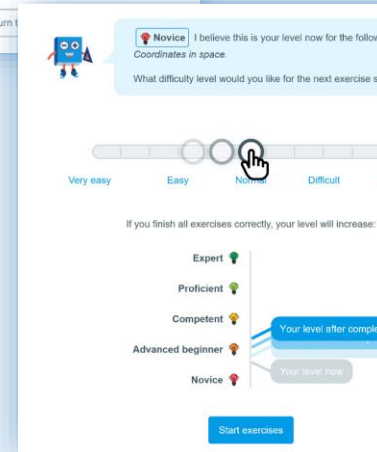
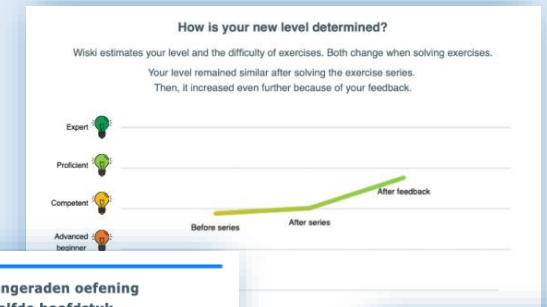
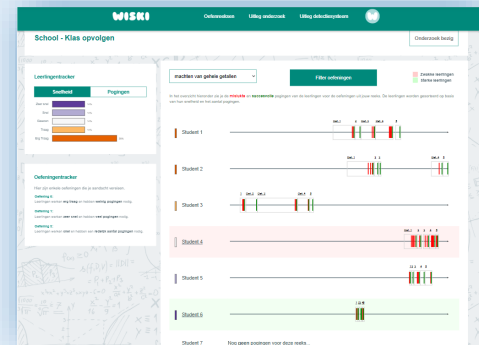


Transparent and Controllable AI Systems for Education

From Designing to Evaluating with Educational Stakeholders



Jeroen Ooge
jeroenooge.be



About Me

*Human-centred explainable AI,
particularly in education*

My short career

MSc fundamental mathematics
MSc applied informatics
2012-2019

KU LEUVEN

PhD in computer science
2019-2023

Assistant professor
in computer science
2023-now



Universiteit
Utrecht



Jeroen Ooge
jeroenooge.be

I Presentation (45 min.)

Transparent and Controllable AI Systems for Education: From Designing to Evaluating with Educational Stakeholders

II Interactive exercise (30 min.)

Make your intelligent educational system more transparent and controllable

I Presentation (45 min.)

Transparent and Controllable AI Systems for Education: From Designing to Evaluating with Educational Stakeholders

II Interactive exercise (30 min.)

Make your intelligent educational system more transparent and controllable

AI can be integrated in education in many ways

Teaching

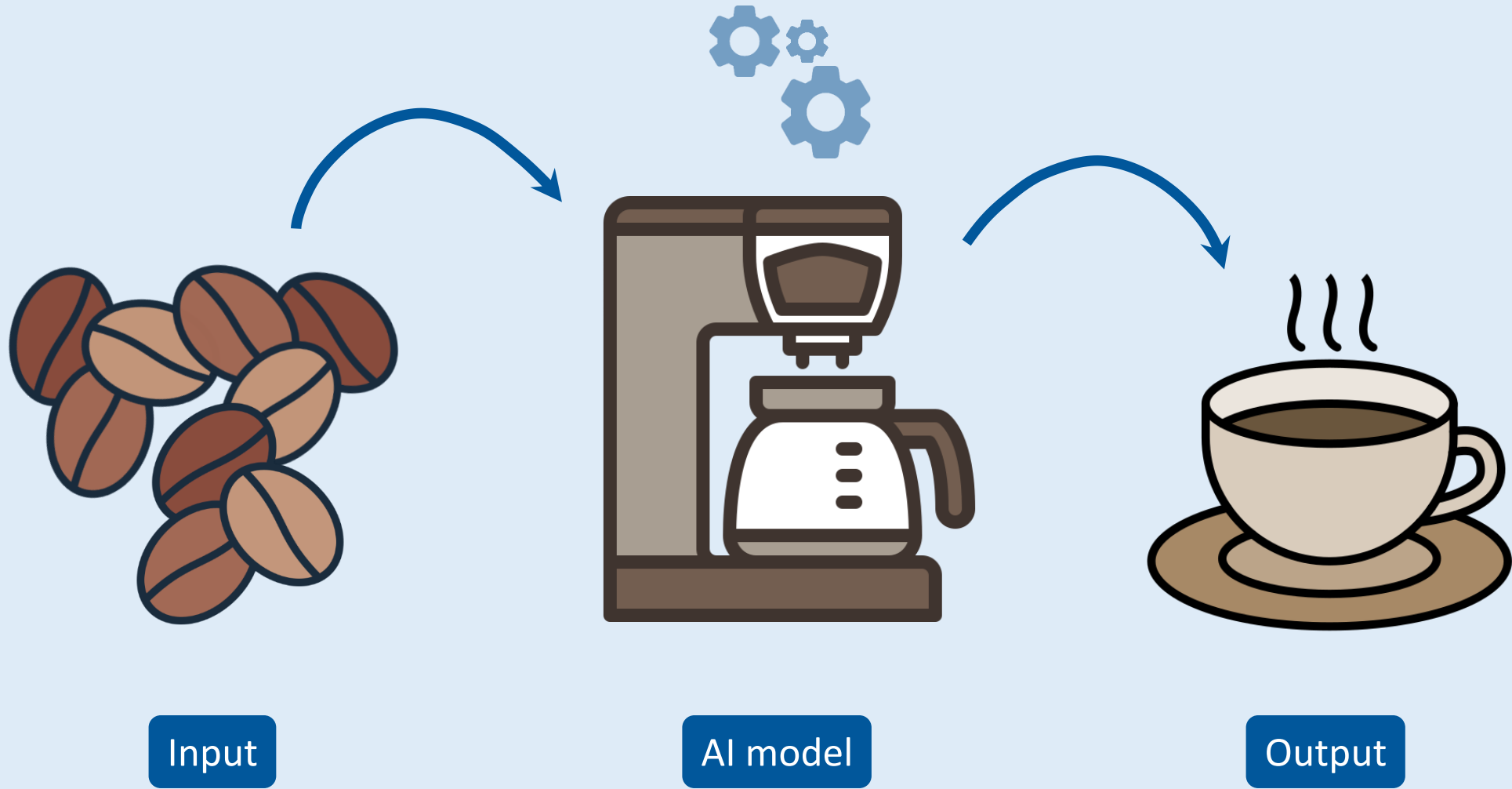
- Teaching-aid
- Teaching quality
- Pedagogical agents
- Training of teachers
- Personalised teaching
- Improving teaching

Student performance

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



WAAAH, AI will take over education!





Available exercises



Recommended exercise



Learner profile



Predicted progress/risk

AaI

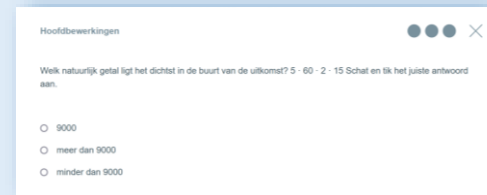
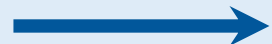
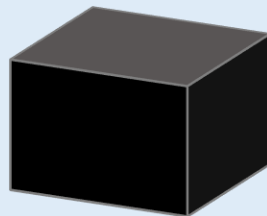
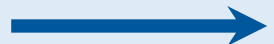
Textual prompt



Exam question



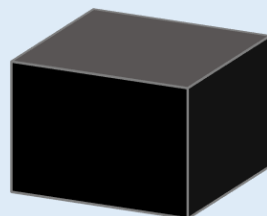
Available exercises



Recommended exercise



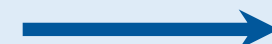
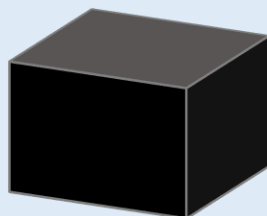
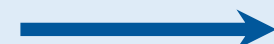
Learner profile



