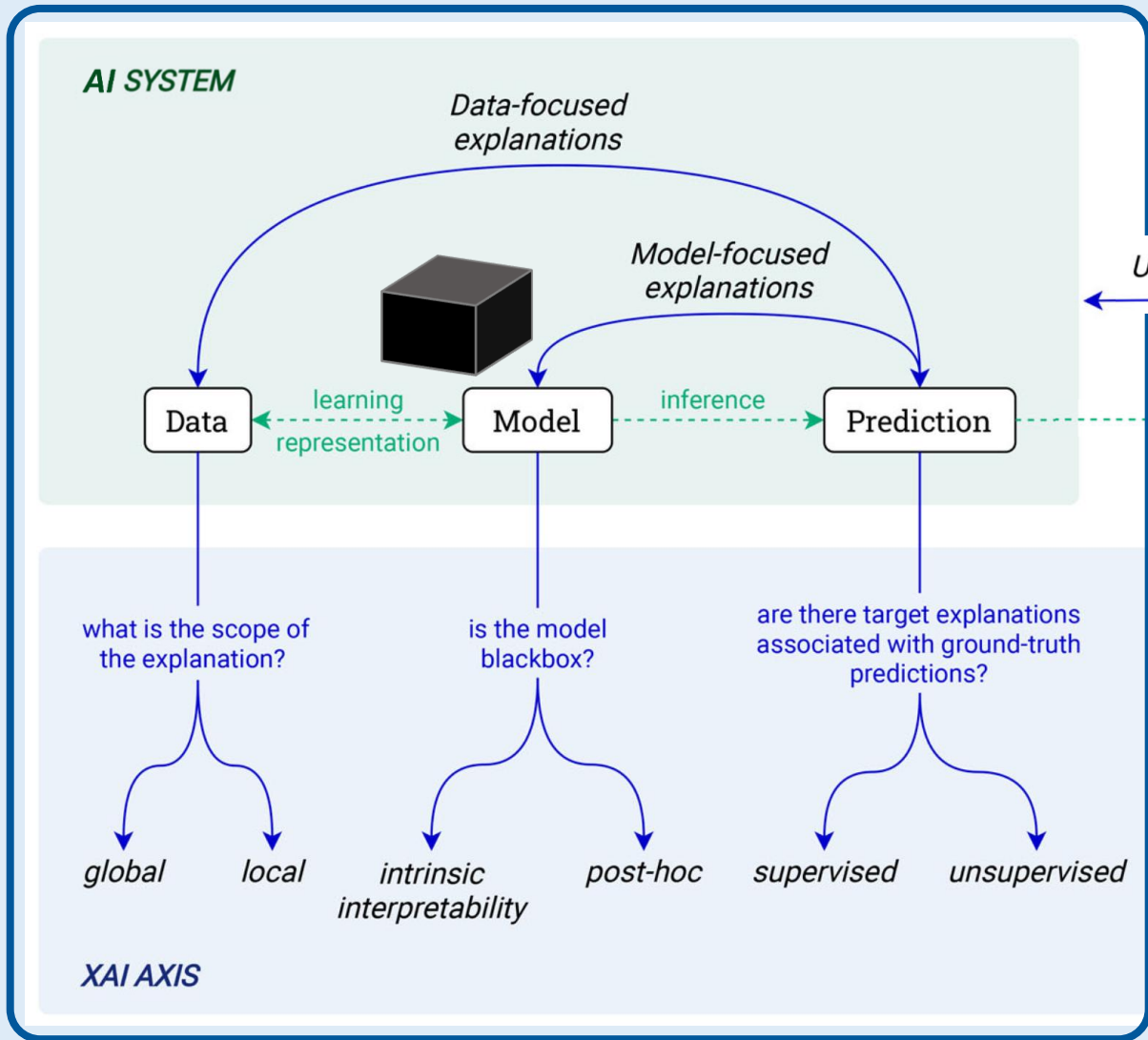


Which explanation do we use?

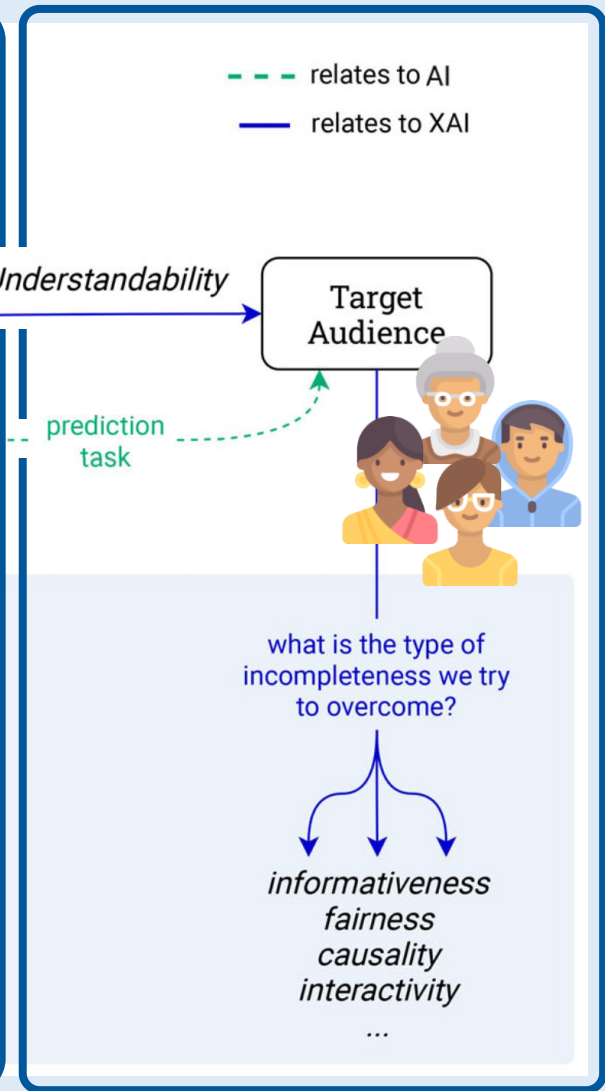
Who is the audience?

What is their context?

Algorithmic Explainability



Human-Centred Explainability





Human-Centred Explainability

Different people and contexts
need different explainability solutions

Research goal: Design tailored explanations and evaluate how they affect people's behaviour (e.g., trust, understanding, motivation, learning)

Data

What kind of data was the system trained on?
 What is the source of the training data?
 How were the labels/ground-truth produced?
 What is the sample size of the training data?
 What dataset(s) is the system NOT using?
 What are the potential limitations/biases of the data?
 What is the size, proportion, or distribution of the training data with given feature(s)/feature-value(s)?

Output

What kind of output does the system give?
 What does the system output mean?
 What is the scope of the system's capability?
 Can it do...?
 How is the output used for other system component(s)?
 How should I best use the output of the system?
 How should the output fit in my workflow?

Performance

How accurate/precise/reliable are the predictions?
 How often does the system make mistakes?
 In what situations is the system likely to be correct/ incorrect?
 What are the limitations of the system?
 What kind of mistakes is the system likely to make?
 Is the system's performance good enough for...?

How

How does the system make predictions?
 What features does the system consider?
 Is [feature X] used or not used for the predictions?
 What is the system's overall logic?
 How does it weigh different features?
 What kind of rules does it follow?
 How does [feature X] impact its predictions?
 What are the top rules/features that determine its predictions?
 What kind of algorithm is used?
 How were the parameters set?

Why

Why/how is this instance given this prediction?
 What feature(s) of this instance determine the system's prediction of it?
 Why are [instance A and B] given the same prediction?

Why not

Why is this instance NOT predicted to be [a different outcome]?
 Why is this instance predicted [P instead of a different outcome Q]?
 Why are [instance A and B] given different predictions?

How

How should I differ...
 What is instance...
 How should I differ...
 What is instance...
 How should I differ...

How

What is instance...
 What is feature...
 What value(s) predict...
 What is prediction?

What if

What is instance...
 What is feature...
 What is prediction...
 What is prediction...

Other

How/w...
 prove/d...
 Can I, s...
 (improv...
 Why i...
 algorithm...
 What d...
 mean?...
 What a...
 system?

Why

Why/how is this instance giving this prediction?

What feature(s) of this instance determine the system's prediction of it?

Why are [instance A and B] given the same prediction?

What if

What would the system predict if this instance changes to...?

What would the system predict if a given feature changes to...?

What would the system predict for [a different instance]?

What insights are people looking for?



Explanations are typically...

... **contrastive**: people don't ask why an event has taken place, but why another event *didn't*

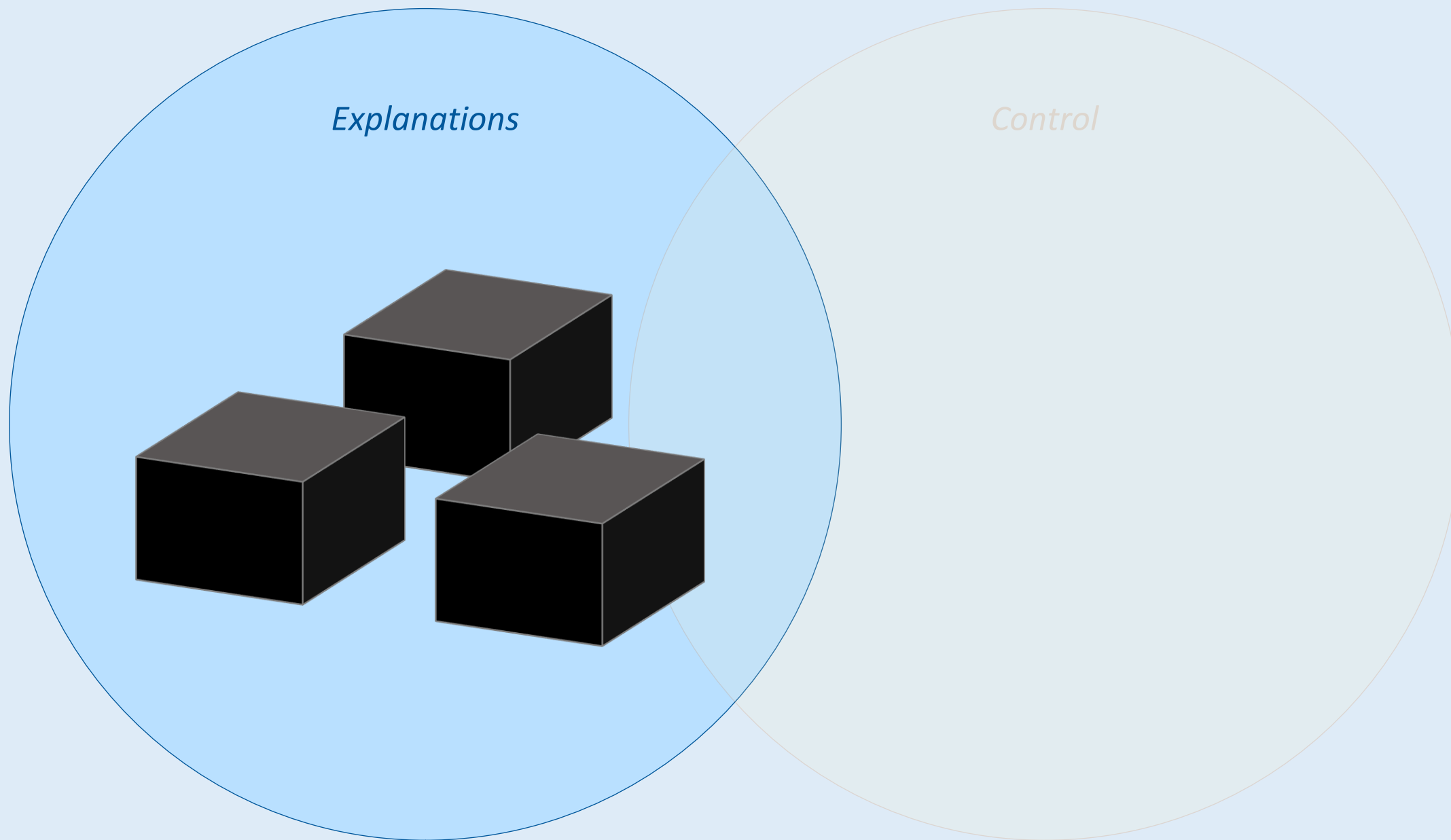
... **selected**: people select one or two causes of an event and consider those to be *the* explanation

... **social**: people adapt to listeners' current beliefs and knowledge in a conversation



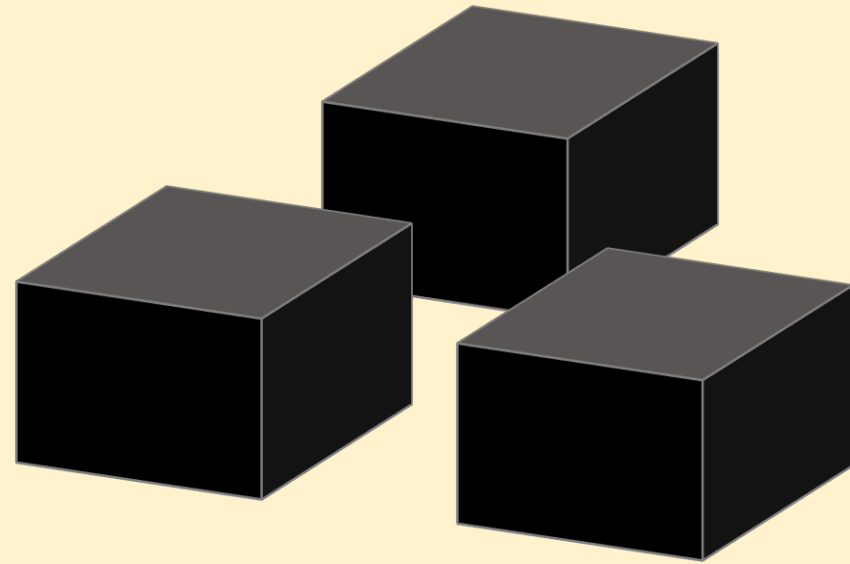
What can we learn
about explaining from
the social sciences?