Predicted progress/risk

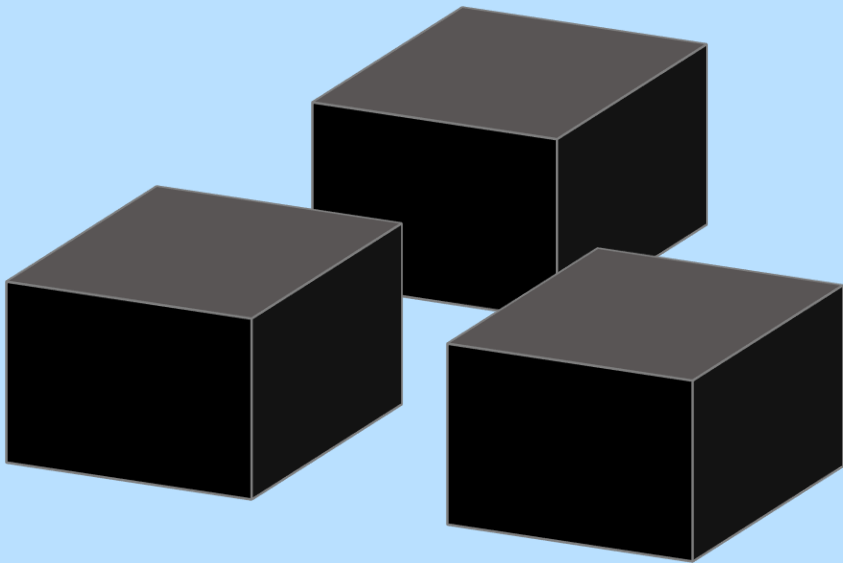


Textual prompt



Exam question

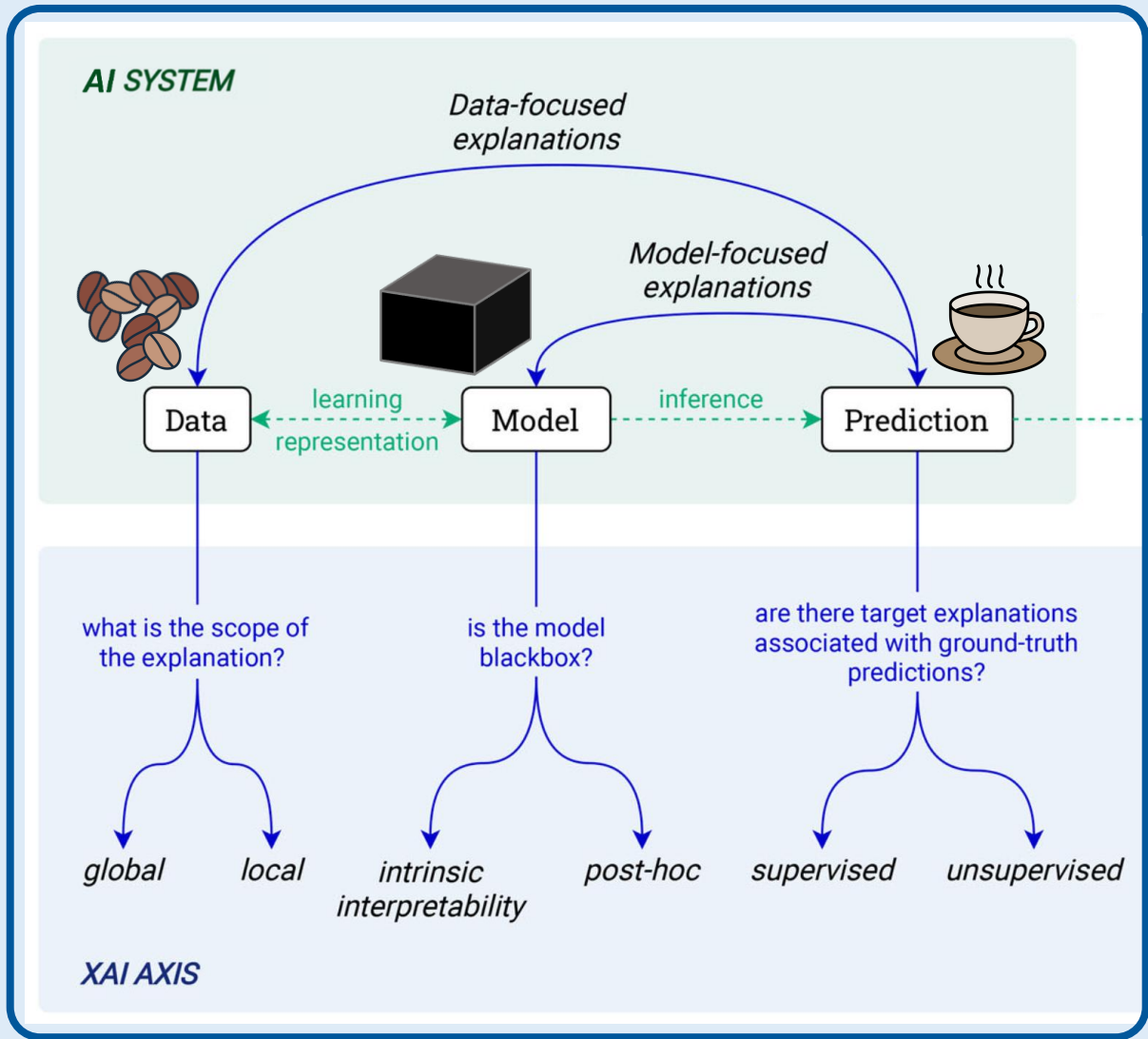
Explanations



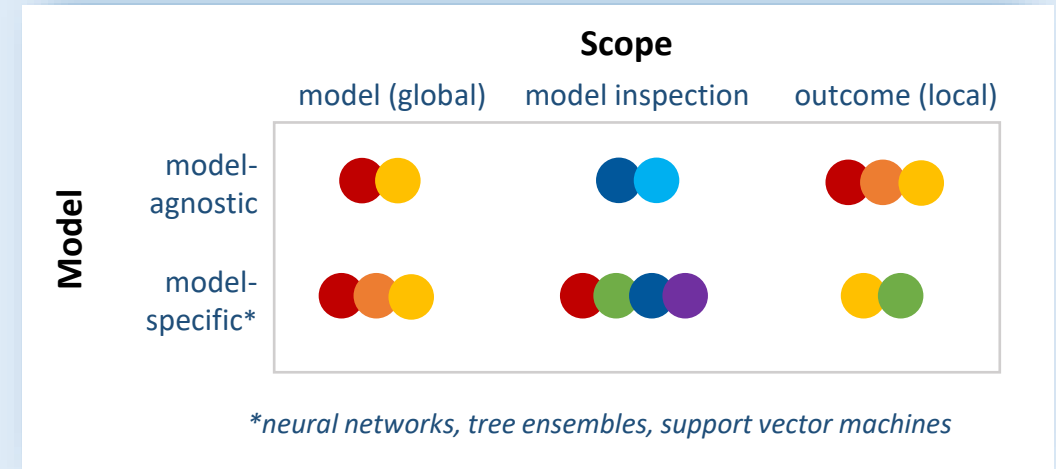
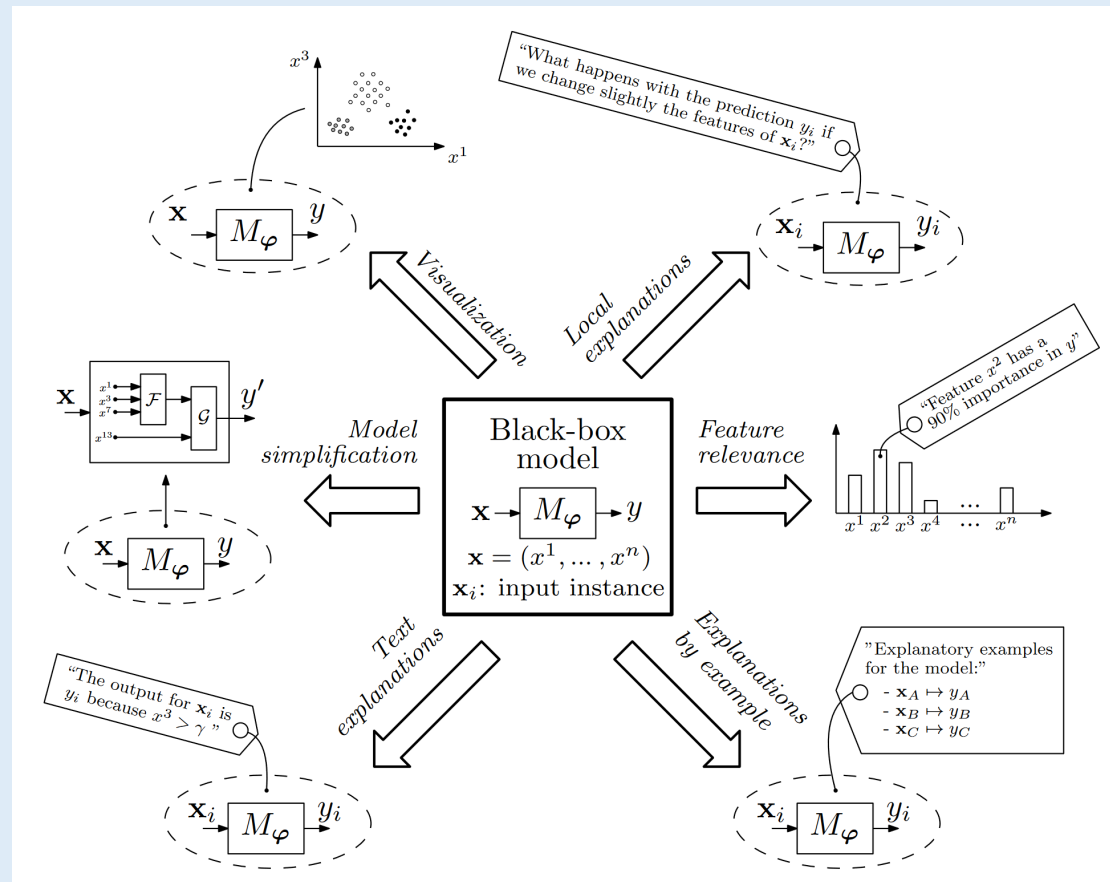
How can we “explain”
these black boxes?