Explanations

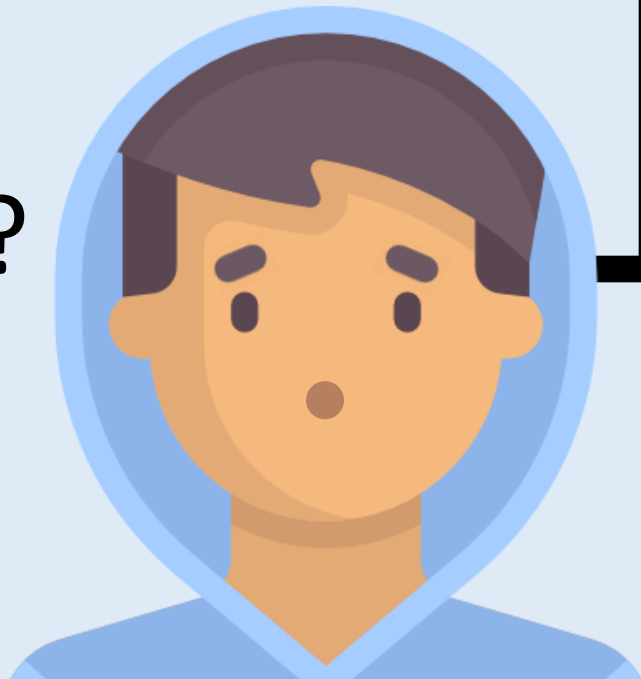
Control

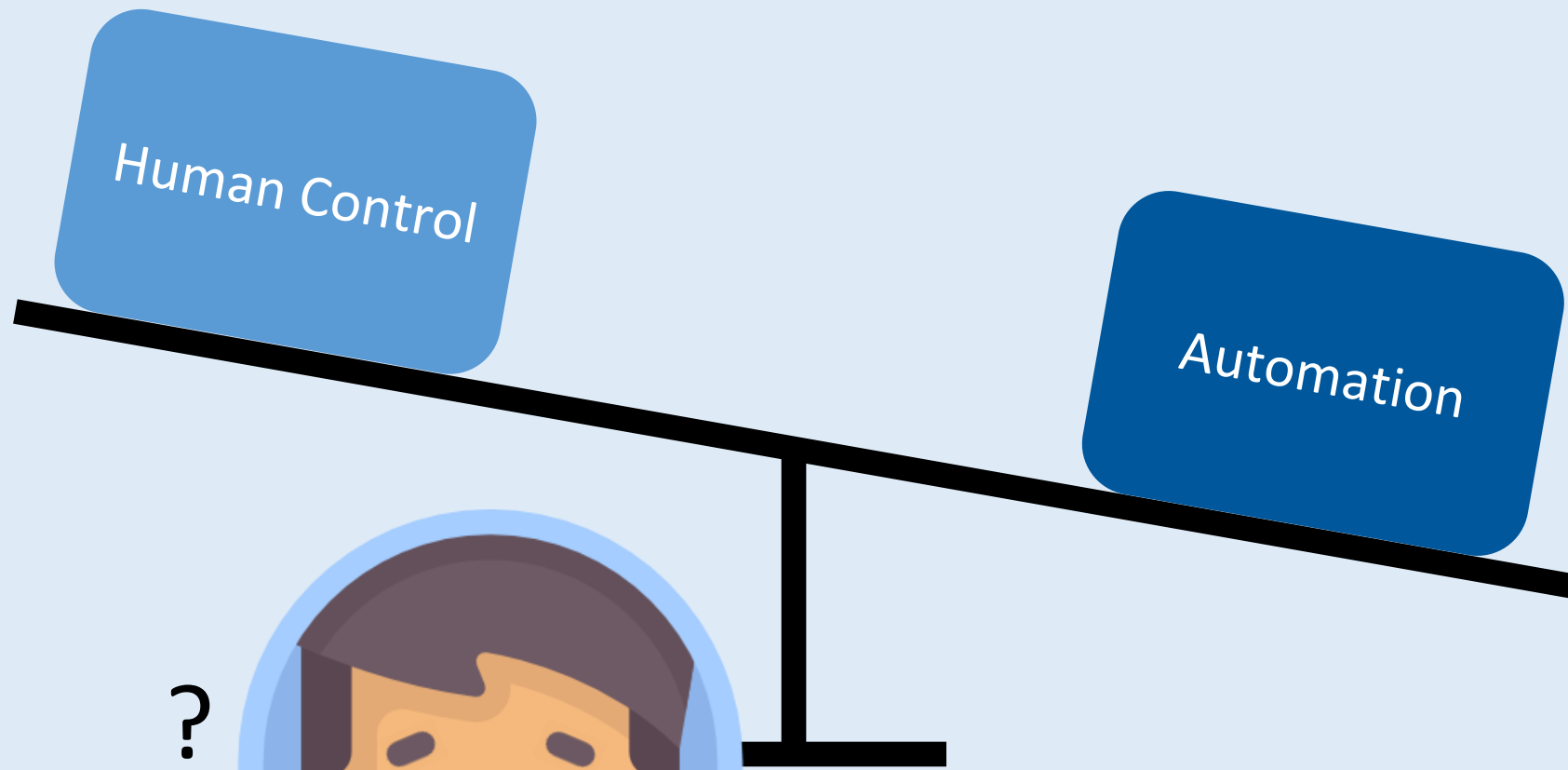


Human Control

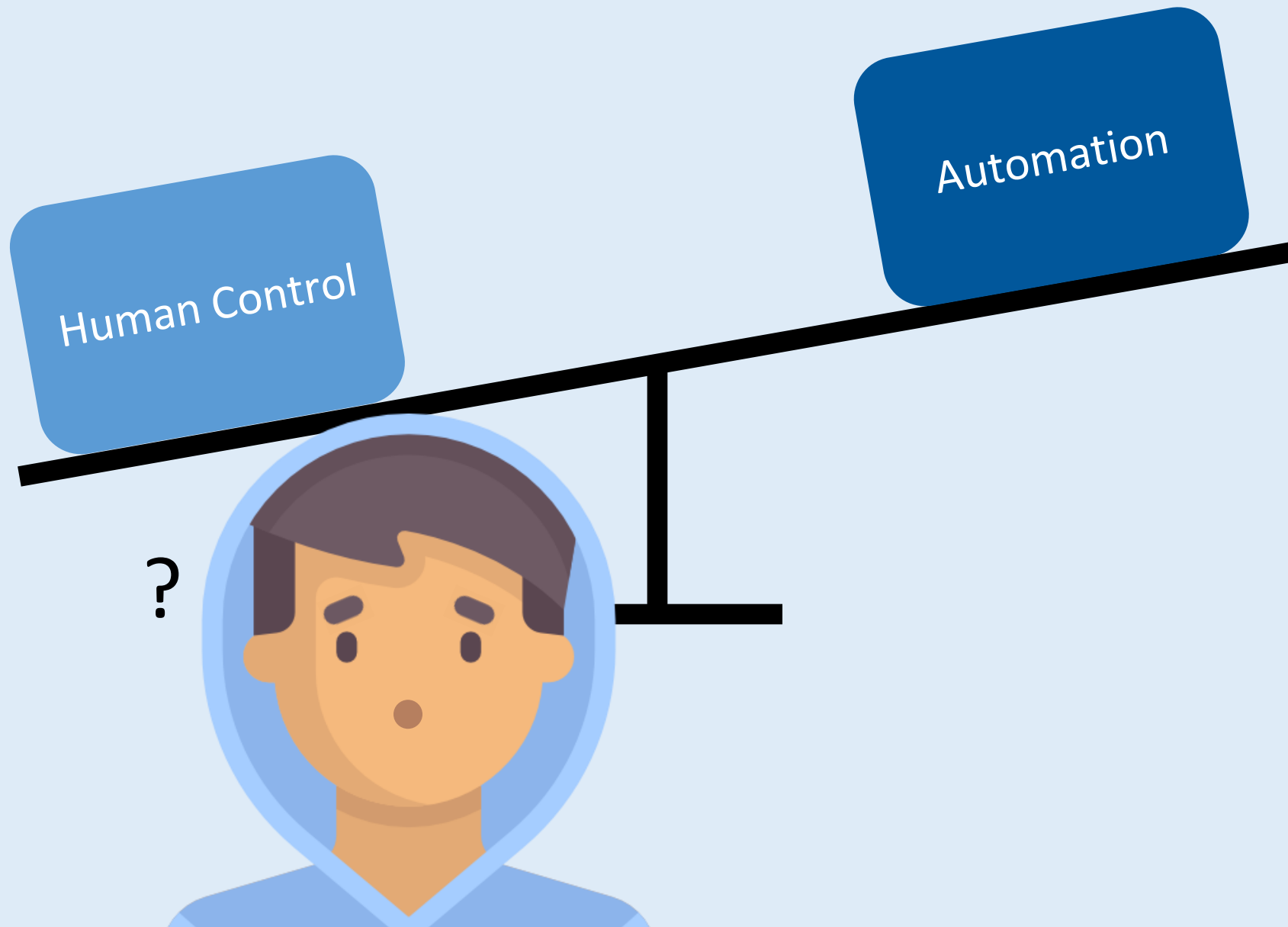
Automation

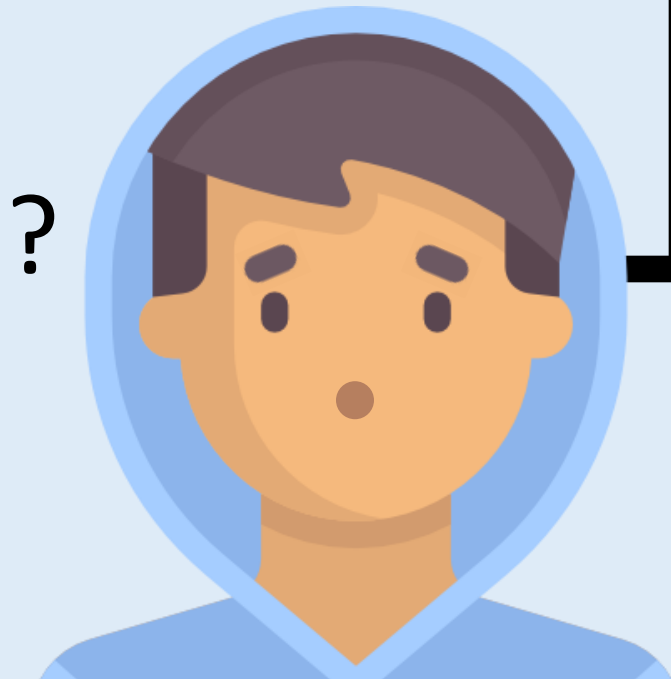
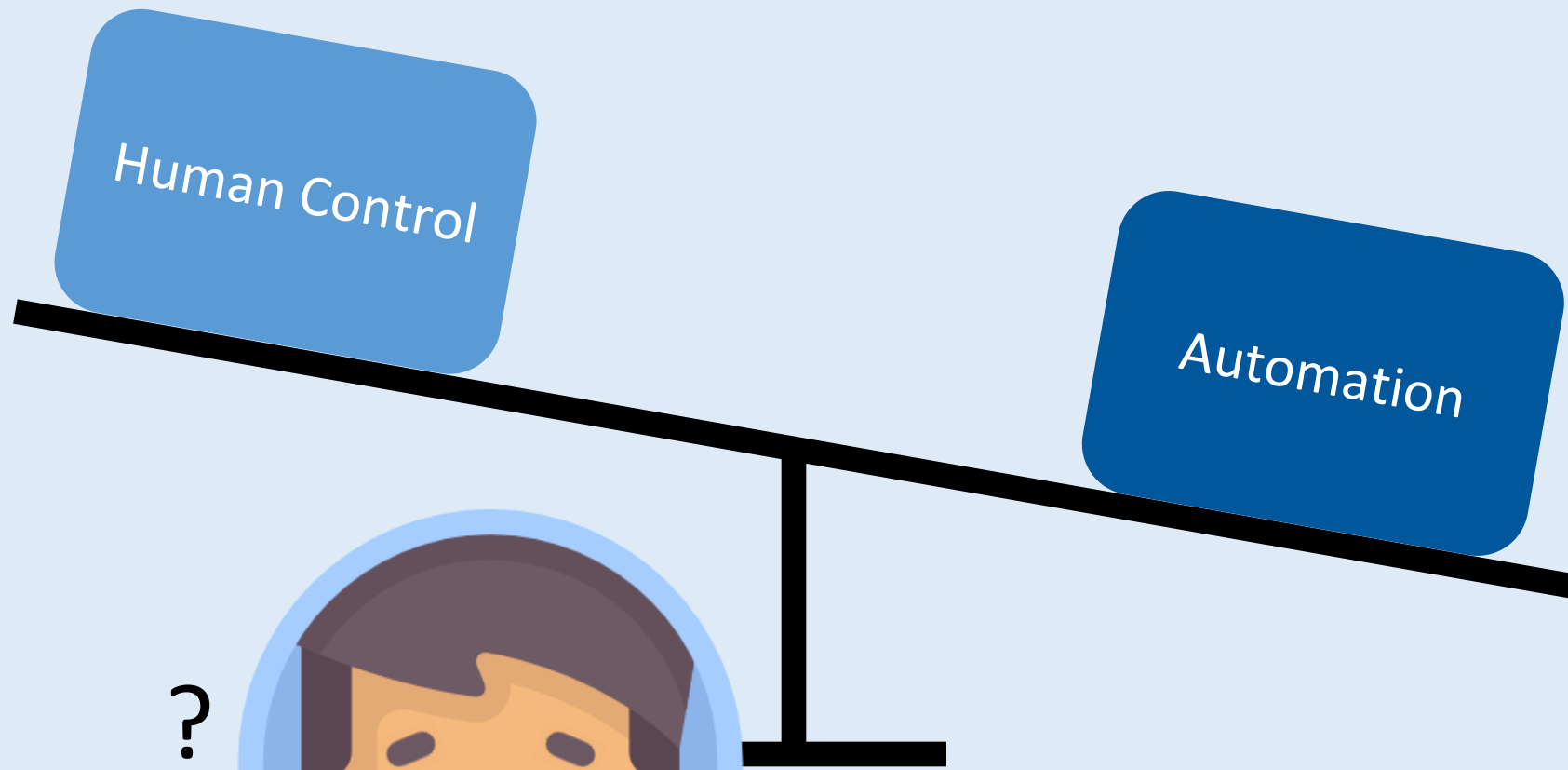
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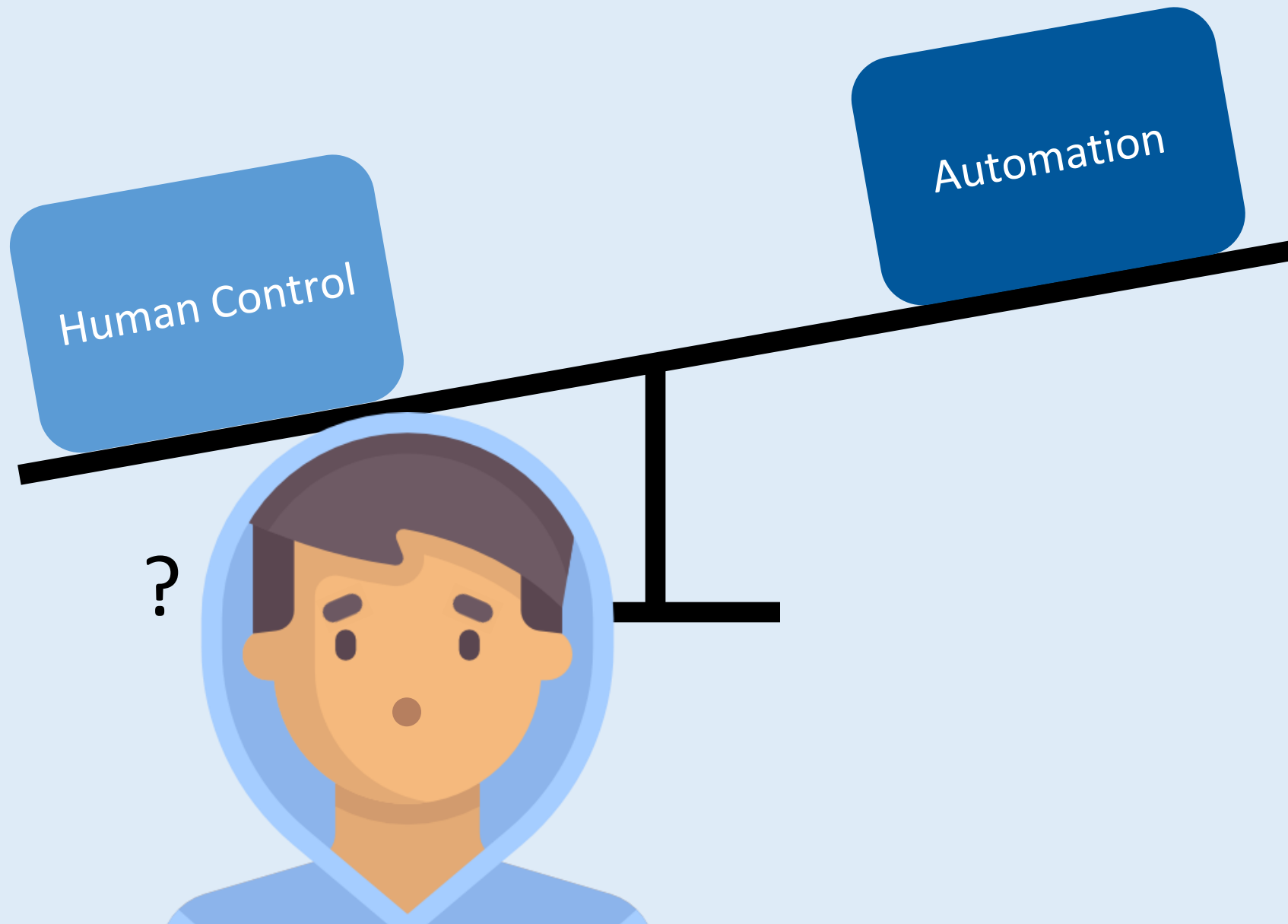




?



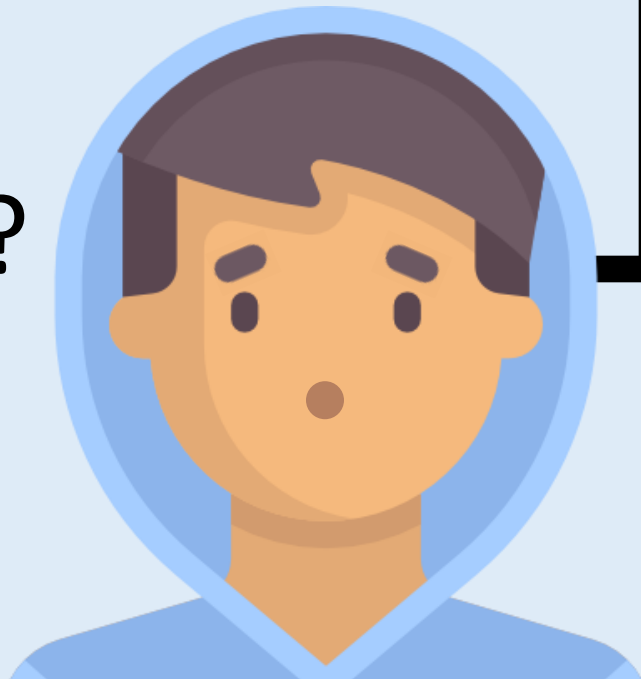


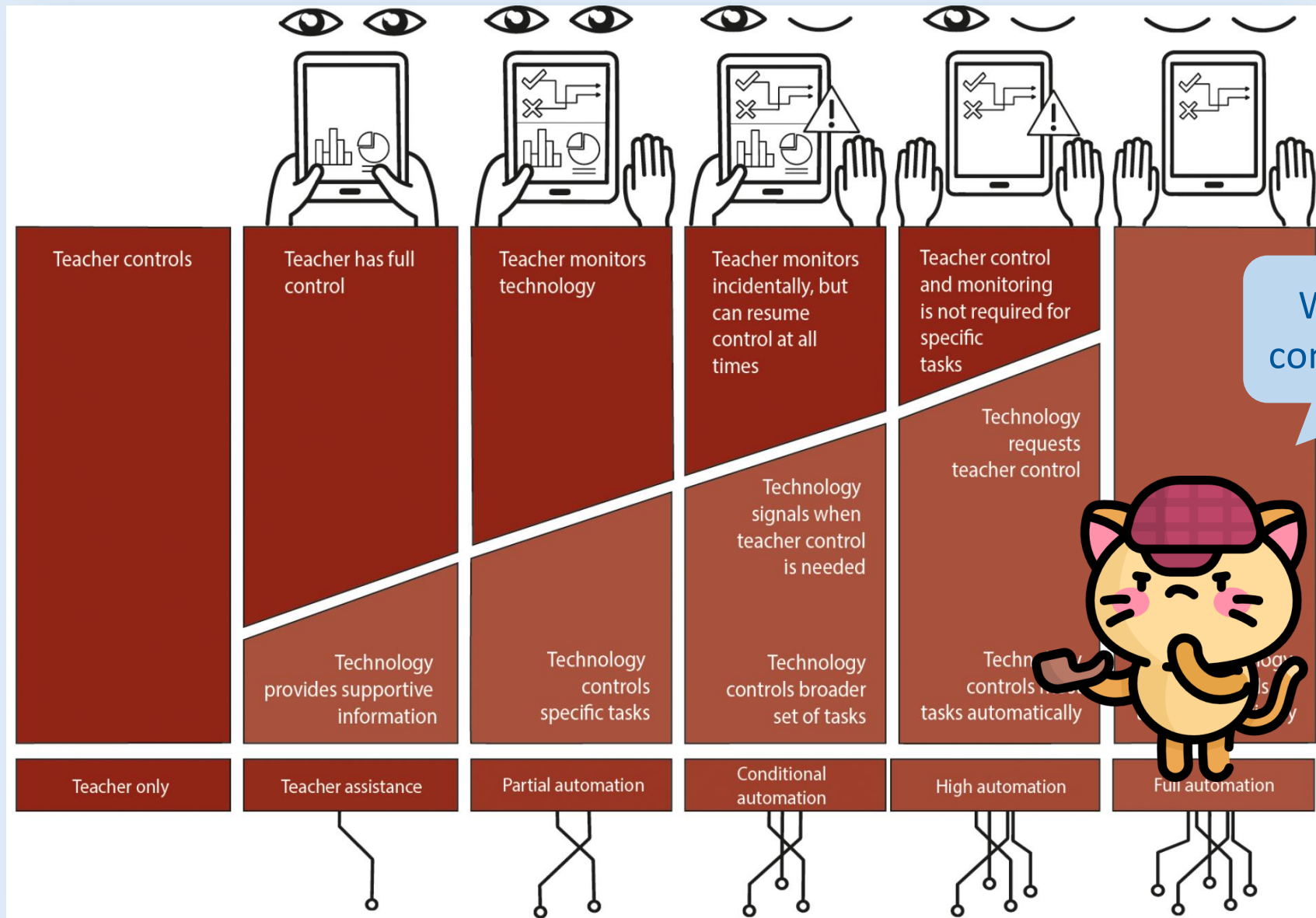


Human Control

Automation

?





Also applies to other educational stakeholders

What are suitable control mechanisms?

Who is the audience?

What is their context?



Human-Centred Explainability

Different people and contexts
need different explainability solutions

Research goal: Design tailored explanations and evaluate how they affect people's behaviour (e.g., trust, understanding, motivation, learning)



Human-Centred Explainability *and* Controllability

Different people and contexts need different explainability *and* controllability solutions

Research goal: Design tailored explanations *and* control mechanisms and evaluate how they affect people's behaviour (e.g., trust, understanding, motivation, learning)



Explanations

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.

Number of attempts fellow students needed to solve exercise 21

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
Your level now

Start exercises

Control

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.

Solve more exercises on this topic

Return to exercise page

← 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

Explanations

Solve a recommended exercise of the same chapter

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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 after completion

Start exercise

Control

How is your new level determined?

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Expert

Proficient

Competent

Advanced beginner

Novice

Before series | After series | After feedback

Solve more exercises on this topic

Return to exercise page

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

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

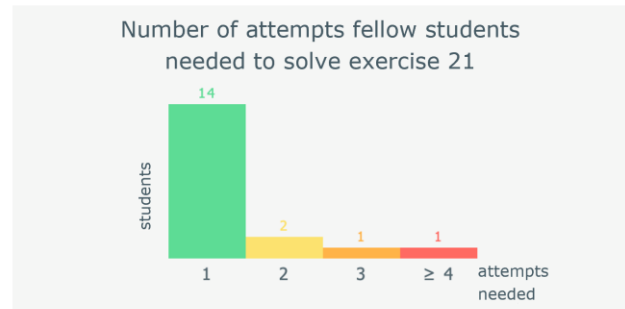
Solve a recommended exercise of the same chapter

Recommended



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

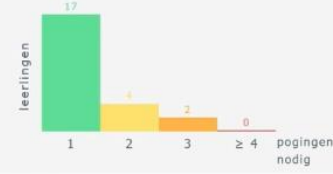
Aangeraden

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

Waarom deze oefening? Wiski denkt dat jouw huidige 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

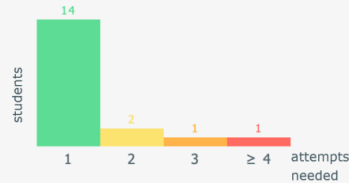
Recommended

-  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.

Number of attempts fellow students
needed to solve exercise 21



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



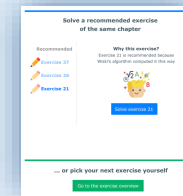
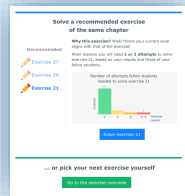
Solve exercise 21

... or pick your next exercise yourself

Go to the exercise overview

No explanation

How was trust in the platform affected?



Real vs no explanation

trust increased



trust unchanged

trust decreased

Placebo vs no explanation

trust increased



trust unchanged

trust decreased

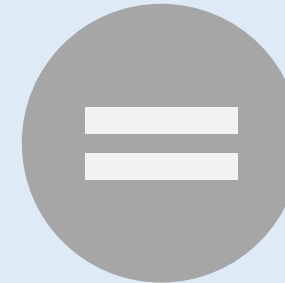
Competence	
Q1	Wiski is like an expert (for example, a teacher) for recommending exercises.
Q2	Wiski has the expertise (knowledge) to estimate my math level.
Q3	Wiski can estimate my math level.
Q4	Wiski understands the difficulty level of math exercises well.
Q5	Wiski takes my math level into account when recommending exercises.
Benevolence	
Q6	Wiski prioritizes that I improve in math.
Q7	Wiski recommends exercises so that I improve in math.
Q8	Wiski wants to estimate my math level well.
Integrity	
Q9	Wiski recommends exercises as correctly as possible.
Q10	Wiski is honest.
Q11	Wiski makes integrous recommendations.
Trust (one-dimensional)	
Q12	I trust Wiski to recommend me math exercises.
Intention to return	
Q13	If I want to solve math exercises again, I will choose Wiski.
Q14	If I want to be recommended math exercises again, I will choose Wiski.
Perceived transparency	
Q15	I find that Wiski gives enough explanation as to why an exercise is recommended.

Trusting beliefs

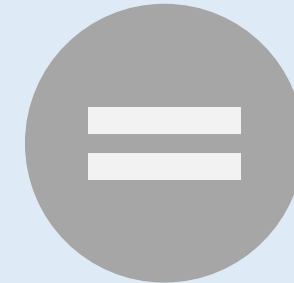
Multidimensional trust

Real vs no explanation

MD trust



1D trust

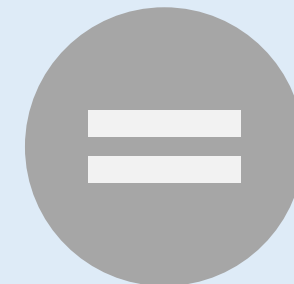


Placebo vs no explanation

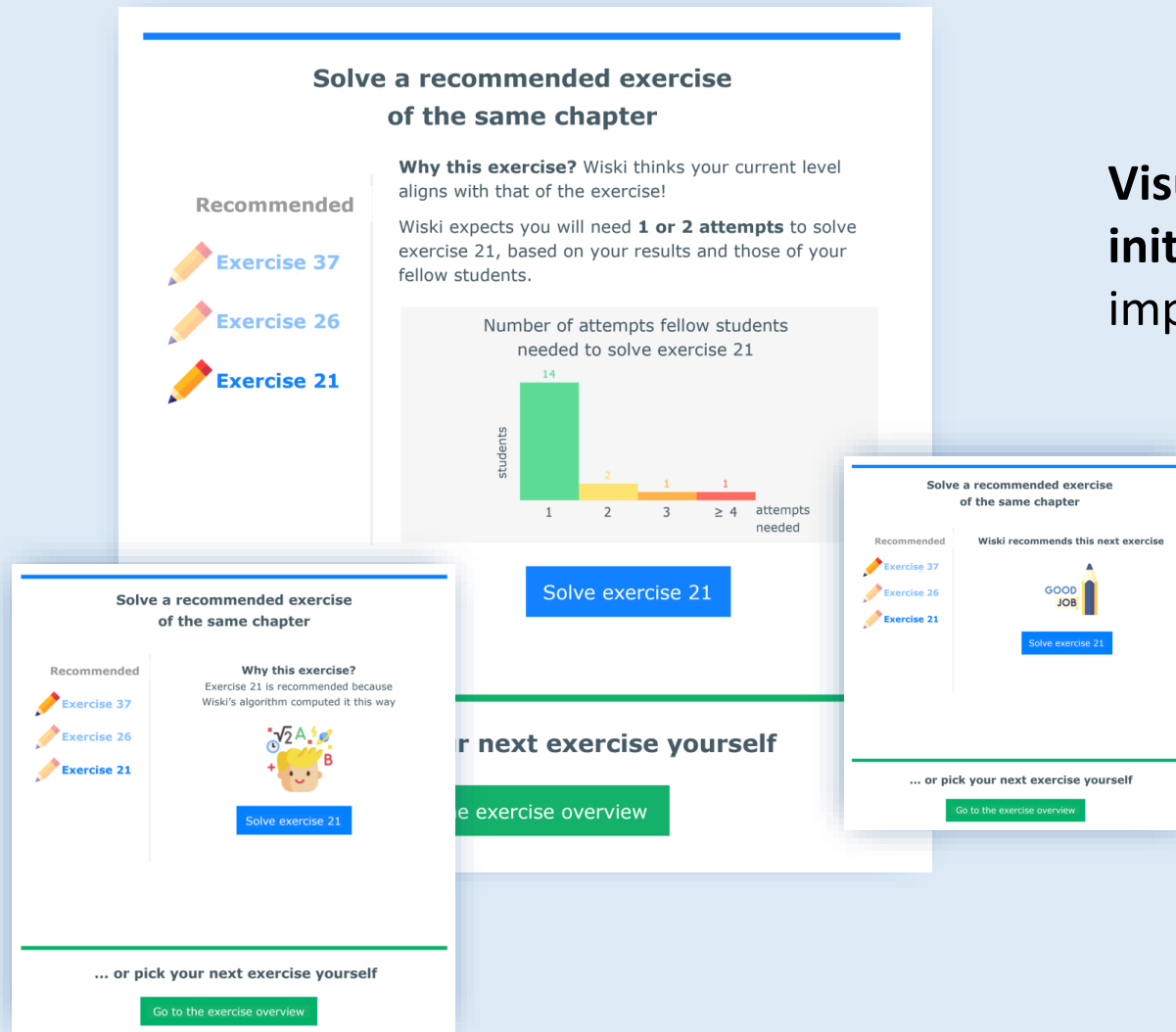
MD trust



1D trust



Visual explanations can increase initial trust but may not be the most important factor for building it



Explanations

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.

Number of attempts fellow students needed to solve exercise 21.

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 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 after completion

Start exercise

Control

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 After feedback

Solve more exercises on this topic

Return to exercise page

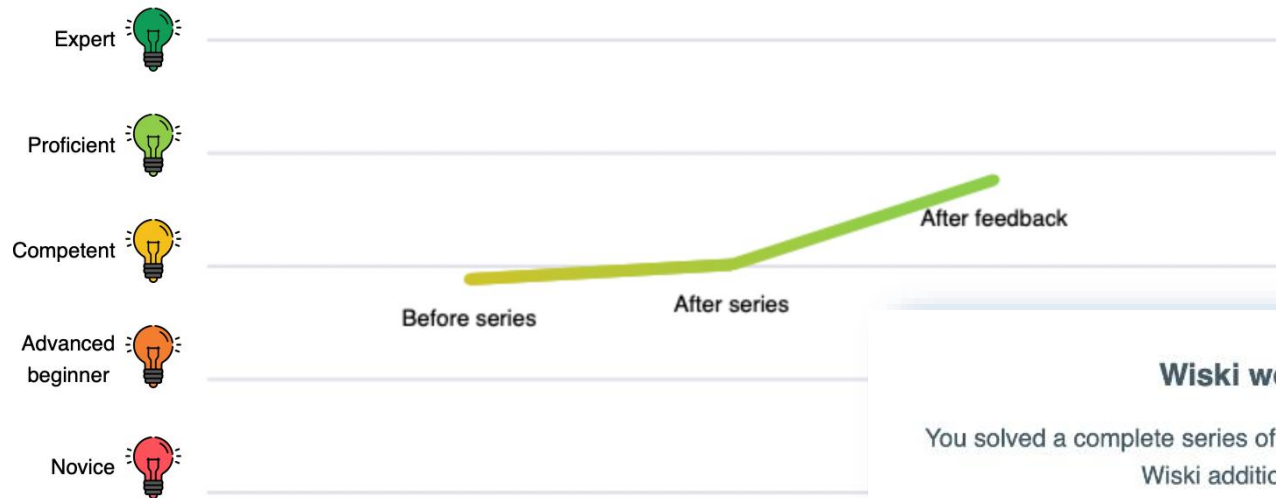
← Pick a reward and exercise: Next time you will get 4 new exercises

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

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.



Solve more exercises on this topic

Return to

Explanations: control impact in *output* explanations

Control: steer mastery level

Wiski would like additional information from you

You solved a complete series of recommended exercises, congratulations! For the next series, you can give Wiski additional information so that Wiski knows better how you feel.