Algorithmic Explainability



Algorithmic Explainability

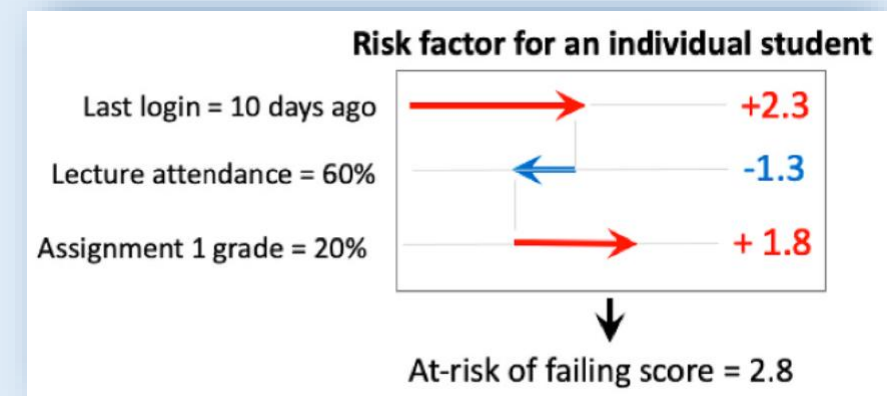
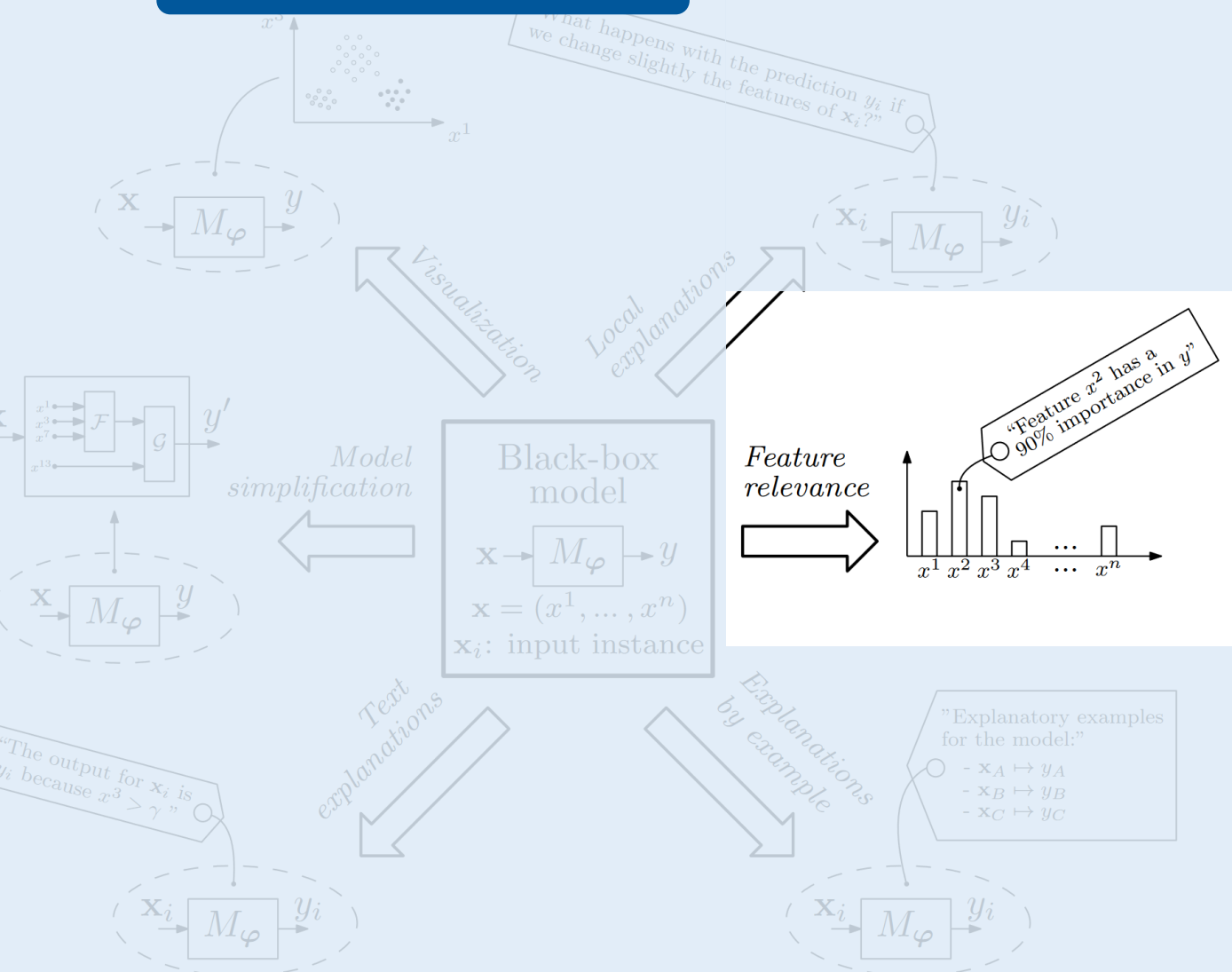


- Decision tree
- Decision rules
- Feature importance
- Saliency mask
- Partial dependence plot
- Sensitivity analysis
- Activation maximisation

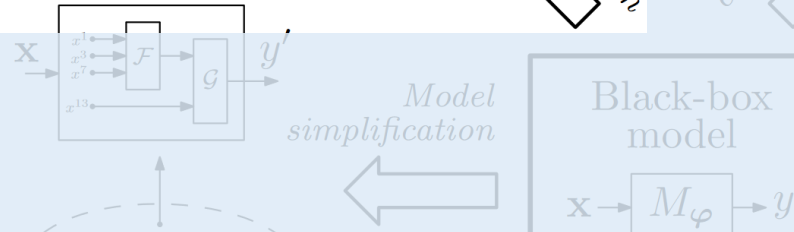
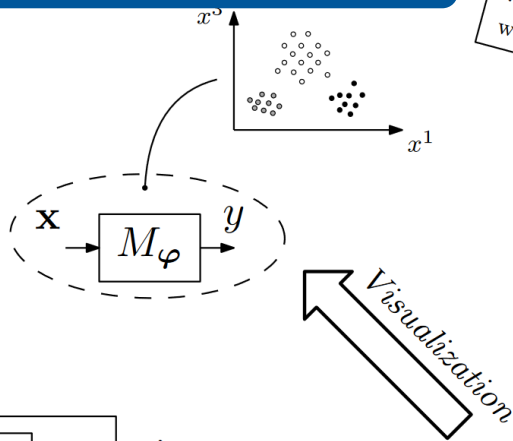
Alejandro Barredo Arrieta et al. 2020. Explainable Artificial Intelligence (XAI): Concepts, taxonomies, opportunities and challenges toward responsible AI. Information Fusion 58: 82–115. <https://doi.org/10.1016/j.inffus.2019.12.012>