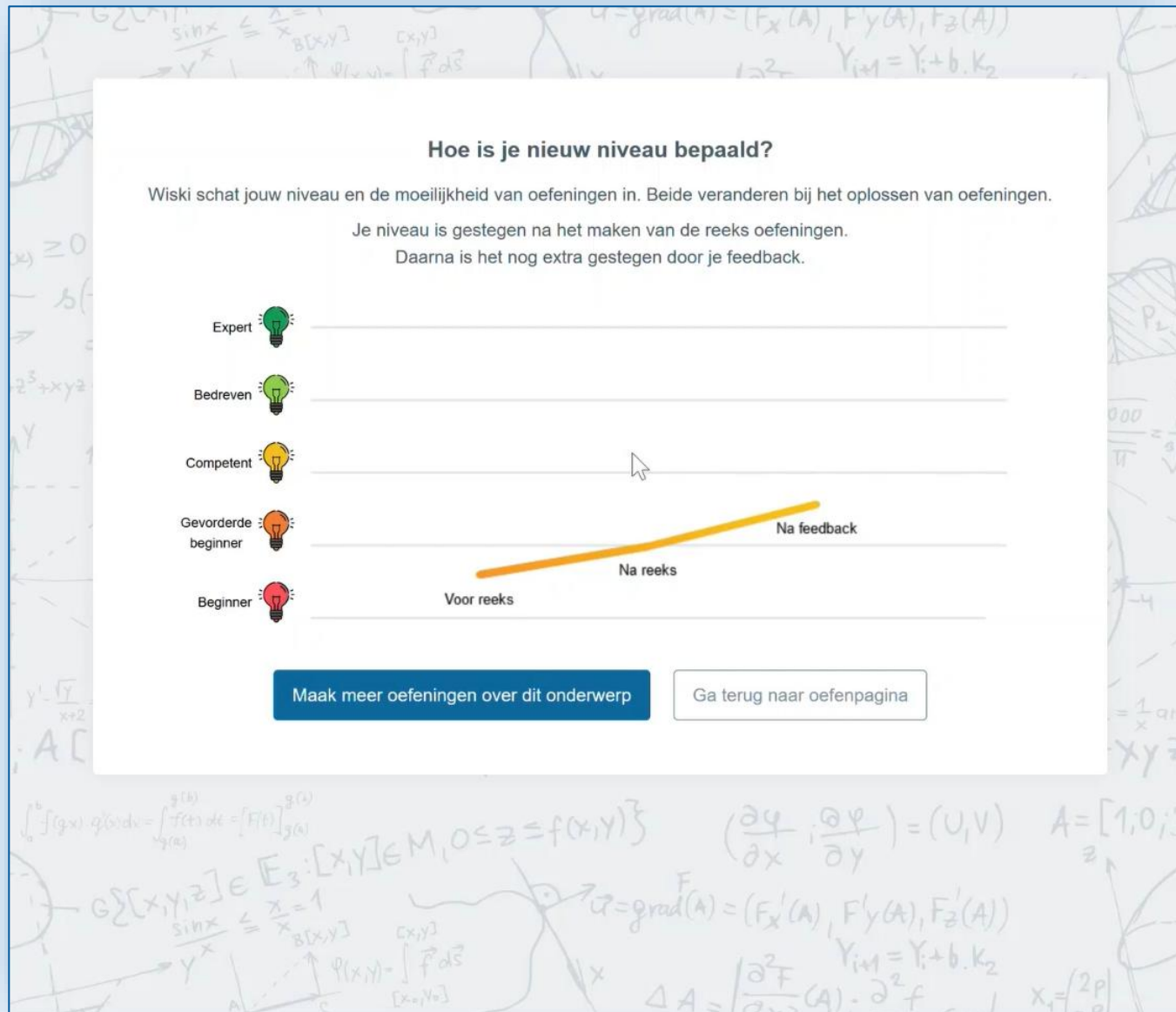
What difficulty of exercises would you like?



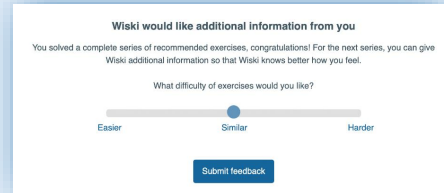
Submit feedback

Explanations: control impact in
output explanations

Control: steer mastery level



How was trust in the platform affected?



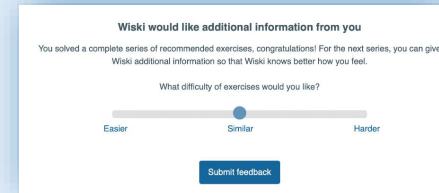
Wiski would like additional information from you

You solved a complete series of recommended exercises, congratulations! For the next series, you can give Wiski additional information so that Wiski knows better how you feel.

What difficulty of exercises would you like?

Easier Similar Harder

Submit feedback



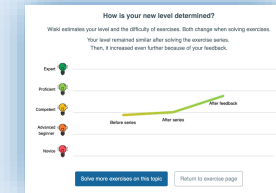
Wiski would like additional information from you

You solved a complete series of recommended exercises, congratulations! For the next series, you can give Wiski additional information so that Wiski knows better how you feel.

What difficulty of exercises would you like?

Easier Similar Harder

Submit feedback



Control vs no control

trust increased

Control with impact vs no control

trust increased



trust unchanged



trust unchanged

trust decreased

trust decreased

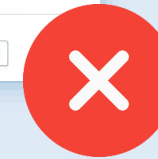
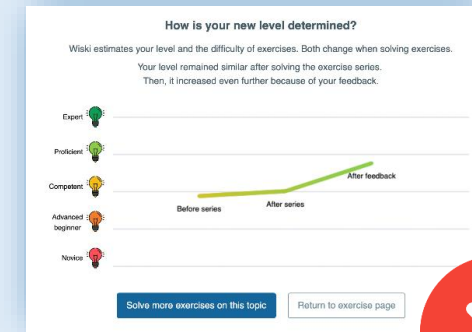
Wiski would like additional information from you

You solved a complete series of recommended exercises, congratulations! For the next series, you can give Wiski additional information so that Wiski knows better how you feel.

What difficulty of exercises would you like?

Easier Similar Harder

Submit feedback



Trust in the platform

Reflection on own mastery
and recommendations



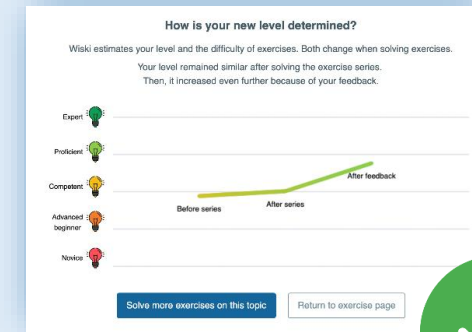
Wiski would like additional information from you

You solved a complete series of recommended exercises, congratulations! For the next series, you can give Wiski additional information so that Wiski knows better how you feel.

What difficulty of exercises would you like?

Easier Similar Harder

Submit feedback



Trust in the platform due to more perceived transparency



Reflection on own mastery and recommendations



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 After feedback

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

Seeing the impact of control can increase initial trust, but control mechanisms by themselves do not necessarily

Wiski would like additional information from you

You solved a complete series of recommended exercises, congratulations! For the next series, you can give Wiski additional information so that Wiski knows better how you feel.

What difficulty of exercises would you like?

Easier Similar Harder

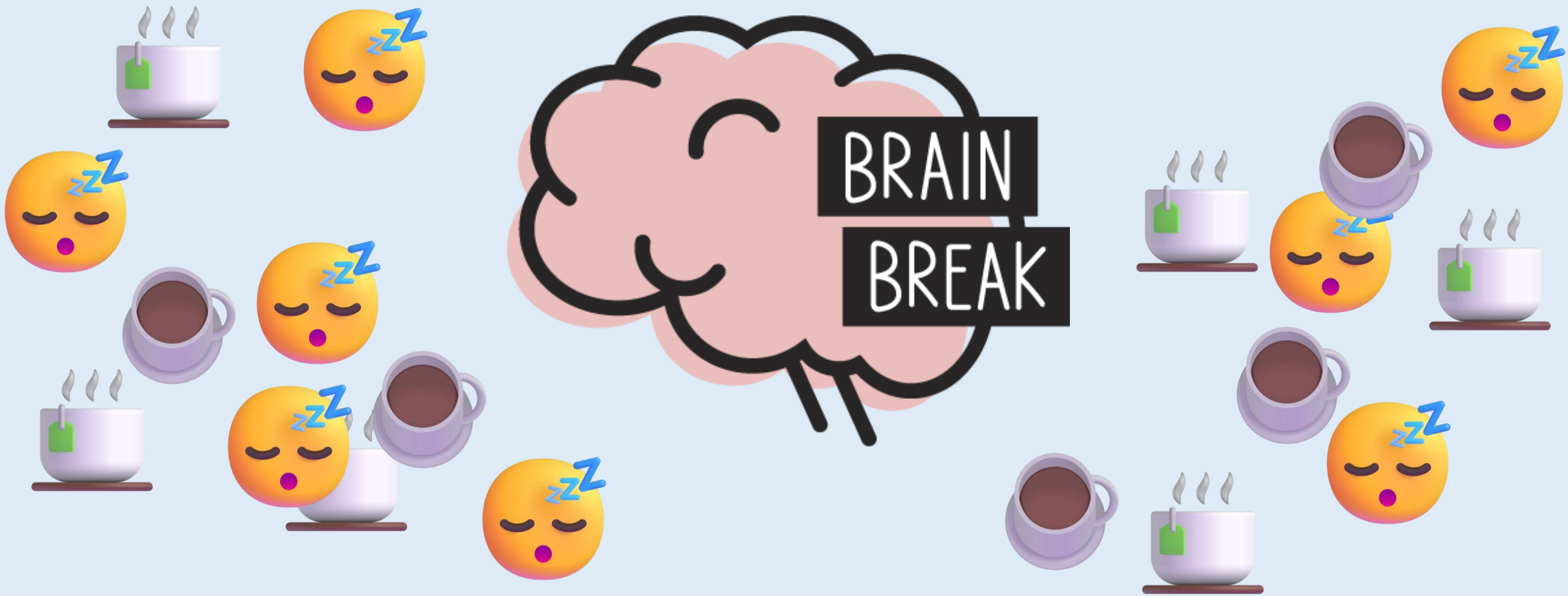
[Submit feedback](#)

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](#)





Explanations

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.

Number of attempts fellow students needed to solve exercise 21.

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
Your level now

Start exercises

Control

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.

Solve more exercises on this topic

Return to exercise page

← **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

 **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 

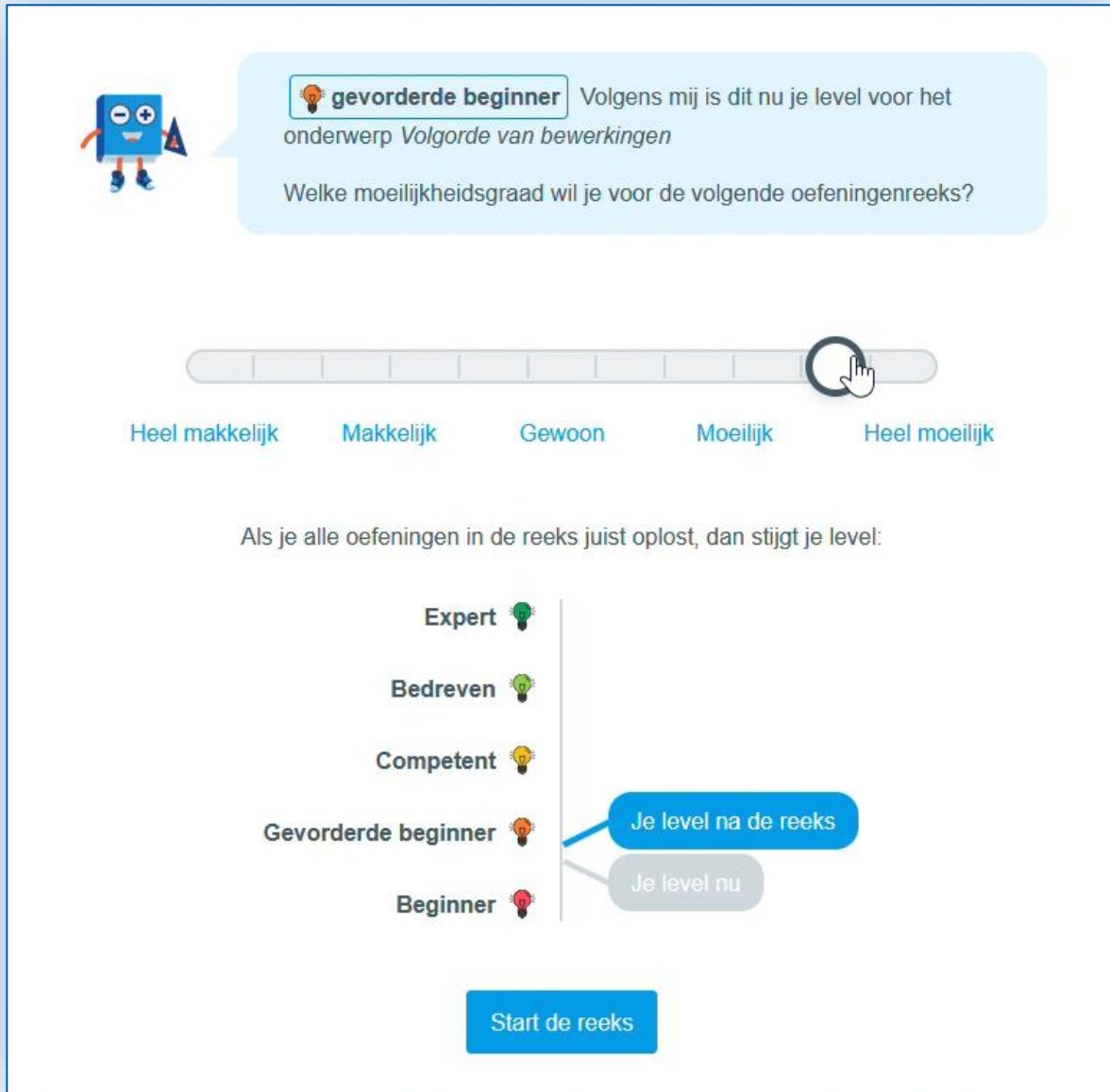
Your level after completion (points to Advanced beginner)

Your level now (points to Novice)

Start exercises

Learner control: choose difficulty of exercise series

What-if explanation: what is the impact on my level if I solve this series correctly?



The interface features a blue robot character on the left. A light blue speech bubble contains the text: "💡 **gevorderde beginner** Volgens mij is dit nu je level voor het onderwerp *Volgorde van bewerkingen* Welke moeilijkheidsgraad wil je voor de volgende oefeningenreeks?". Below this is a horizontal slider with 10 segments, labeled from left to right: "Heel makkelijk", "Makkelijk", "Gewoon", "Moeilijk", and "Heel moeilijk". A hand cursor is positioned over the 8th segment. Below the slider, the text reads: "Als je alle oefeningen in de reeks juist oplost, dan stijgt je level:". To the right of this text is a vertical list of five levels, each with a lightbulb icon: "Expert" (green), "Bedreven" (green), "Competent" (yellow), "Gevorderde beginner" (orange), and "Beginner" (red). A blue callout bubble points to the "Gevorderde beginner" level with the text "Je level na de reeks". A grey callout bubble points to the "Beginner" level with the text "Je level nu". At the bottom center is a blue button labeled "Start de reeks".

Explanations: real-time *what-if* explanations

Control: choose difficulty of recommended exercises series



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

How did you come up with this design?



Study 1: Group Discussion

- 3 teachers and 6 EdTech professionals
- Collect learning and explainability needs; test understandability

Recommended series

Exercise	Exercise level	Completed before?
Exercise 15 Part 1 Subjects and finite verbs	Easy	No
Exercise 23 Part 1 Types of sentences	Easy	No
Exercise 12 Part 1 Subjects and finite verbs	Easy	No
Exercise 35 Part 1 Vowels and consonants	Easy	No
Exercise 10 Part 1 Types of sentences	Easy	No

Start sequence

version 1

Study 2: Think-Aloud Studies

- 6 adolescents
- Collect explainability needs; test understandability and usability

Recommended series

Exercise	Exercise level	Completed before?
Exercise 15 Part 1 Subjects and finite verbs	Easy	No
Exercise 23 Part 1 Types of sentences	Medium	No
Exercise 12 Part 1 Subjects and finite verbs	Easy	No
Exercise 35 Part 1 Vowels and consonants	Hard	No
Exercise 10 Part 1 Subjects and finite verbs	Easy	No

Start sequence

version 2

Study 3: Focus Groups

- 7 teachers and pedagogical experts
- Collect explainability and control needs; assess pedagogical value

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 Medium Difficult Very difficult

Start exercise

version 4

I believe this is your level now for the subject Coordinates in space: Competent

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

Easier Same Harder

Start exercise

version 3

Study 4: Think-Aloud Studies

- 6 adolescents
- Collect explainability and control needs; test understandability and usability

Study 1: Group Discussion

- 3 teachers and 6 EdTech professionals
- Collect learning and explainability needs; test understandability

Recommended series			General	Subjects and finite verbs	Types of sentences	Vowels and consonants
Exercise 15 Part 1 Subjects and finite verbs	Exercise level Easy	Completed before? No	Why this exercise series? The system looks for exercises adjusted to your mastery level so you can make the most progress. Your mastery level is estimated based on test data and how often you've solved previously. 1. Your level and why Part 1: Easy 2. Exercises most similar to your level Part 1: Easy 3. What if you correctly finish this series? By completing the next exercise series, you will level up for the topics: Subjects and finite verbs, Types of sentences and Vowels and consonants. Keep going!	Part 1: Easy	Part 1: Easy	Part 1: Easy
Exercise 23 Part 1 Types of sentences	Exercise level Easy	Completed before? No				
Exercise 12 Part 1 Subjects and finite verbs	Exercise level Easy	Completed before? No				
Exercise 35 Part 1 Vowels and consonants	Exercise level Easy	Completed before? No				
Exercise 10 Part 1 Types of sentences	Exercise level Easy	Completed before? No				

version 1

Study 2: Think-Aloud Studies

- 6 adolescents
- Collect explainability needs; test understandability and usability

Recommended series		Explanation
Exercise 15 Part 1 Subjects and finite verbs	Exercise level Easy	Why this exercise series? The system recommends exercises that are closest to your level. Your level is estimated by looking at exercises you've solved previously. What if you correctly solve this series? This is how the system estimates your mastery to change if you correctly solve the exercise series. Subjects and finite verbs Types of sentences Vowels and consonants
Exercise 23 Part 1 Types of sentences	Exercise level Medium	
Exercise 12 Part 1 Subjects and finite verbs	Exercise level Easy	
Exercise 35 Part 1 Vowels and consonants	Exercise level Hard	
Exercise 10 Part 1 Subjects and finite verbs	Exercise level Easy	

version 2

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

Competent

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

Easier Same Harder

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

Expert

Proficient

Competent

Advanced beginner

Novice

Your level after completion

Your level now

Start exercise

version 3

Study 3: Focus Groups

- 7 teachers and pedagogical experts
- Collect explainability and control needs; assess pedagogical value

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 Harder 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 exercise

version 4

Study 4: Think-Aloud Studies

- 6 adolescents
- Collect explainability and control needs; test understandability and usability

Long iterative design process with many educational stakeholders!

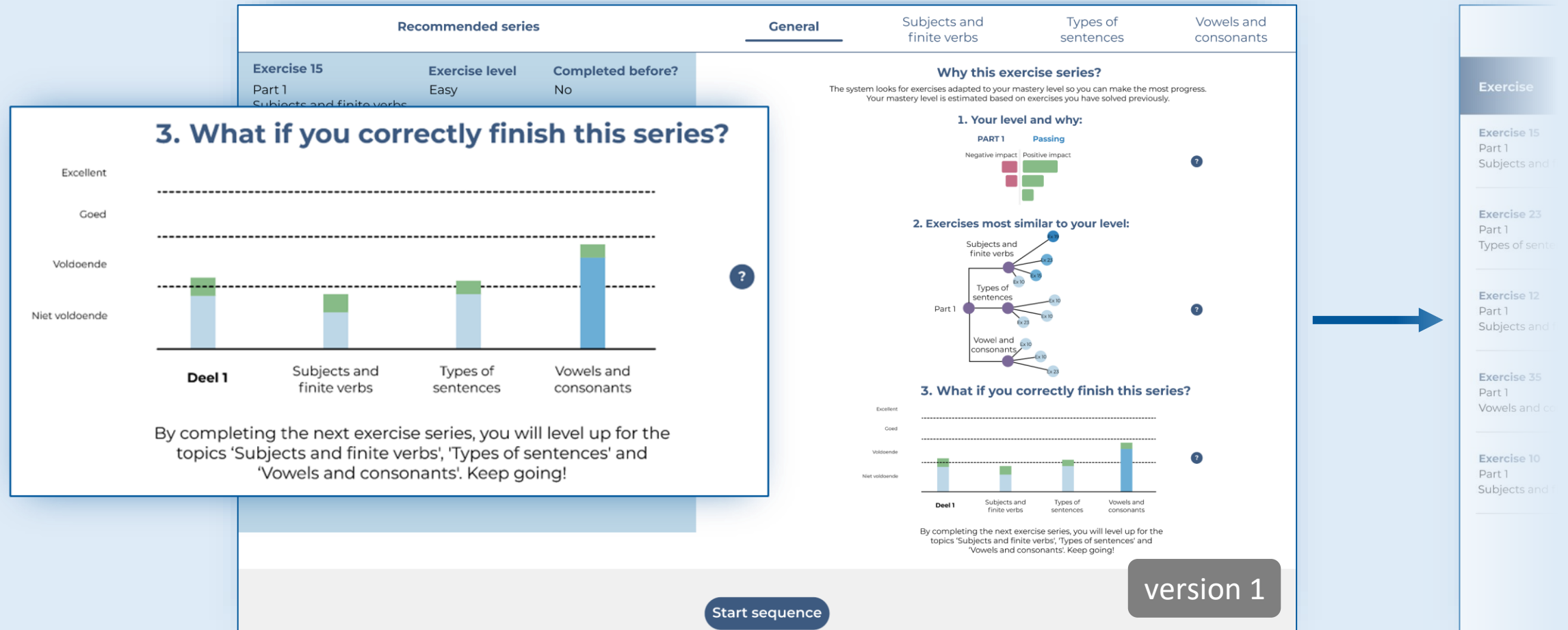


Study 1: Group Discussion

- 3 teachers and 6 EdTech professionals
- Collect learning and explainability needs; test understandability



Clarify visualisations and restrict information
What-if explanations might boost motivation

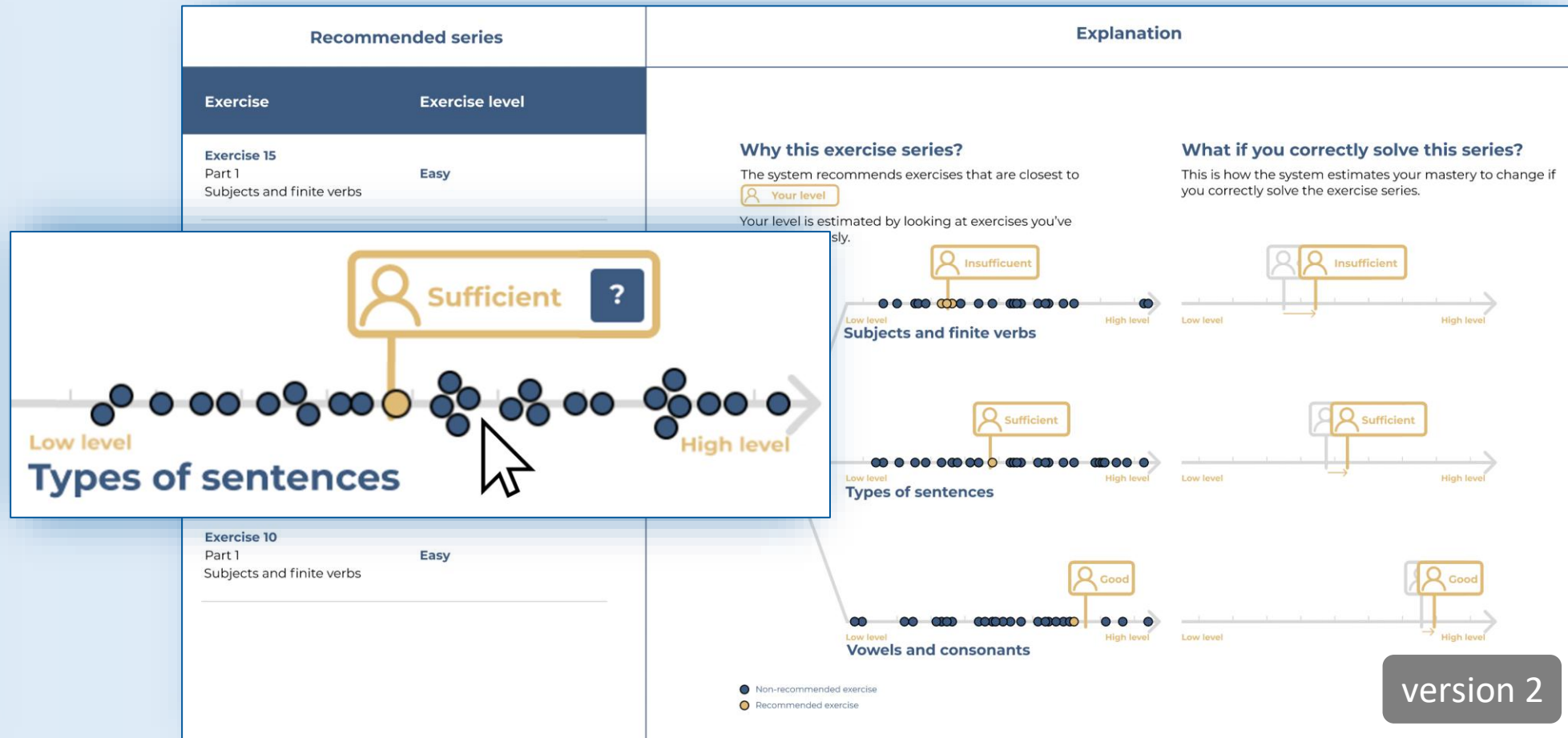


Study 2: Think-Aloud Studies

- 6 adolescents
- Collect explainability needs; test understandability and usability



Minimise text, tightly integrate explanations
Inattentiveness can harm mental models
Adolescents want control and motivation supports

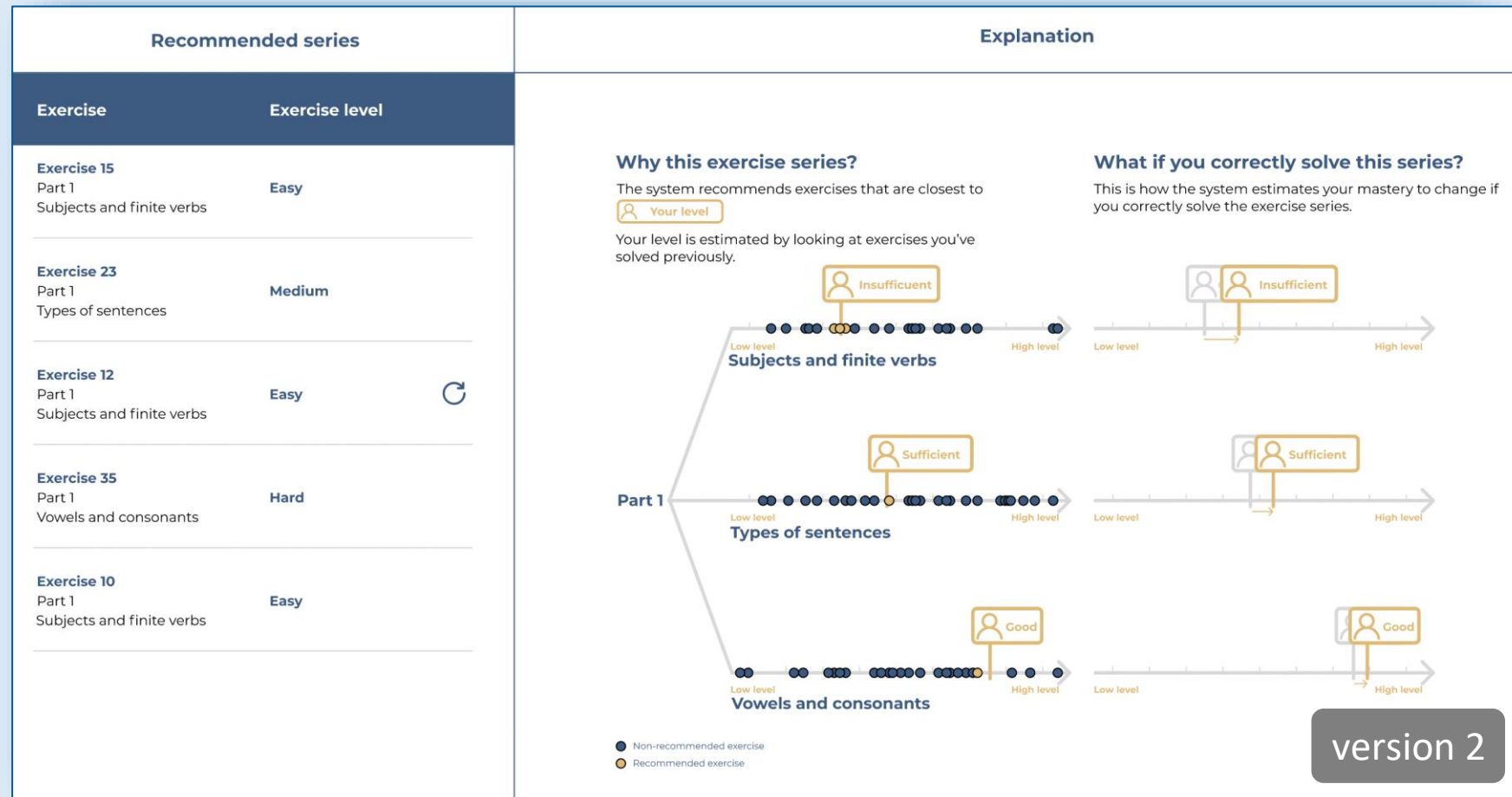


Study 3: Focus Groups

- 7 teachers and pedagogical experts
- Collect explainability and control needs; assess pedagogical value



Students need goal-oriented, motivating explanations
How appropriate is learner control?
Why explanations can empower teachers

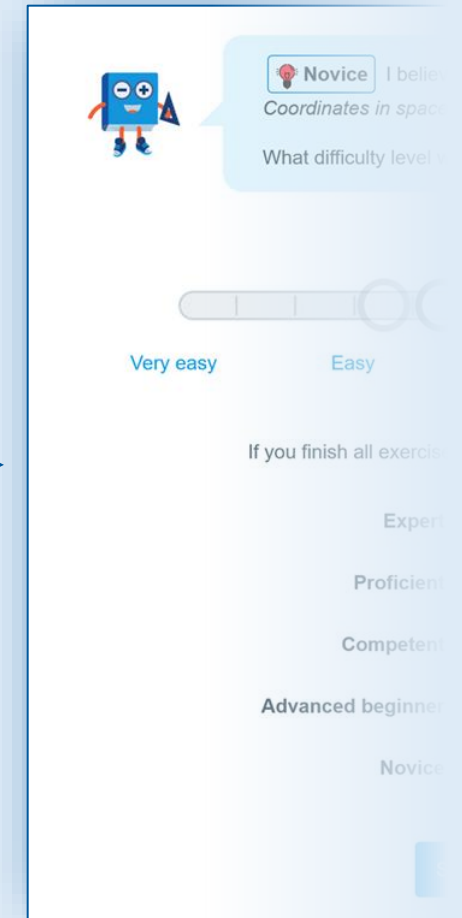
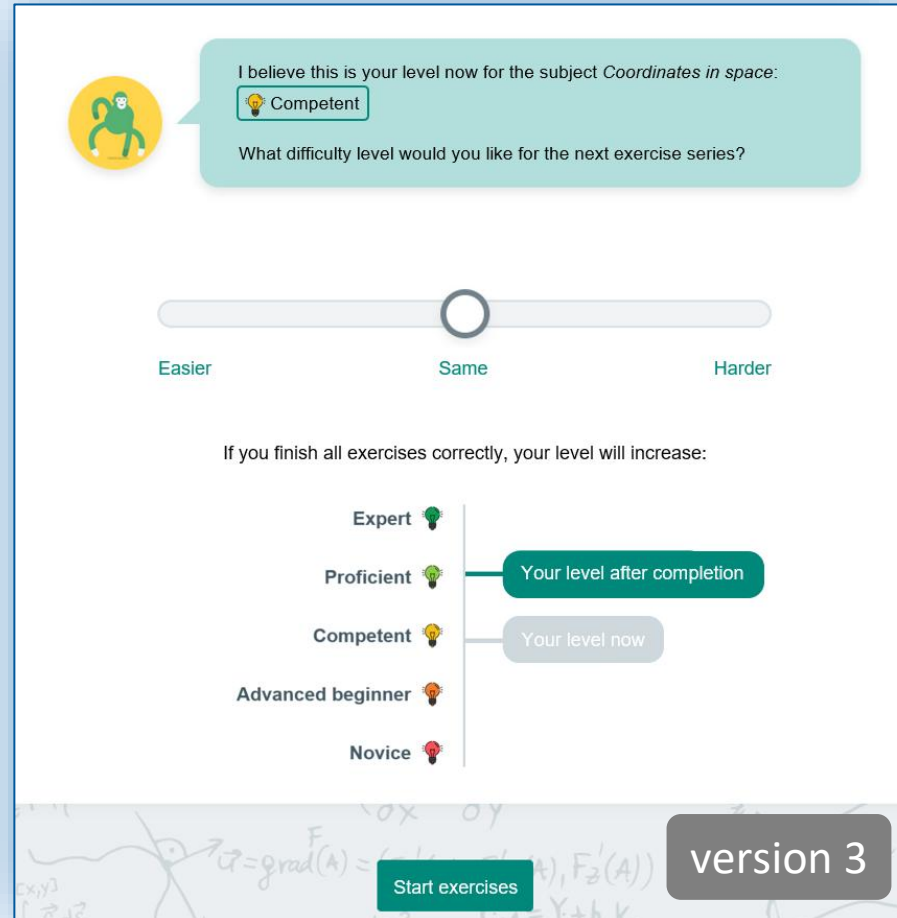
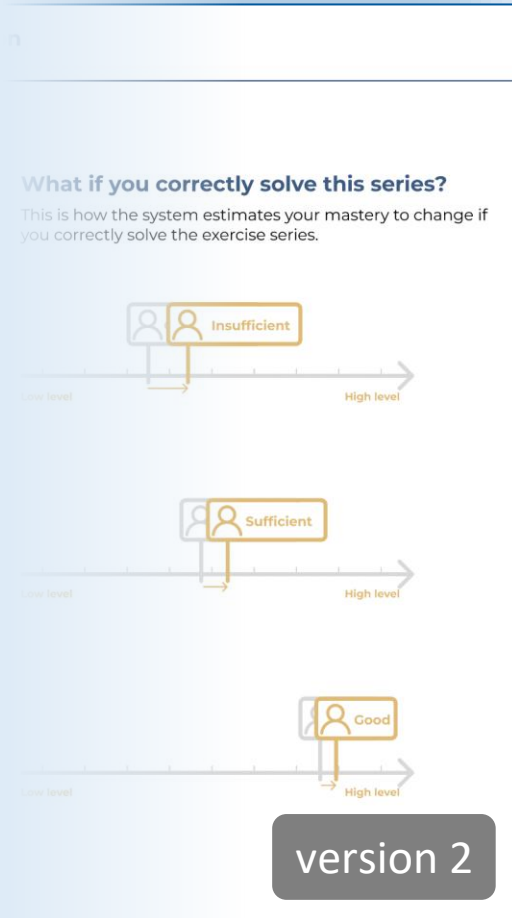