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>

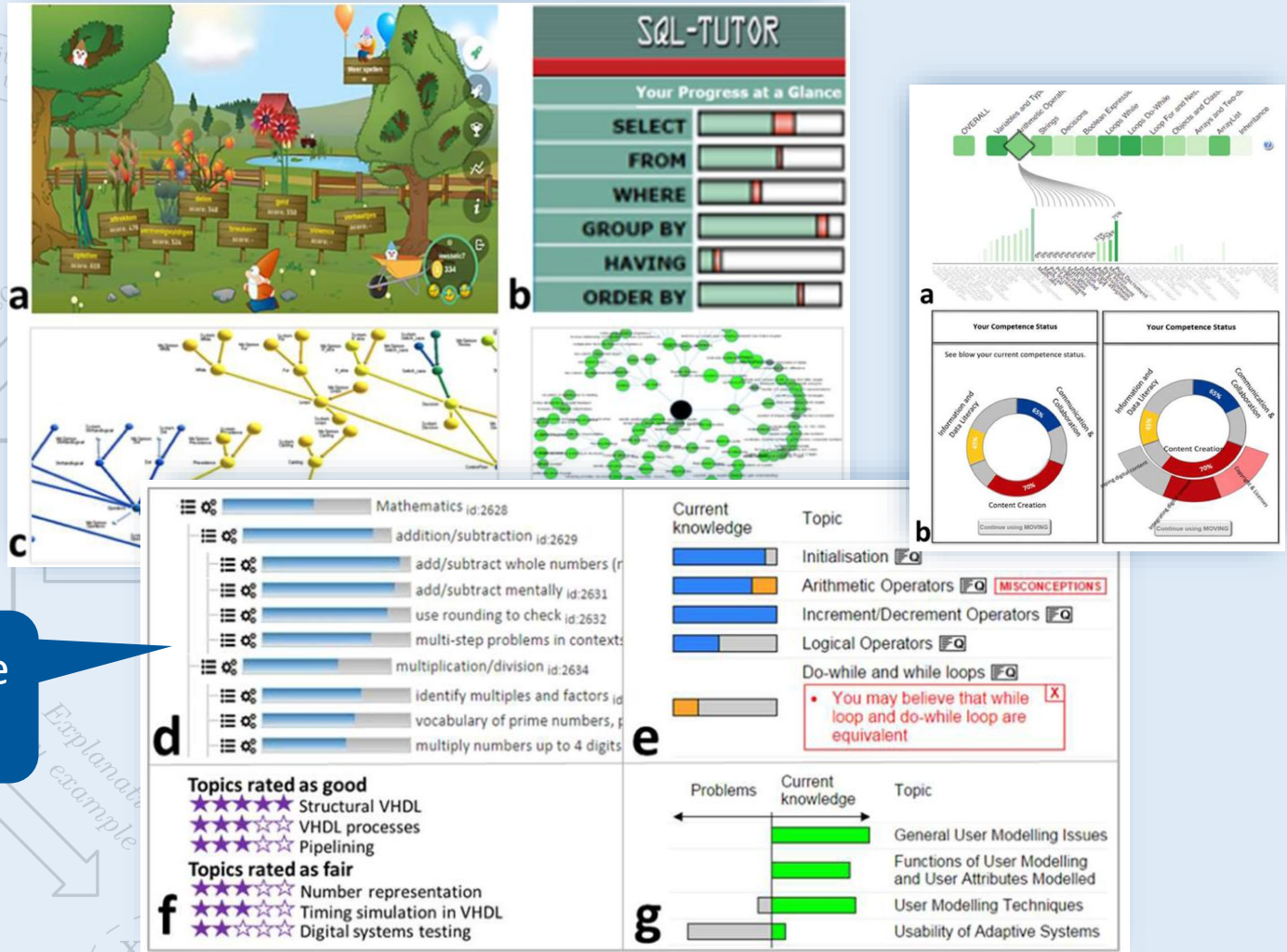
Algorithmic Explainability



Algorithmic Explainability



Open learner models often require algorithmic skill estimation



Some of your reflections

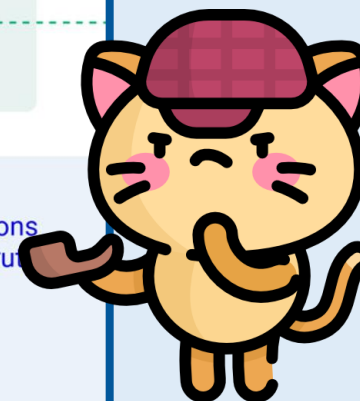
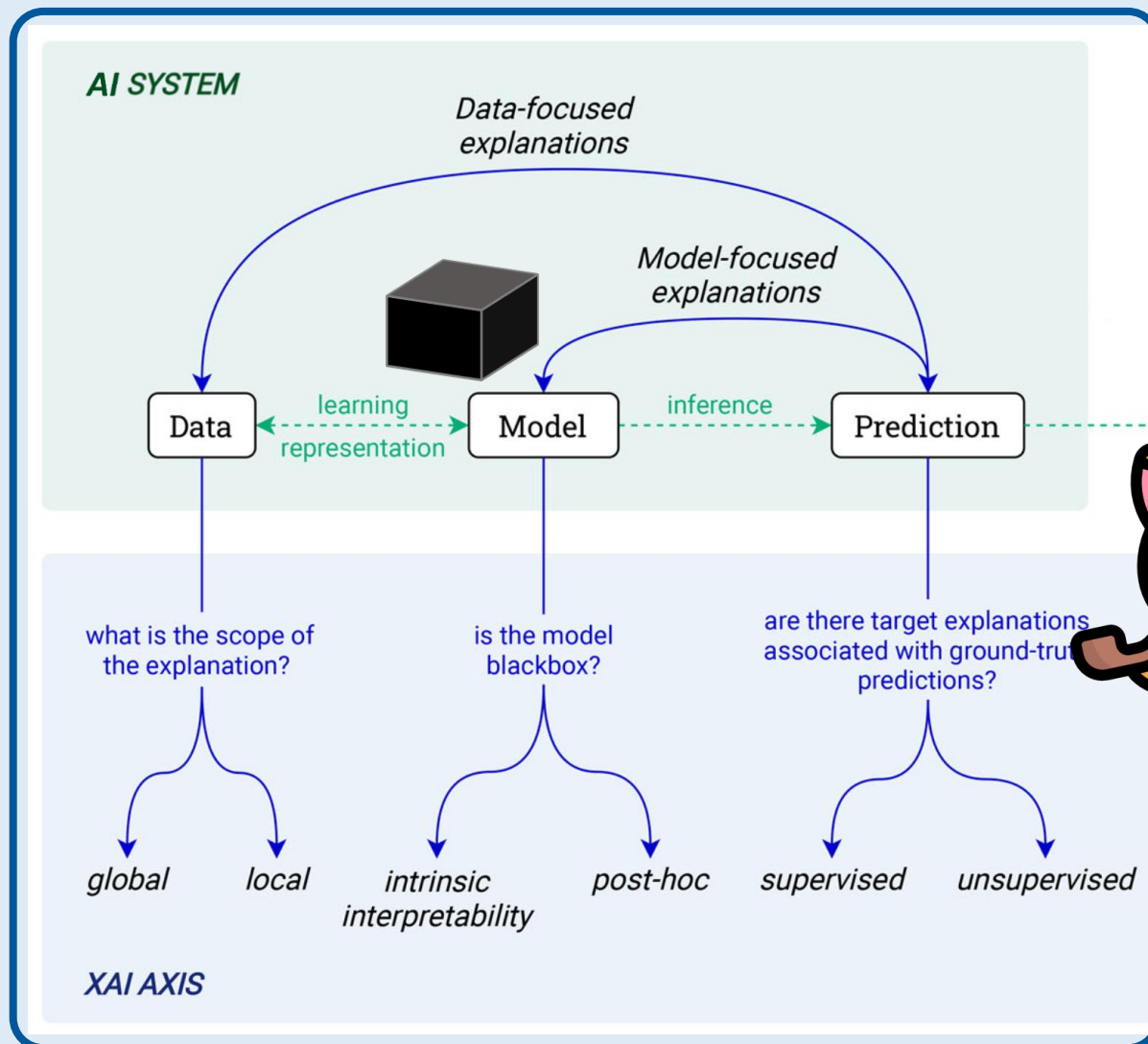
I had never really thought about how **one explanation won't work for everyone**. This makes the design challenge even more complex. - [REDACTED]

There's a delicate balance between making explanations **useful without overwhelming** the user or revealing too much of the AI's internal complexity. - [REDACTED]

What stood out to me is how **different people need different explanations**. A student might want to know why they got a low score, while a teacher might want to understand patterns across the whole class. - [REDACTED]



Algorithmic Explainability



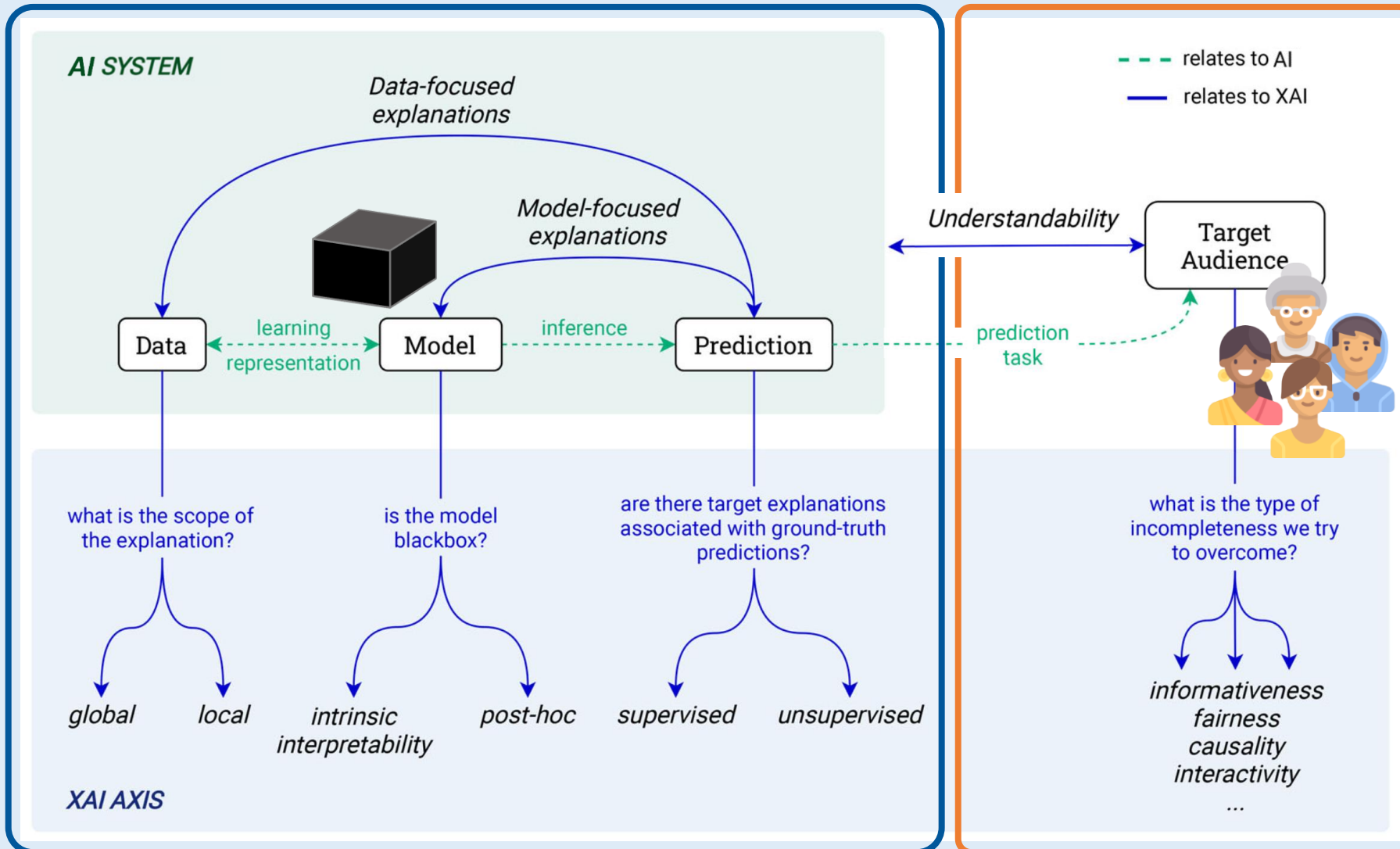
Which explanation do we use?