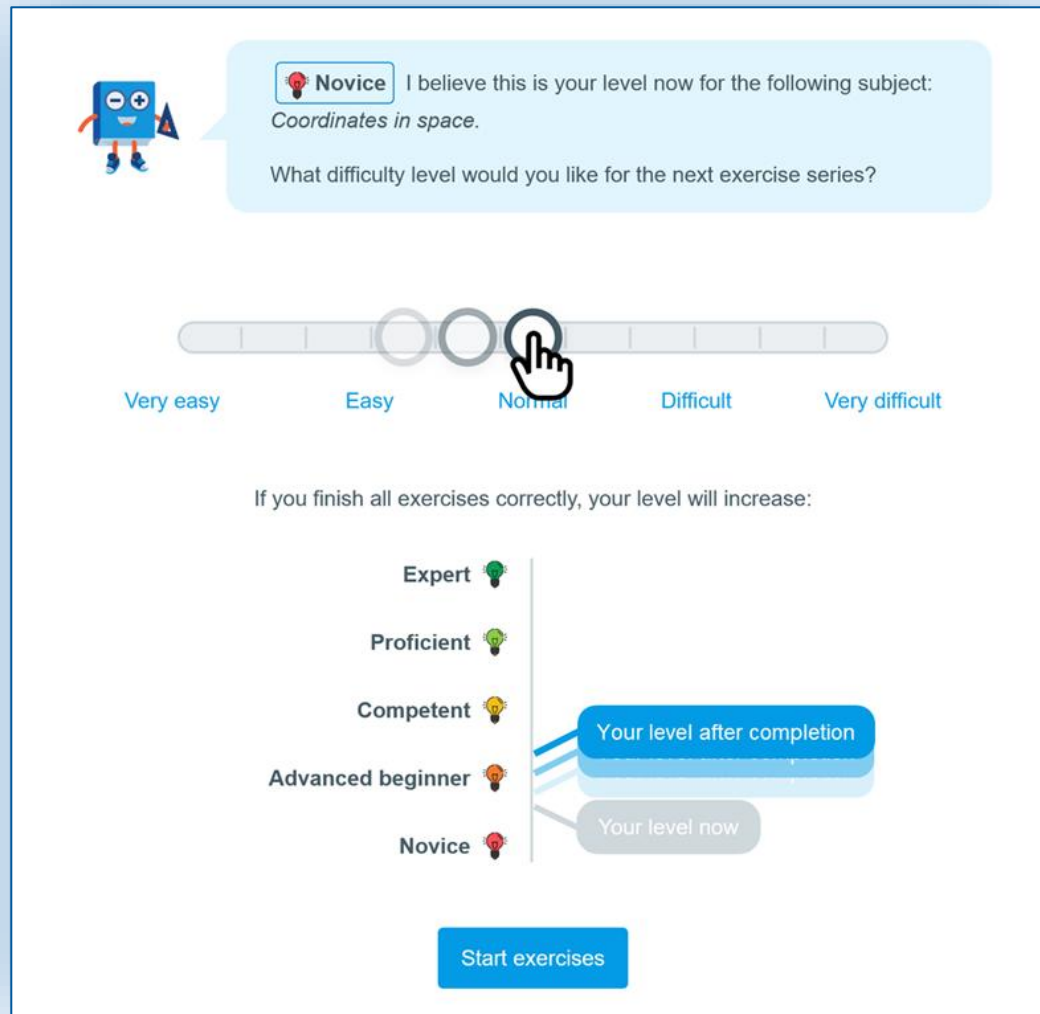
Study 4: Think-Aloud Studies

- 6 adolescents
- Collect explainability and control needs; test understandability and usability



Control stimulates self-reflection
What-if explanations clarify progress





Why explanations desirable for teachers, not for adolescents

What-if explanations and learner control might **motivate and engage**

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

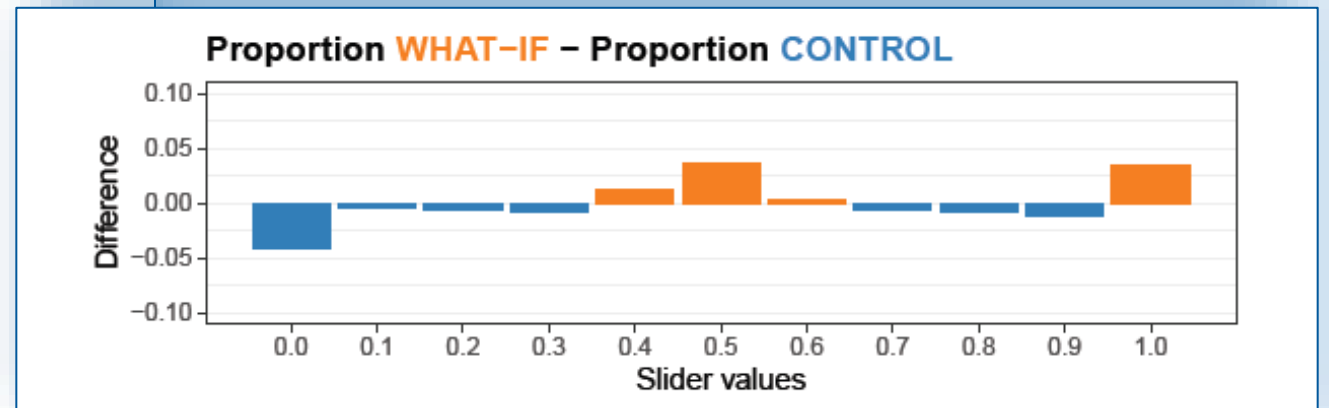
Your level after completion

Your level now

Start exercises

PRELIMINARY RESULTS!

***What-if* explanations can encourage teenagers to try harder exercises, but do not necessarily affect initial trust, metacognition, motivation, or performance**



Explanations

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.

Number of attempts fellow students needed to solve exercise 21.

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 **Normal** Difficult Very difficult

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

- Expert
- Proficient
- Competent
- Advanced beginner
- Novice

Your level after completion: Competent

Your level after completion: Novice

Start exercise

Control

How is your new level determined?

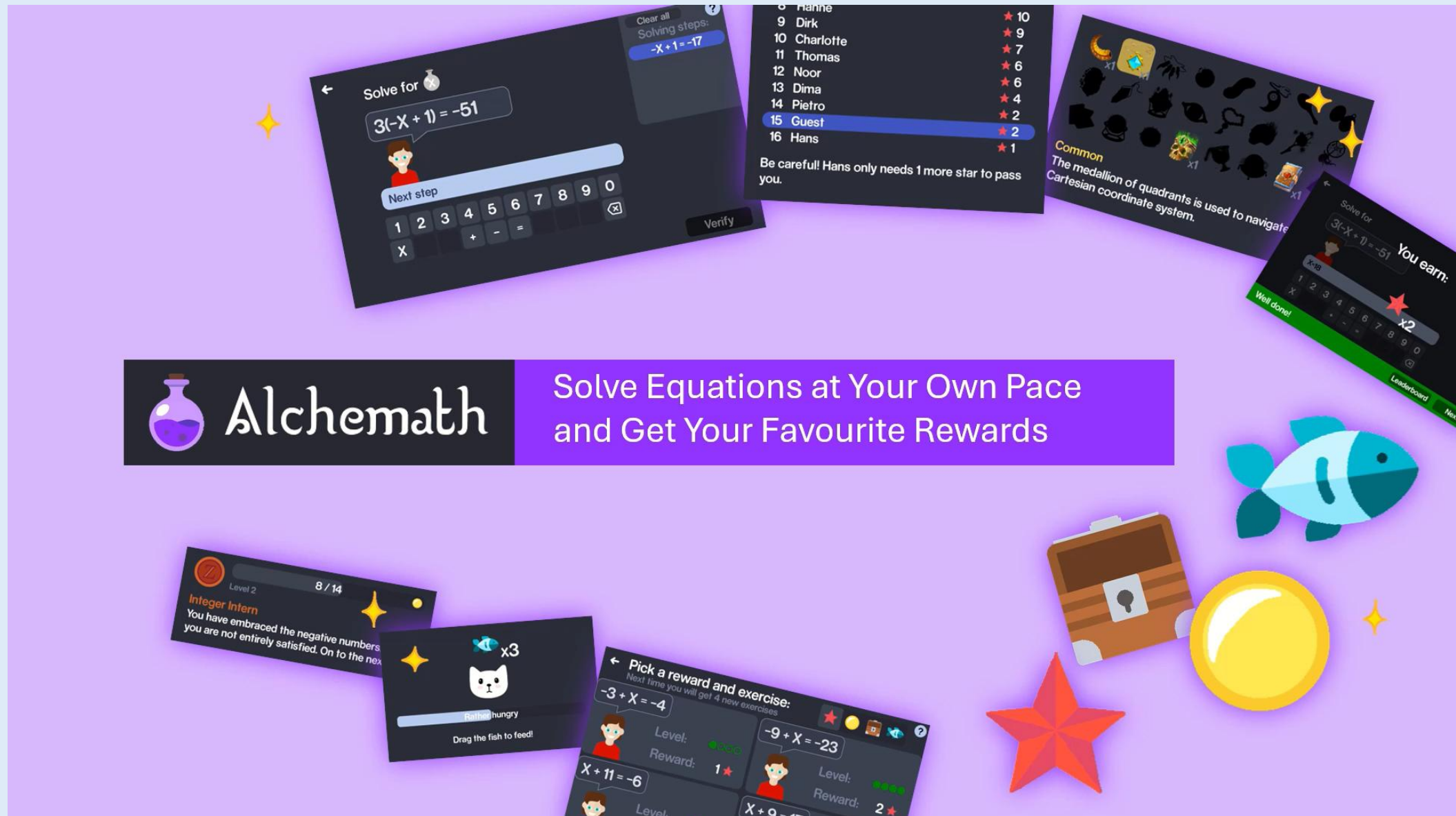
Wiski estimates your level and the difficulty of exercises. Both change when solving exercises. Your level remained similar after solving the exercise series. Then, it increased even further because of your feedback.

Solve more exercises on this topic

Return to exercise page

← **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



← 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



I How to adapt education?

Examples of adaptation in education

II What is my research about?

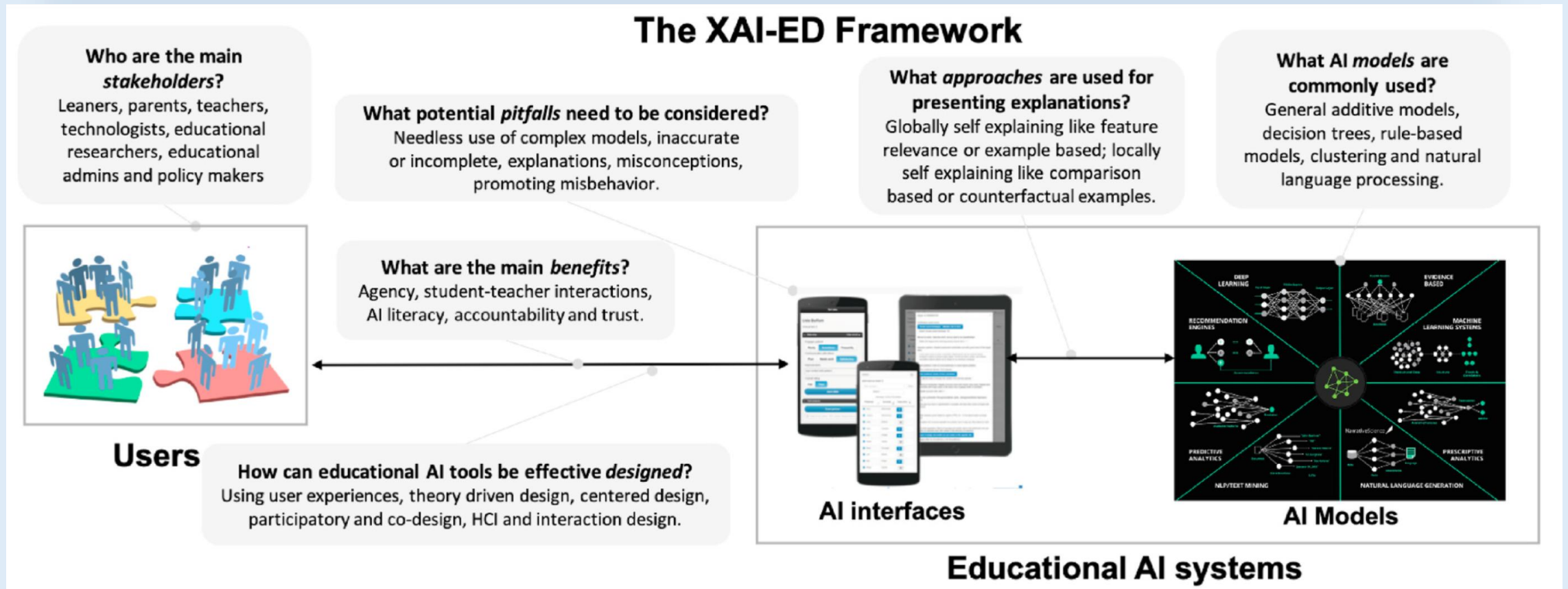
Transparent and controllable

AI systems for education

III How can you contribute?

Exercise & ideas for master's theses

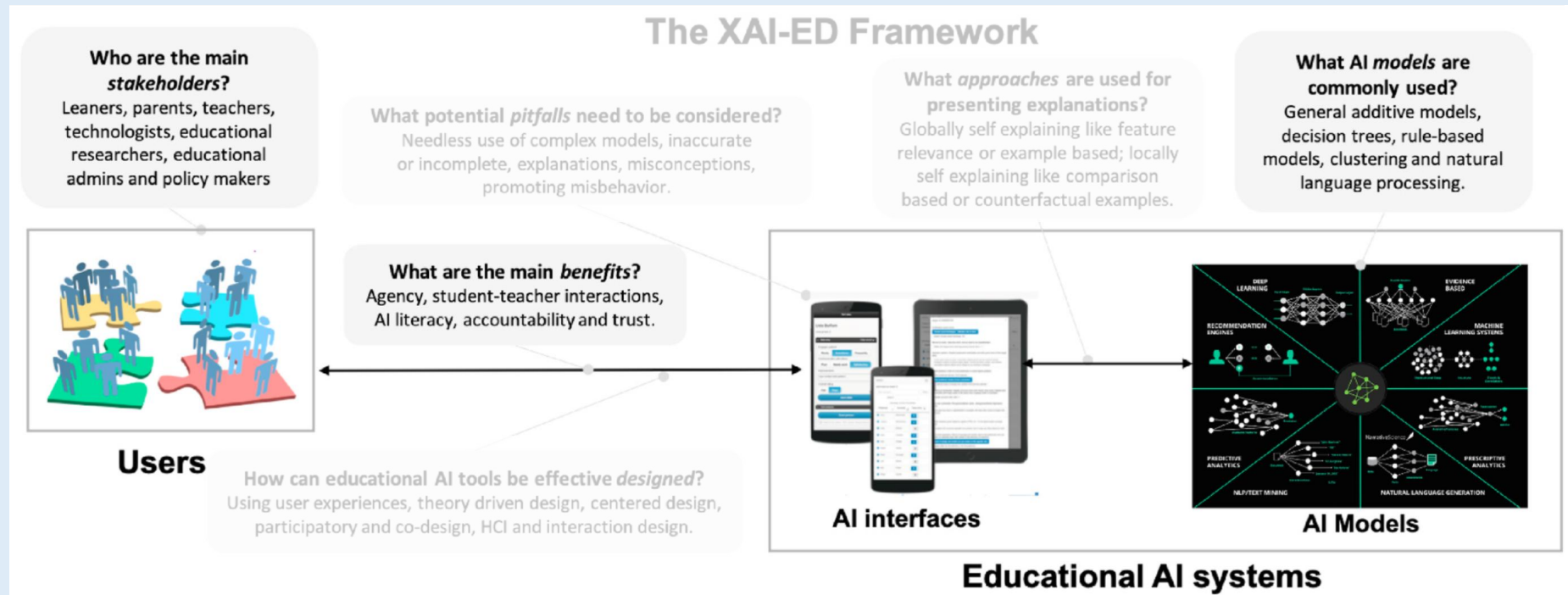
Exercise: Transparent and controllable adaptive systems at Utrecht University



Step 1: Describe an adaptive system for UU

1 Who is the target audience?

3 Which adaptive techniques are used?

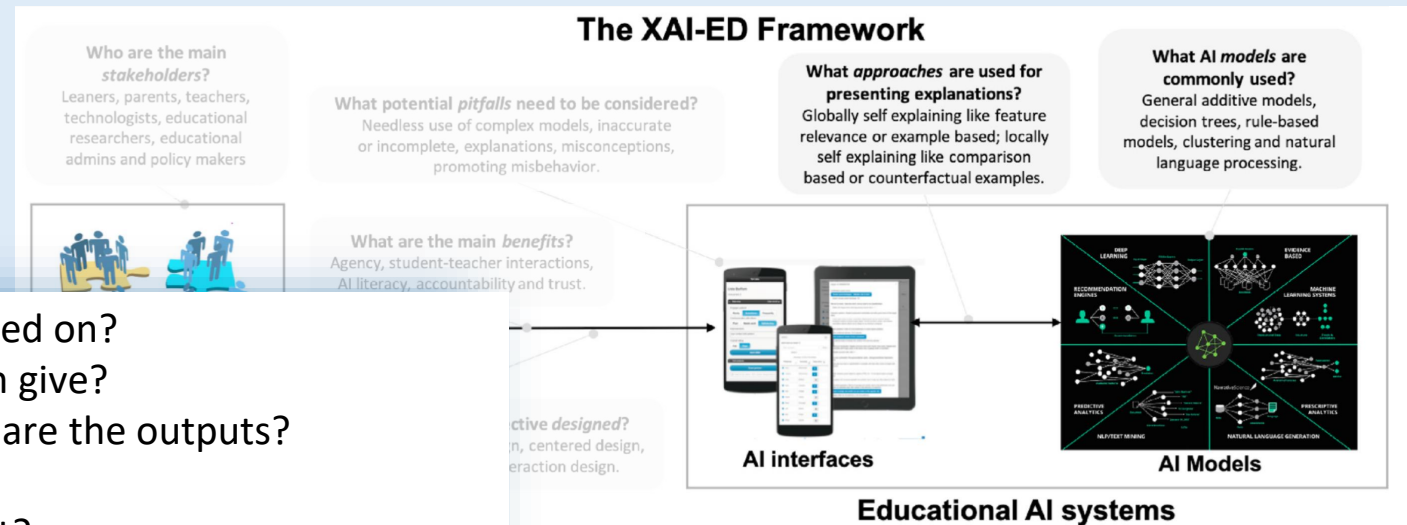


2 How does the system support education?

Step 2: Add transparency and control

4 How to integrate explanations and control into the system?

Data: What kind of data was the system trained on?
Output: What kind of output does the system give?
Performance: How accurate/precise/reliable are the outputs?
How: How does the system obtain outputs?
Why: Why/how is this input giving this output?
Why not: Why does this input not have a different output?
How to be that: How should this input change to get a different output?
How to still be this: What is the change permitted for this input to still get the same output?
What if: What would the system predict if this input changes to...?



I How to adapt education?

Examples of adaptation in education

II What is my research about?

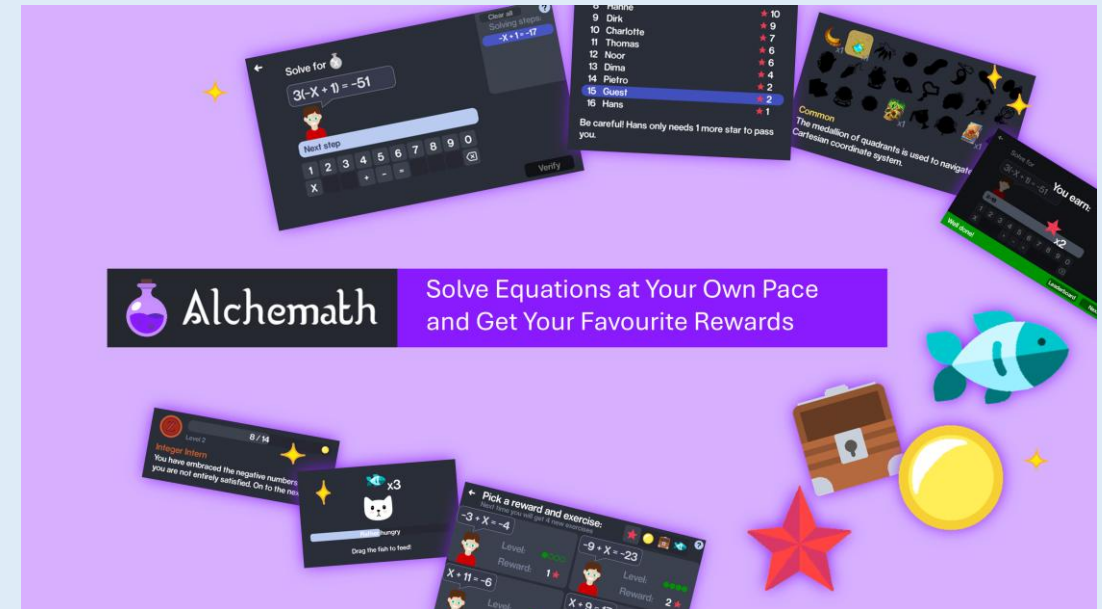
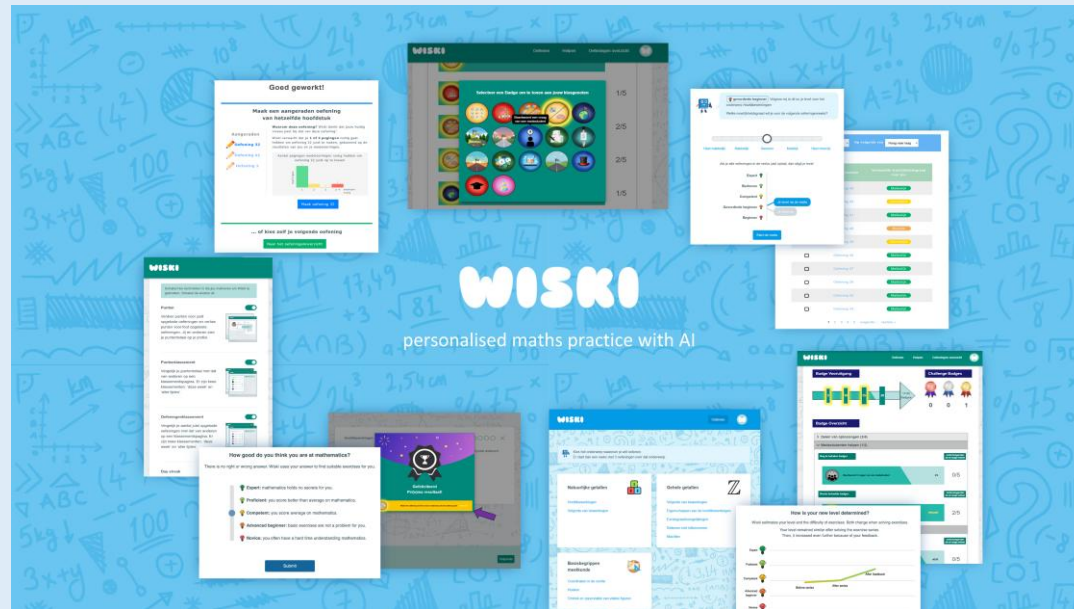
Transparent and controllable

AI systems for education

III How can you contribute?

Exercise & ideas for master's theses

Idea 1: alternative operationalisations



Extend existing adaptive applications with cognitively engaging explanations and control mechanisms

e.g., can teachers create content more efficiently with AI?

Idea 2: adaptive planning

Outside class		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
Offline	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		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
Individually	Individually						Play a game Eye-tracking practicum	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	
		Conduct research Opdracht 1 TAs en Robin	Conduct research	Case study Research design exercise: diary	Case study Research design exercise: case study	Case study Research design exercise: experiment		

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?