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 the system be different?
 What is the instance?
 How should the system be different?
 What is the instance?

How

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

What if

What if the instance changes?
 What if the feature changes?
 What if the value changes?

Other

How/why 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?



The XAI-ED Framework

Who are the main *stakeholders*?

Leaners, parents, teachers, technologists, educational researchers, educational admins and policy makers

What potential *pitfalls* need to be considered?

Needless use of complex models, inaccurate or incomplete, explanations, misconceptions, promoting misbehavior.

What *approaches* are used for presenting explanations?

Globally self explaining like feature relevance or example based; locally self explaining like comparison based or counterfactual examples.

What AI *models* are commonly used?

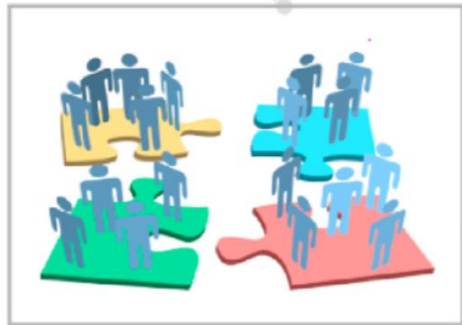
General additive models, decision trees, rule-based models, clustering and natural language processing.

What are the main *benefits*?

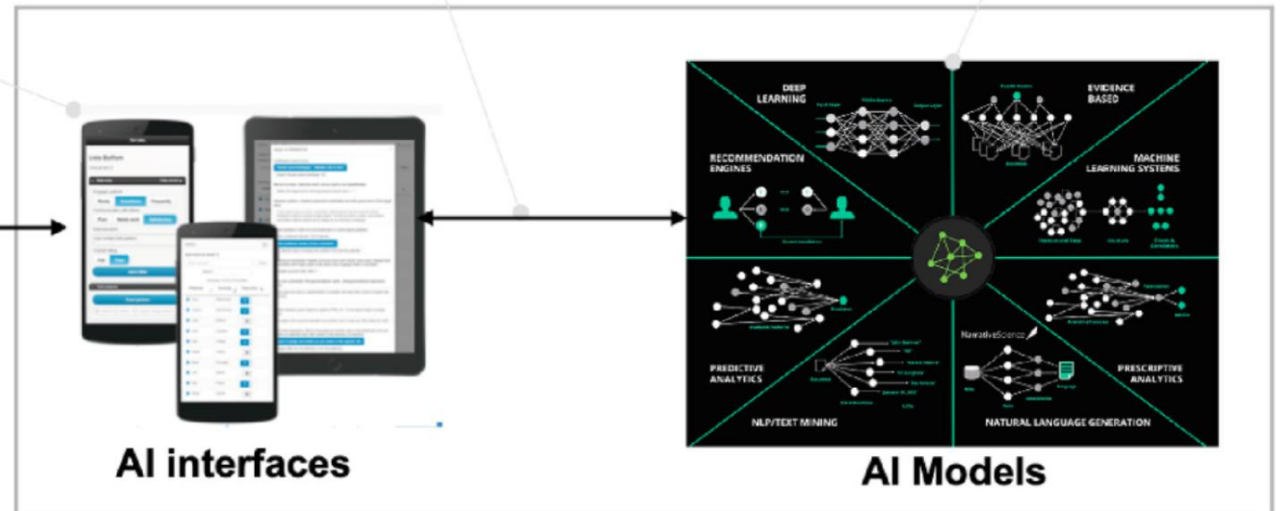
Agency, student-teacher interactions, AI literacy, accountability and trust.

How can educational AI tools be effective *designed*?

Using user experiences, theory driven design, centered design, participatory and co-design, HCI and interaction design.



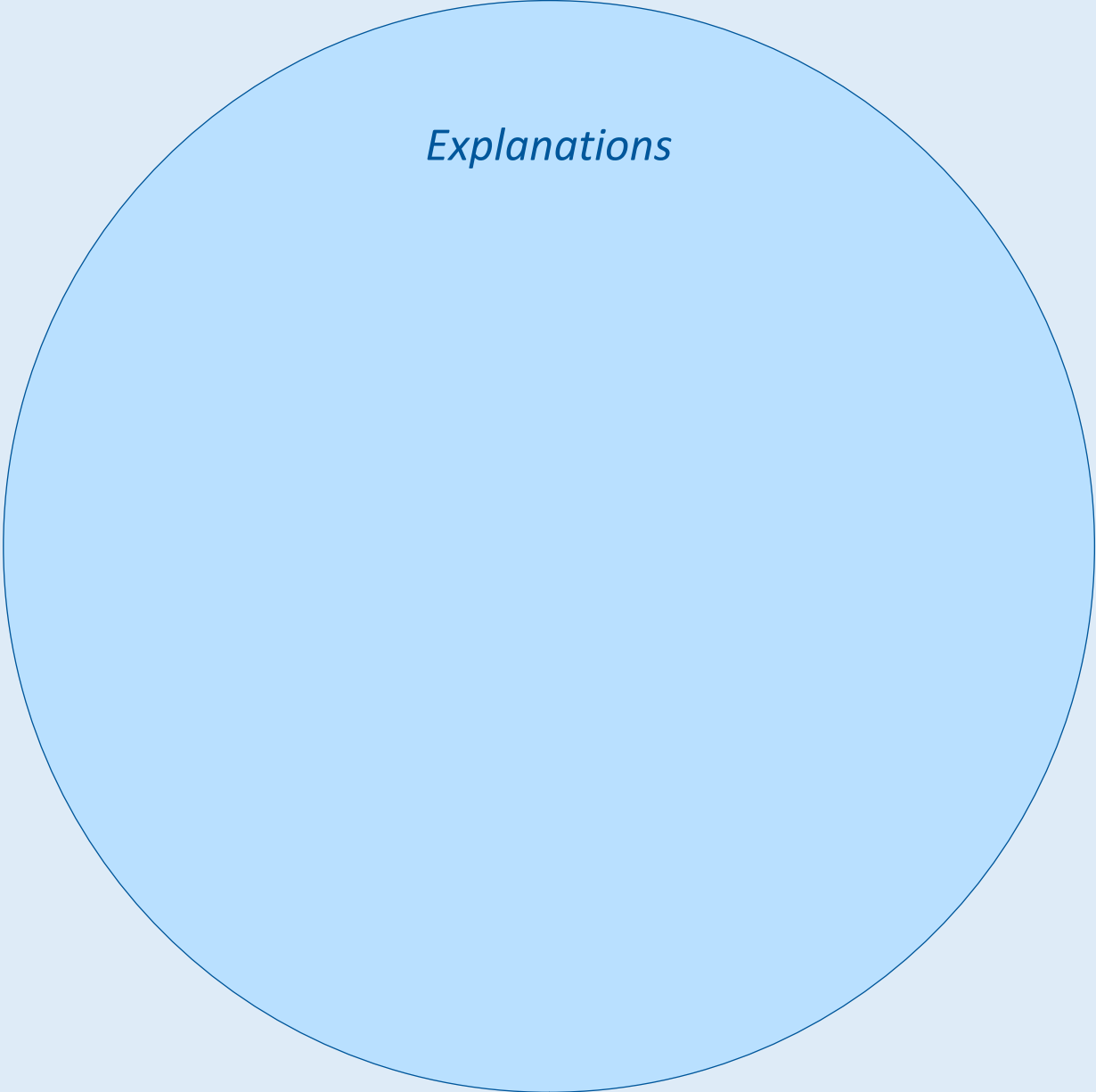
Users



AI interfaces

AI Models

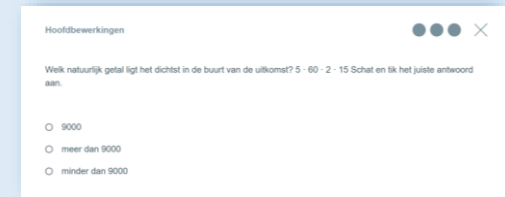
Educational AI systems



Explanations



Available exercises



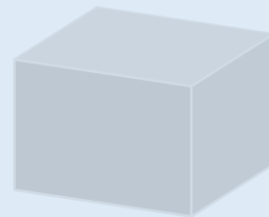
Recommended exercise



WAAAH, we need to accept everything AI "says"!



Predicted progress/risk



Exam question

Textual prompt

Some of your reflections

what happens when teachers and students **disagree with the AI's feedback**? Who gets the final say and how do we prevent over-trust or blind acceptance of automated systems in classrooms? - [REDACTED]

AI should be a tool to help us learn better, reflect more, and **feel more in control** not just another black box making decisions for us. - [REDACTED]



Explanations

Control

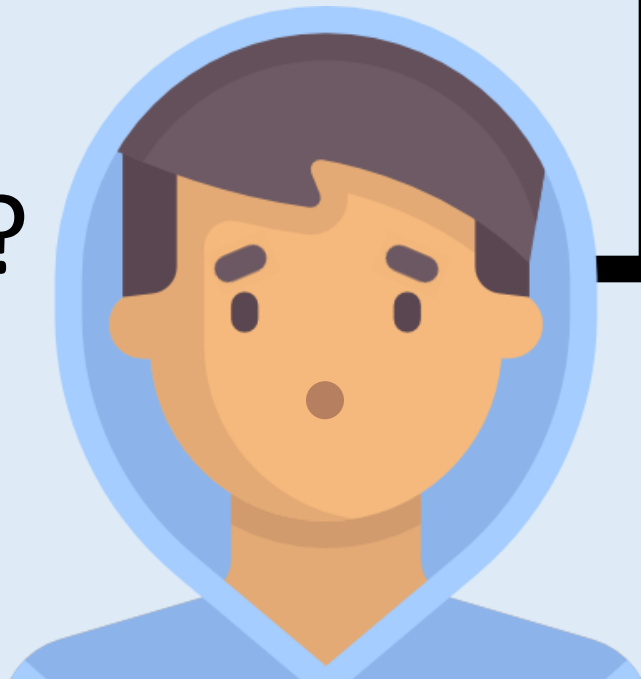
What are suitable
control mechanisms?

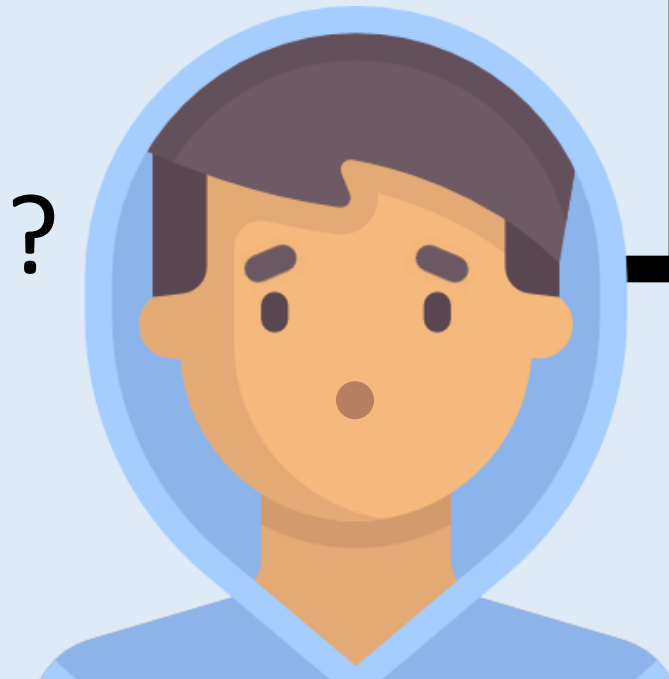
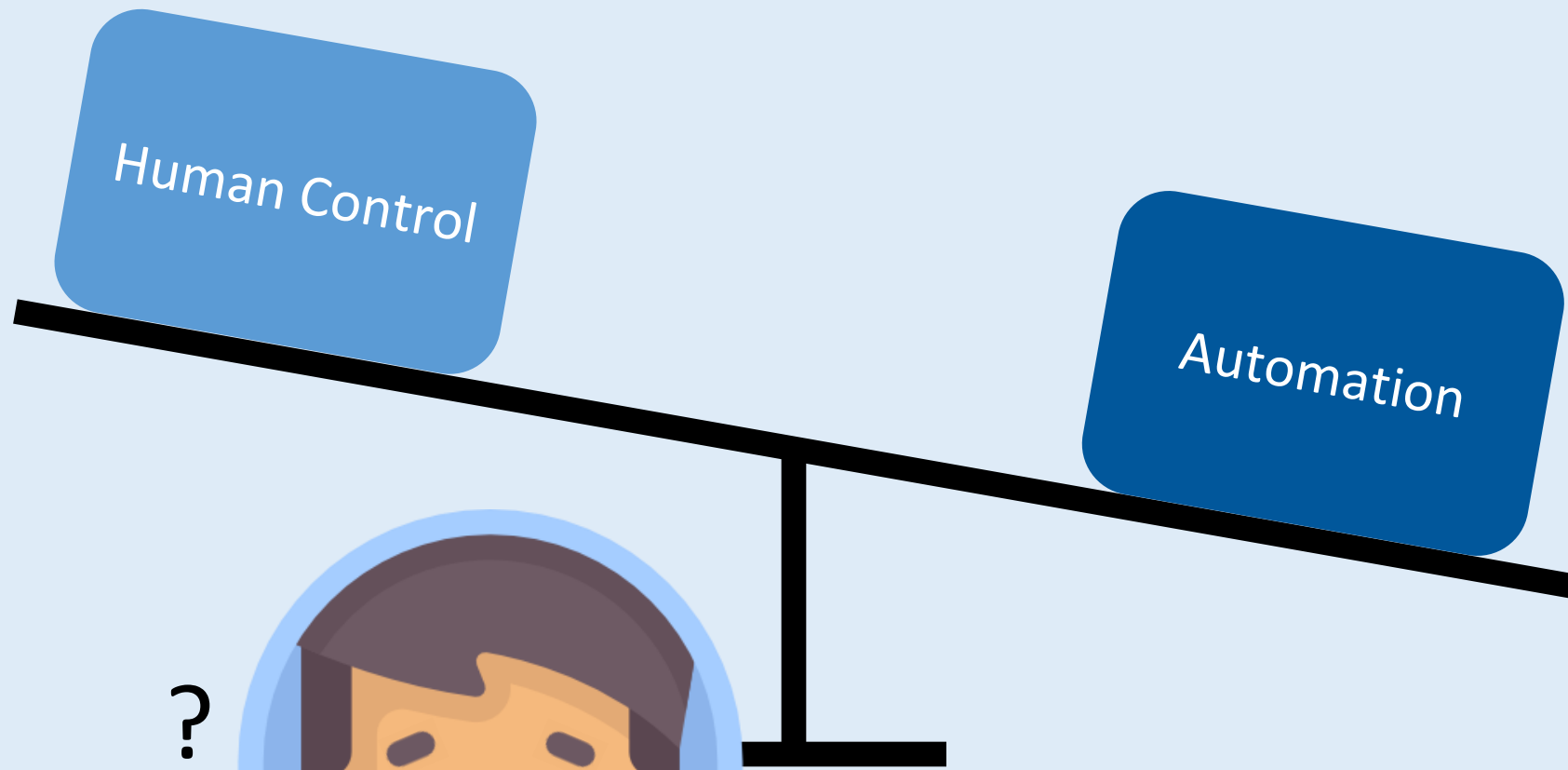