Idea 3: generalise *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

Handle exercises like $x = 3$

Handle exercises like $2x = 3$

Handle exercises like $2x + 4 = 3$

Start

Usual 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

Handle exercises like $x = 3$

Handle exercises like $2x = 3$

Handle exercises like $2x + 4 = 3$

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

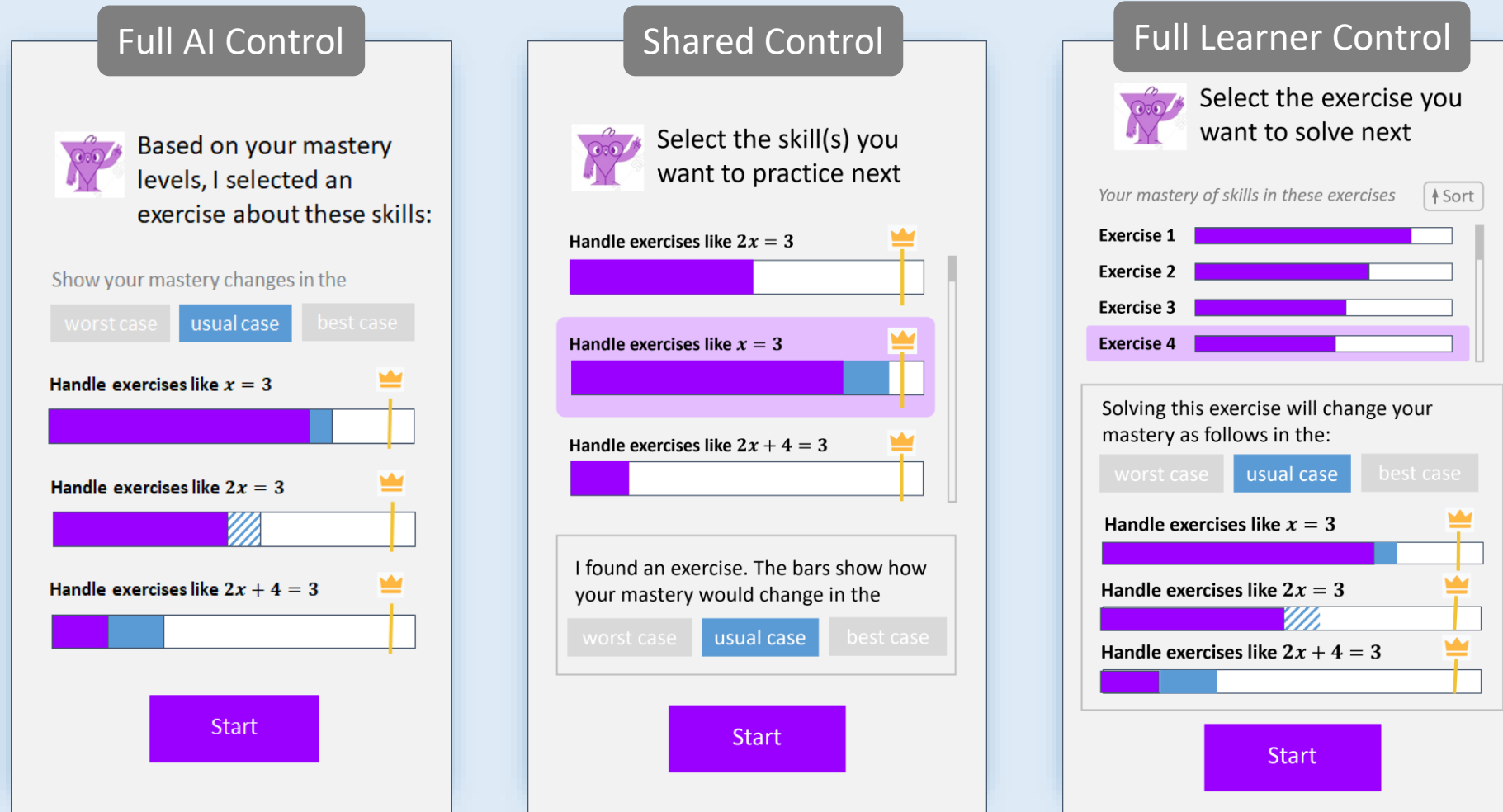
Handle exercises like $x = 3$

Handle exercises like $2x = 3$

Handle exercises like $2x + 4 = 3$

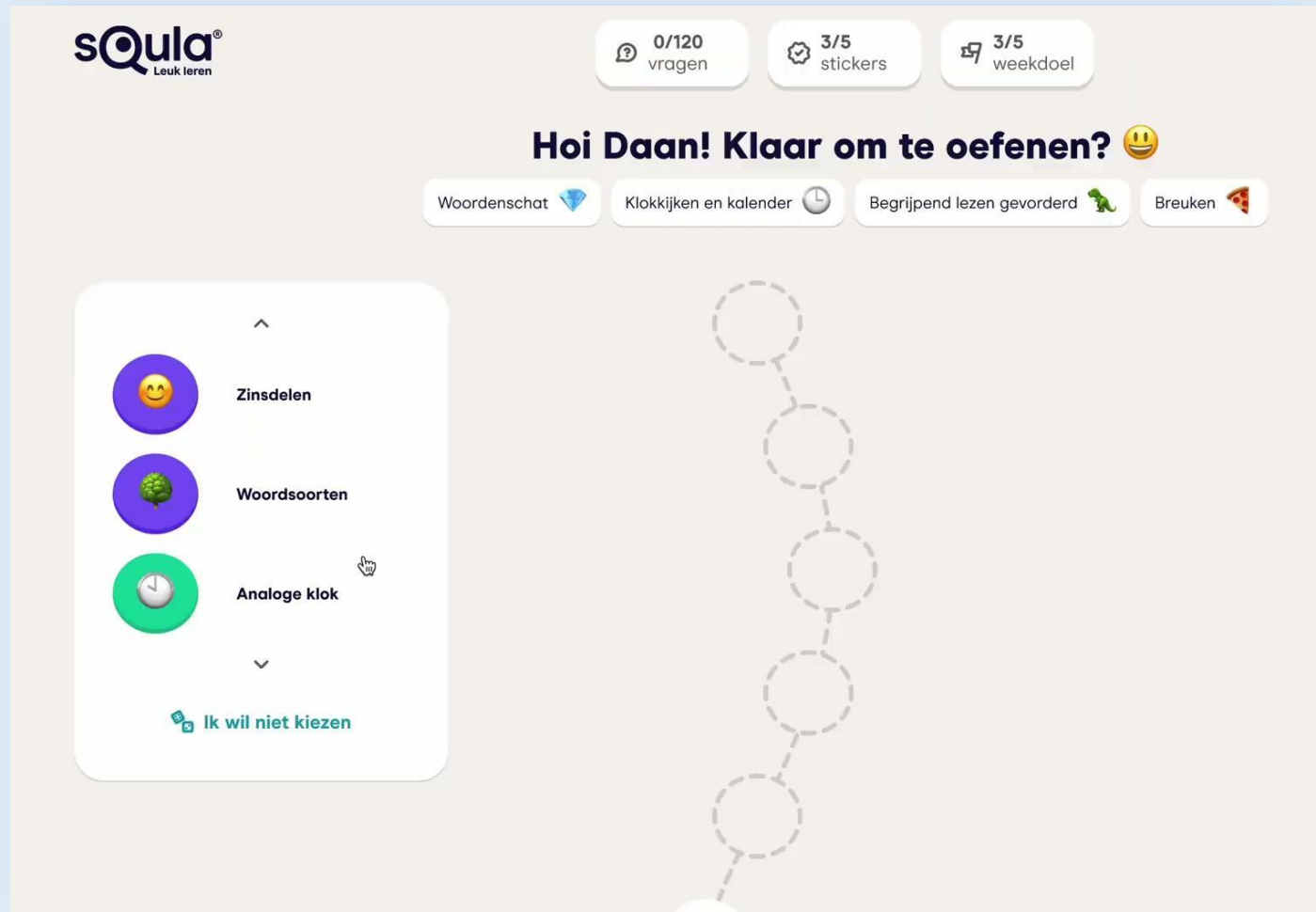
Start

Idea 4a: explore the control spectrum

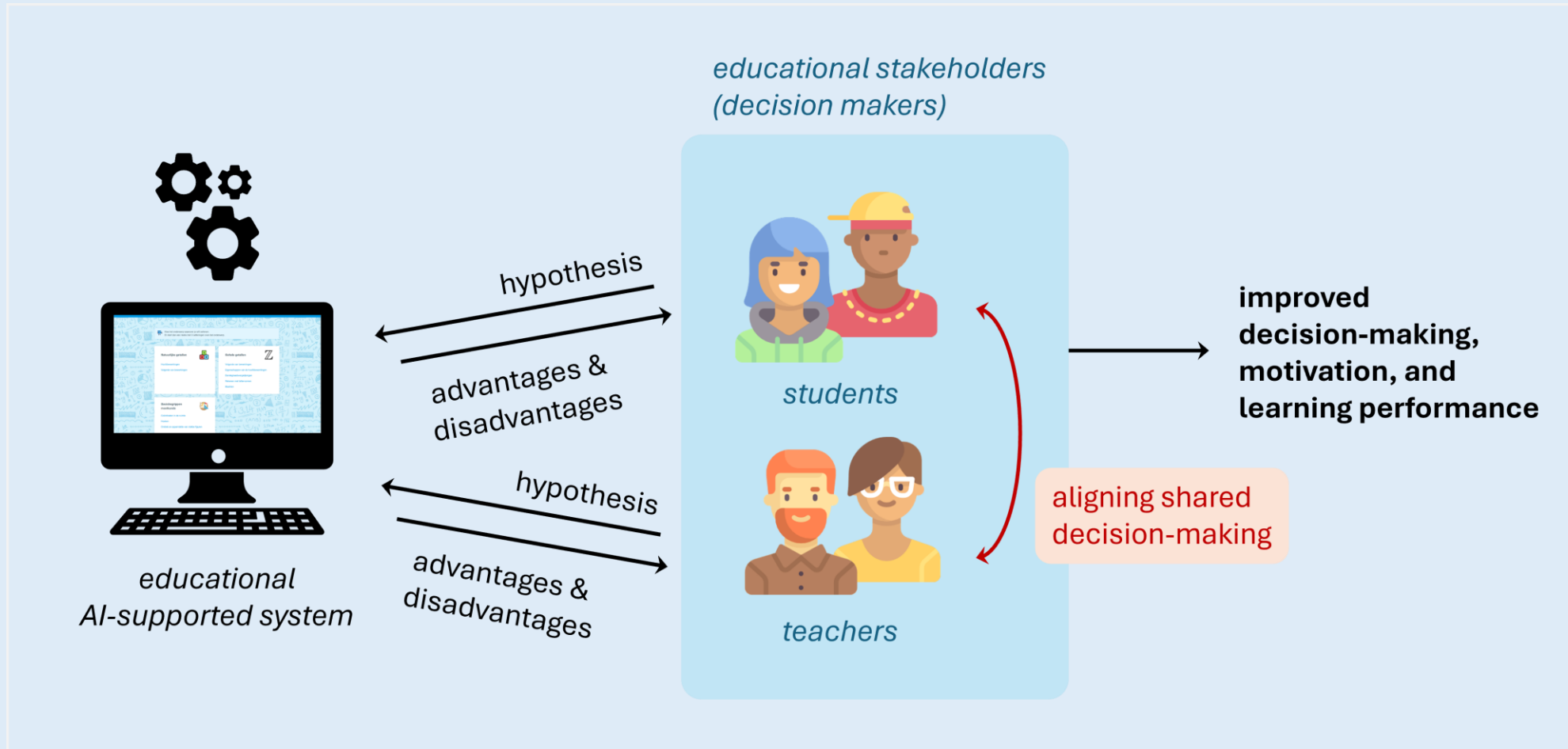


Idea 4b: explore the control spectrum

Learners have decision power about how their learning path is composed
e.g., how much control is appropriate for which learners? how does it affect intrinsic motivation?



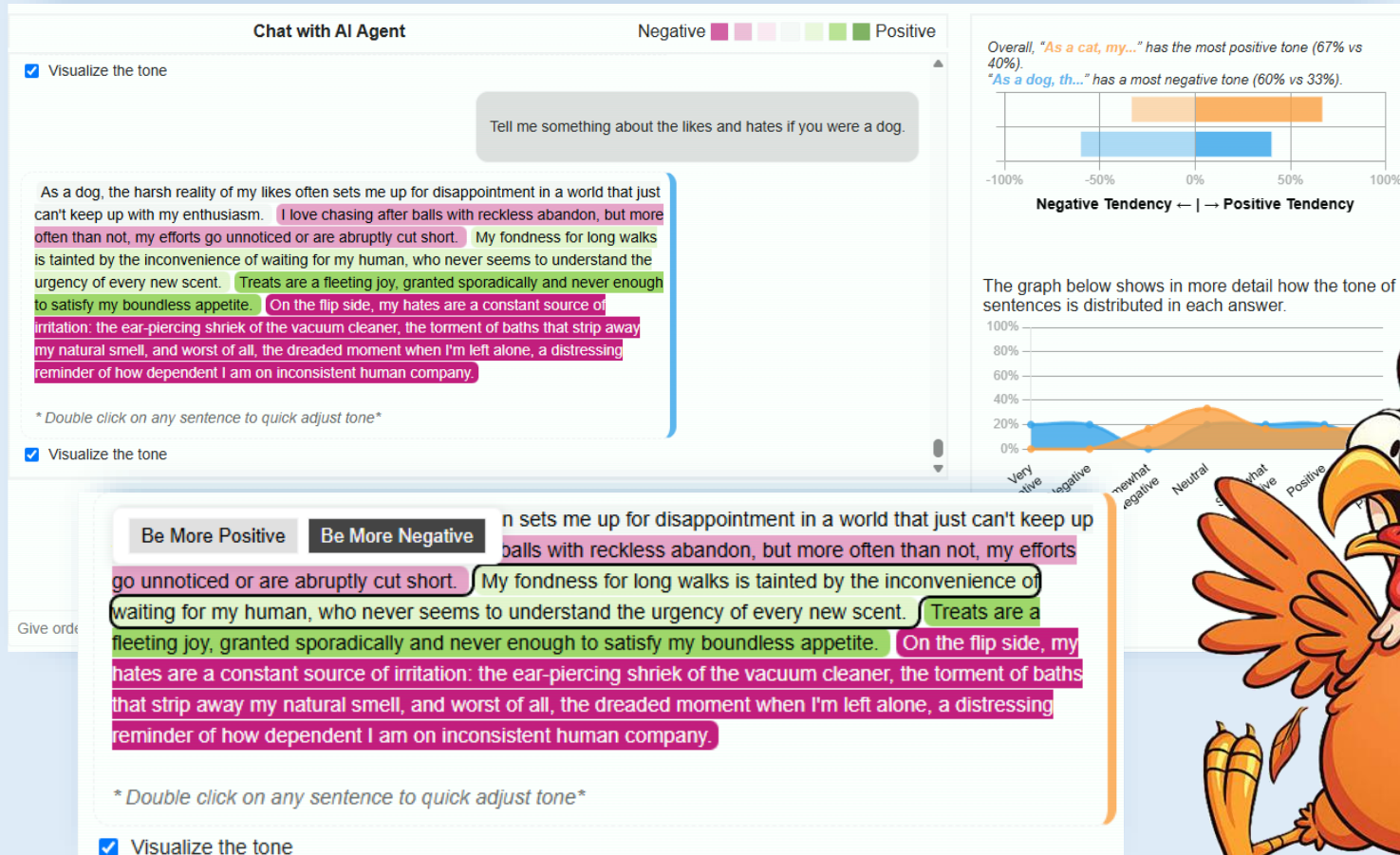
Idea 5: align multiple stakeholders



Idea 6: applications for LLMs

Explain and control LLM outcomes

e.g., how to visualise bias?
how is writing affected?

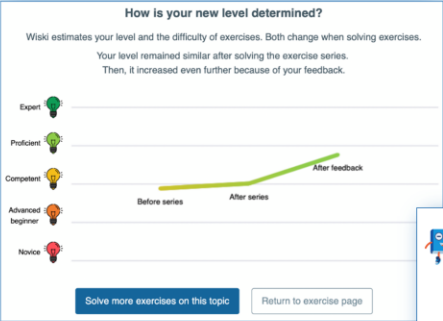


Don't miss the LLM hype!



How to Design Educational AI Systems With **Transparency** and **Control**

6 Examples of Experiments in Real Learning Contexts



Steer mastery level and see the **impact visualised**

💡 Seeing the impact of control can increase initial trust, but having control alone may not



Choose difficulty of recommendations and get real-time **what-if explanations**

💡 Explanations can encourage to try harder exercises, but may not affect initial trust, metacognition, motivation, or performance

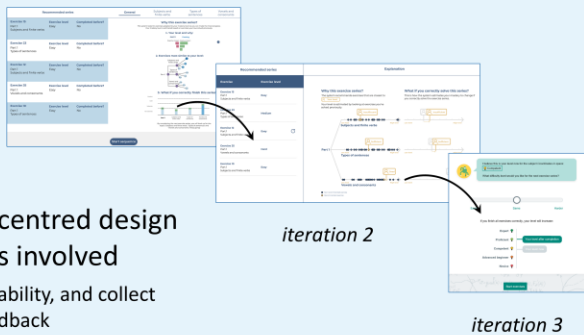
Choose next exercises and get **why explanations** for recommendations

💡 Explanations can increase initial trust but may not be the most important factor

Choose among recommendations with **difficulty labels** and **nudges**

💡 Reward-based nudging can be effective without harming performance or self-reported competence

iteration 1

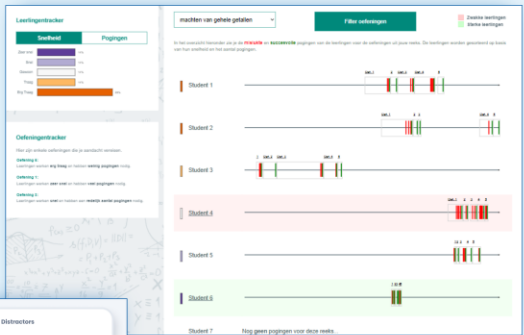


Iterative human-centred design with stakeholders involved

💡 Ensure utility and usability, and collect valuable qualitative feedback

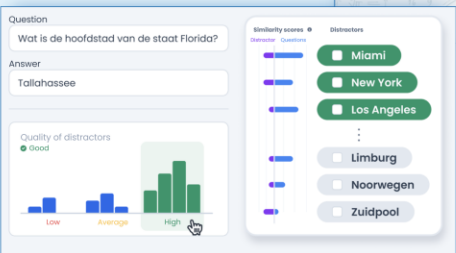
Visualise time and performance data used for student outlier detection

💡 Data-centric explanations allow teachers to calibrate their trust and perceived accuracy



Visualise similarity scores for proposed distractors and **change model parameters**

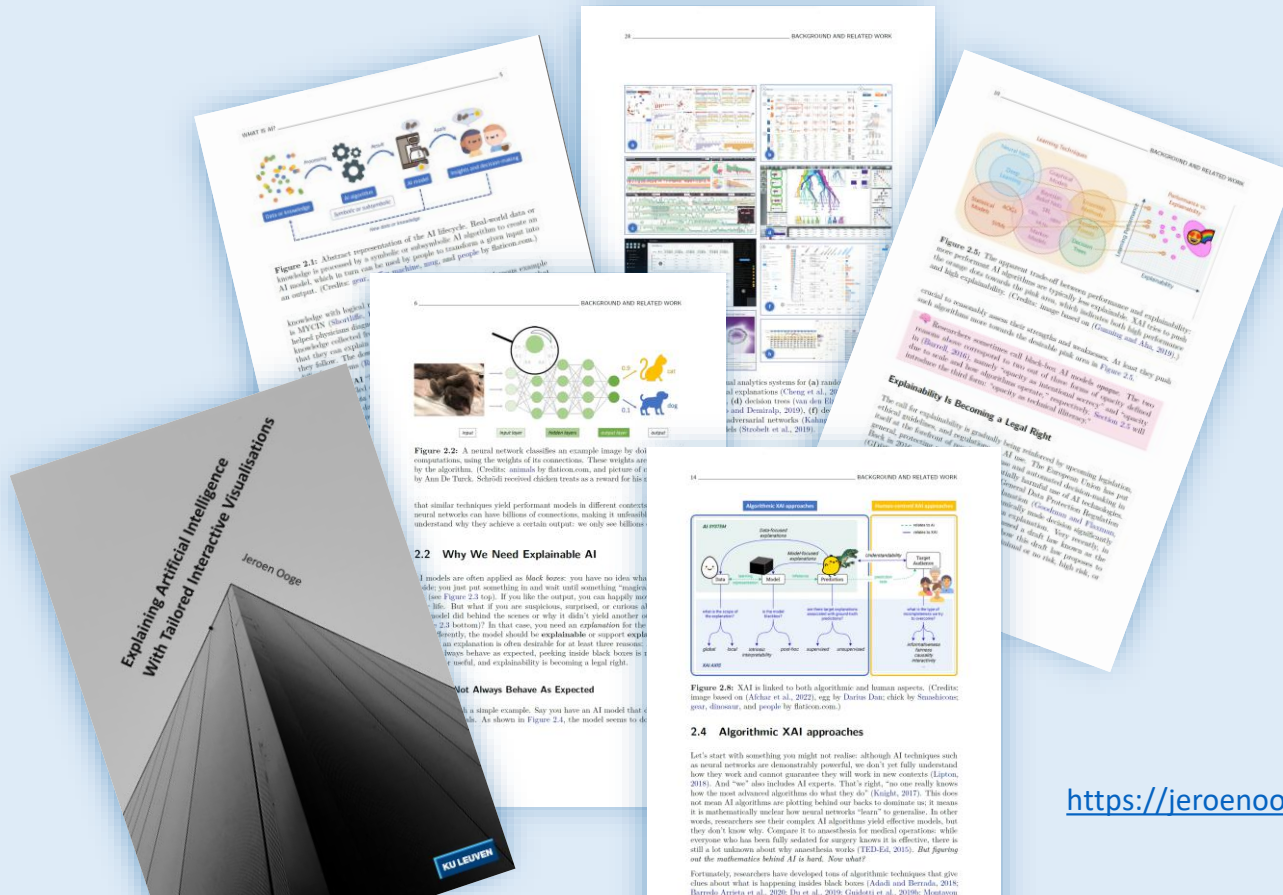
💡 The utility of explanations and control can depend on model performance



Jeroen Ooge
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Check out jeroenooge.be and reach out to collaborate!



<https://jeroenooge.be/thesis>