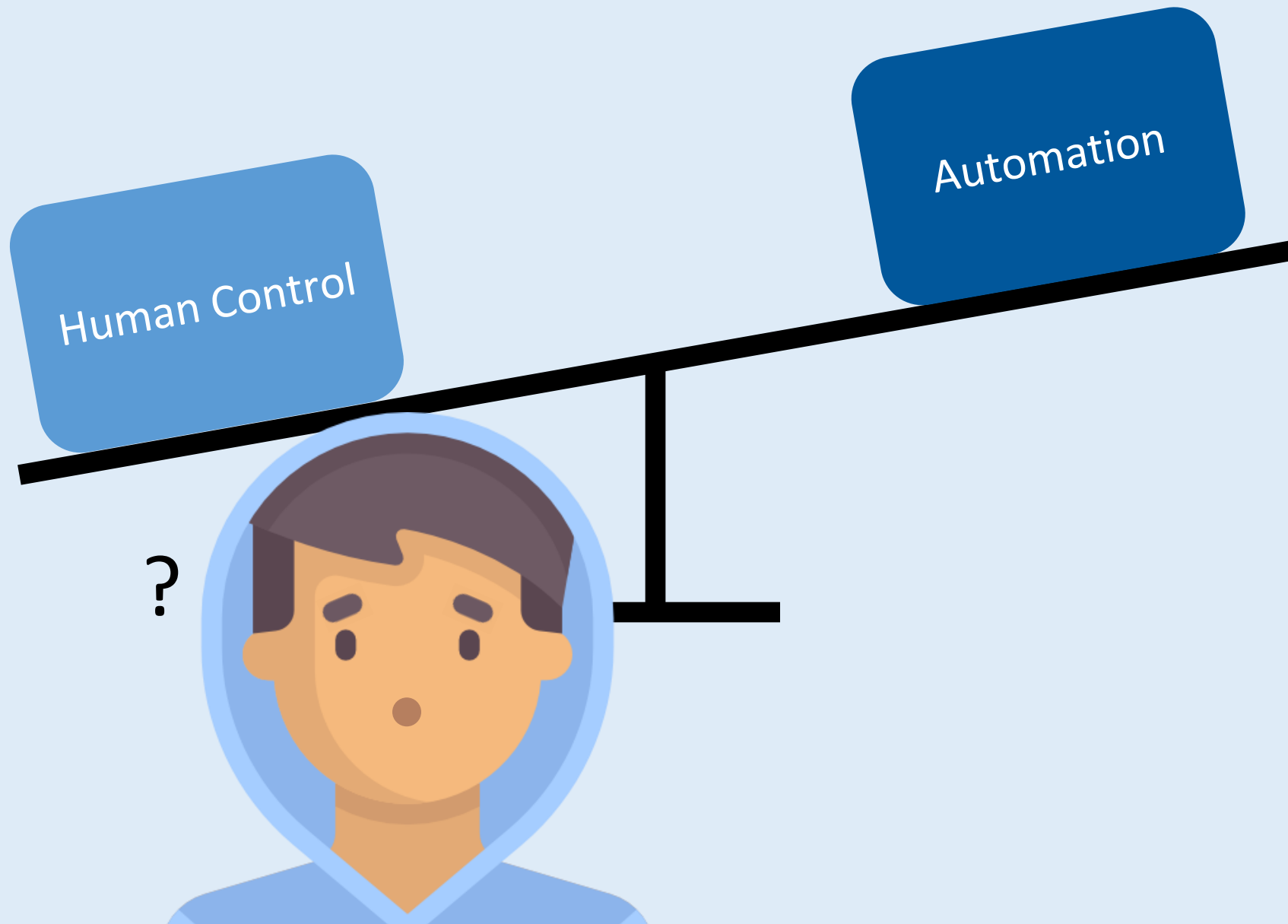
Human Control

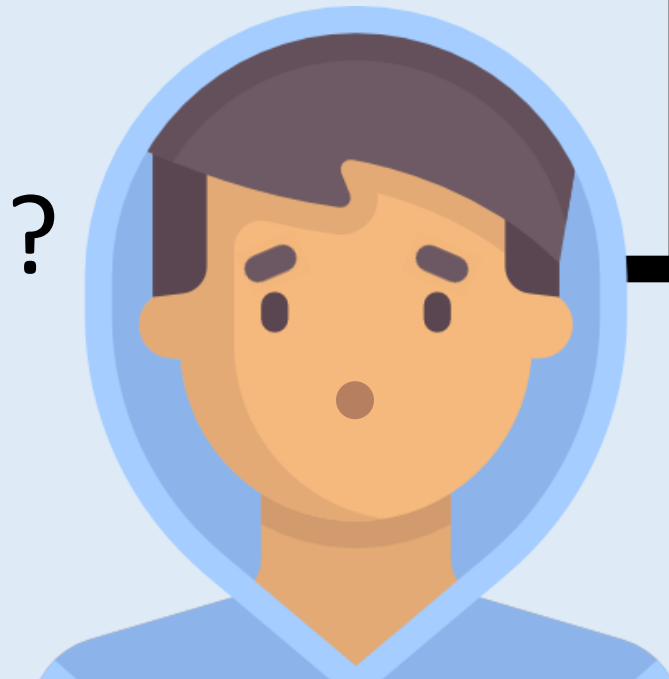
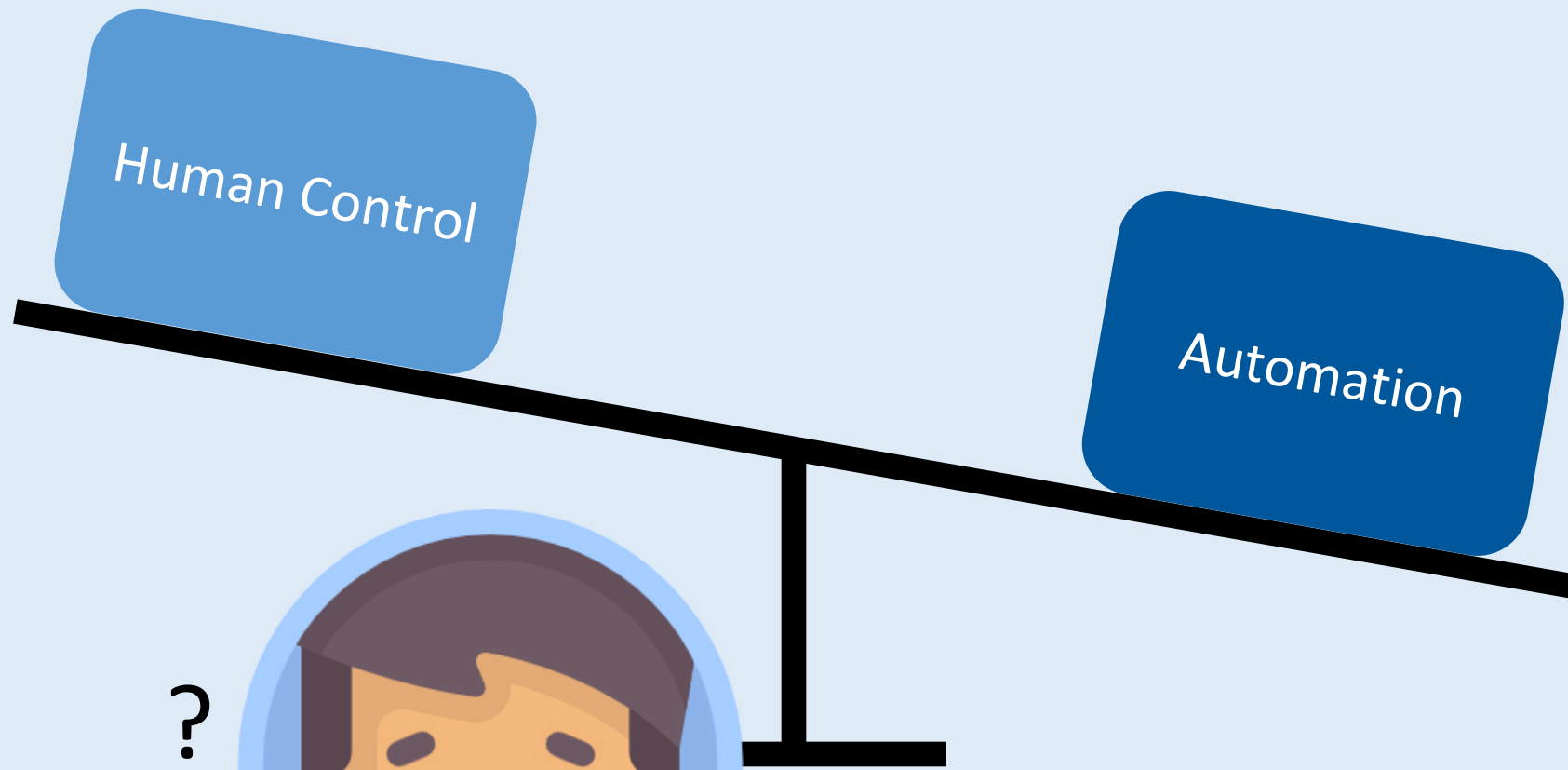
Automation

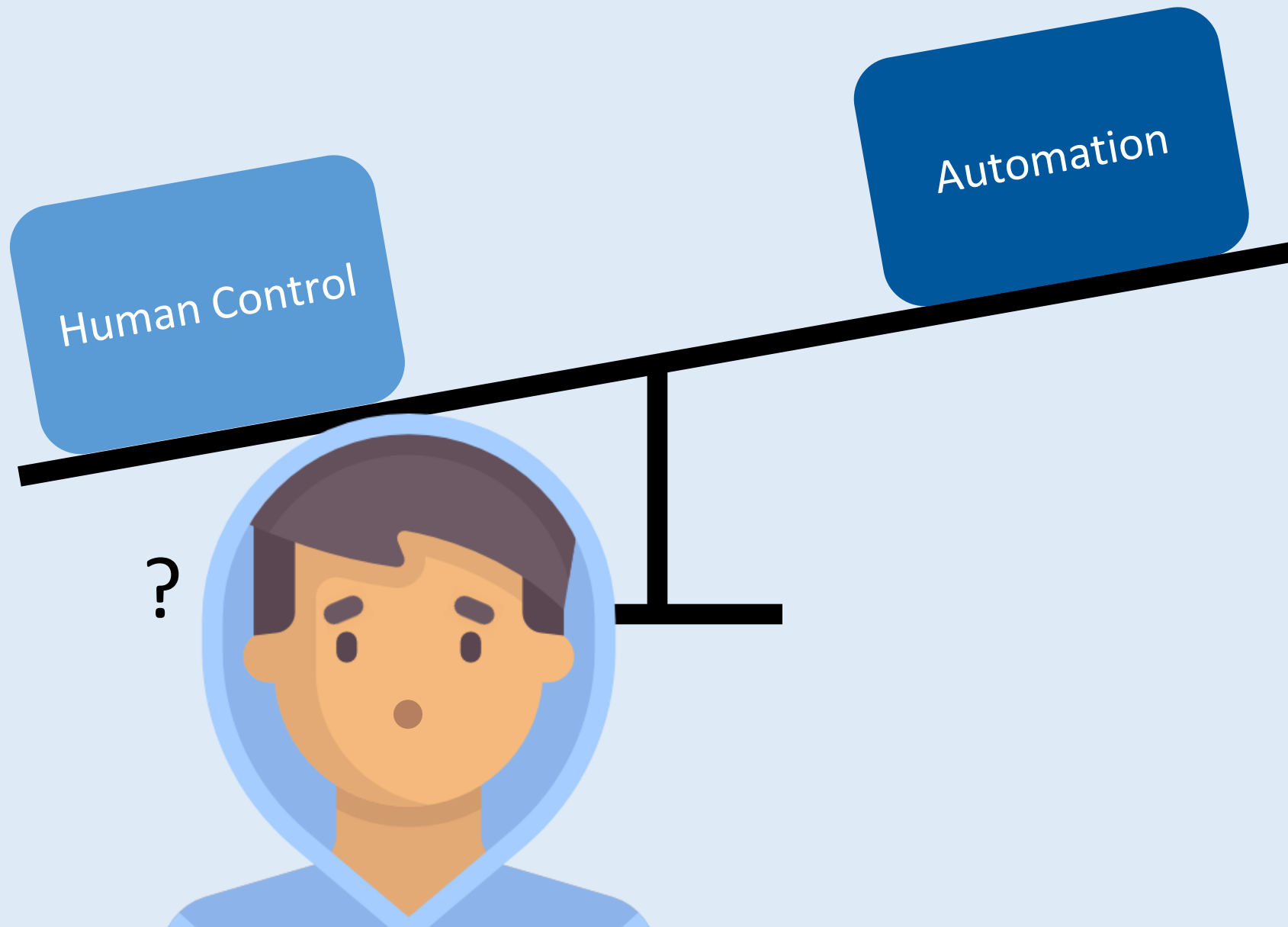
?







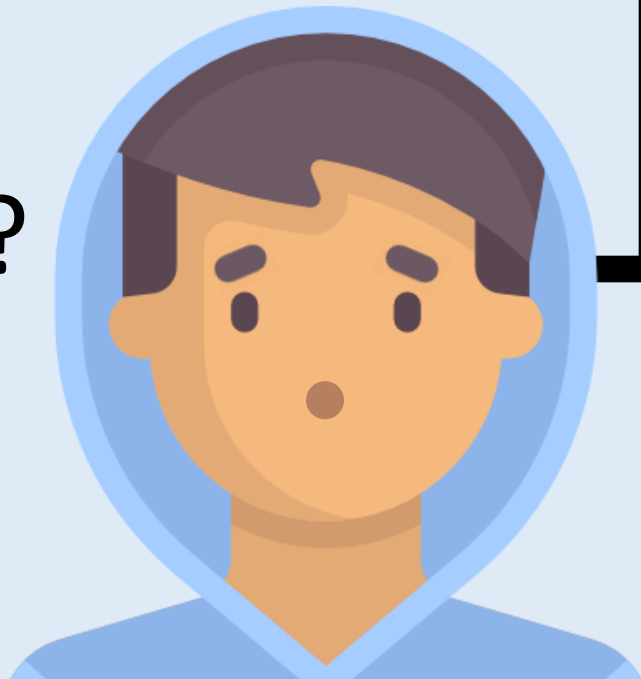




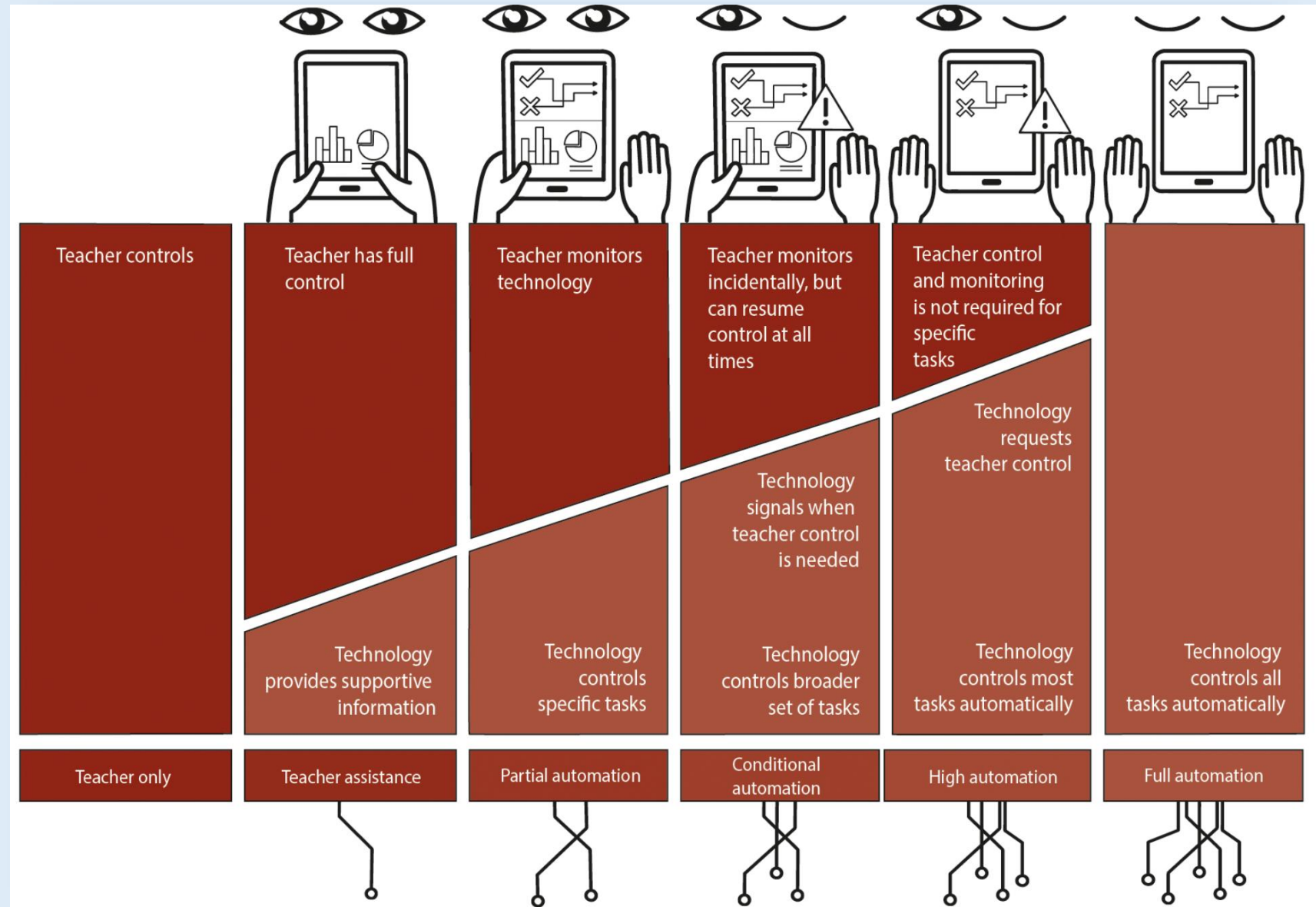
Human Control

Automation

?



Also applies to
other educational
stakeholders





Explanations

Solve a recommended exercise of the same chapter

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.

Recommended

- Exercise 37
- Exercise 26
- Exercise 21

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

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.

Expert
Proficient
Competent
Advanced beginner
Novice

Before series After series After feedback

Solve more exercises on this topic Return to exercise page

WISKI

School - Klas opvolgen

Levensgrootte

Studenten

Progrissen

Student 1

Student 2

Student 3

Student 4

Student 5

Student 6

Student 7

Vraag

Wat is de hoofdstad van de staat Florida?

Antwoord

Tallahassee

Kwaliteit afleiders

Goed

Laag Gemiddeld Hoog

Gelijkaardigheid

Afleidings vragen

Miami

New York

Los Angeles

Limburg

Noorwegen

Zuidpool

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

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Before series After series After feedback

Solve more exercises on this topic Return to exercise page

WISKI

School - Klas opvolgen

Levenslijn

Wat is de hoofdstad van de staat Florida?

Antwoord: Tallahassee

Kwaliteit afleiders: Goed

Laag Gemiddeld Hoog

Vraag: Wat is de hoofdstad van de staat Florida?

Antwoord: Tallahassee

Kwaliteit afleiders: Goed

Laag Gemiddeld Hoog

Gelijkwaardigheid: Afleiders: Miami, New York, Los Angeles, Limburg, Noorwegen, Zuidpool

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

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

Je bent nu de reeks

Start de reeks

WISKI

Oefenen Helpen Oefeningen overzicht

Op volgende van Hoog naar laag

Verwachte moeilijkheidsgraad voor jou

Oefening 43 **Makkelijk**

Oefening 42 **Makkelijk**

Oefening 41 **Makkelijk**

Oefening 40 **Makkelijk**

Oefening 39 **Makkelijk**

Oefening 38 **Makkelijk**

Oefening 37 **Makkelijk**

Oefening 36 **Makkelijk**

Oefening 35 **Makkelijk**

Oefening 34 **Makkelijk**

1 2 3 4 5 volgende > laatste >

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 klassementpagina. Er zijn twee klassementen: 'deze week' en 'aller tijden'.

Oefeningenklassement

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

Day streak

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

WISKI

Oefenen Helpen Oefeningen overzicht

Gefeliciteerd Prijsma resultaat!

Volgde

WISKI

Oefenen

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

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
Huisdriehoek
Omrekenen en oppervlakte van vlakke figuren

WISKI

Oefenen Helpen Oefeningen overzicht

Badge Vooruitgang

Challenge Badges

Badge Overzicht

Delen van oplossingen (2/4)

Medestudenten helpen (1/2)

Wag te behalen badges

Heb je behaalde badges

How is your new level determined?

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Expert
Proficient
Competent
Advanced beginner
Novice

Before series **After series**

WISKI

personalised maths practice with AI

Volgorde van bewerkingen



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

- ☒ 0
- ☐ -144
- ☐ 72
- ☐ 144

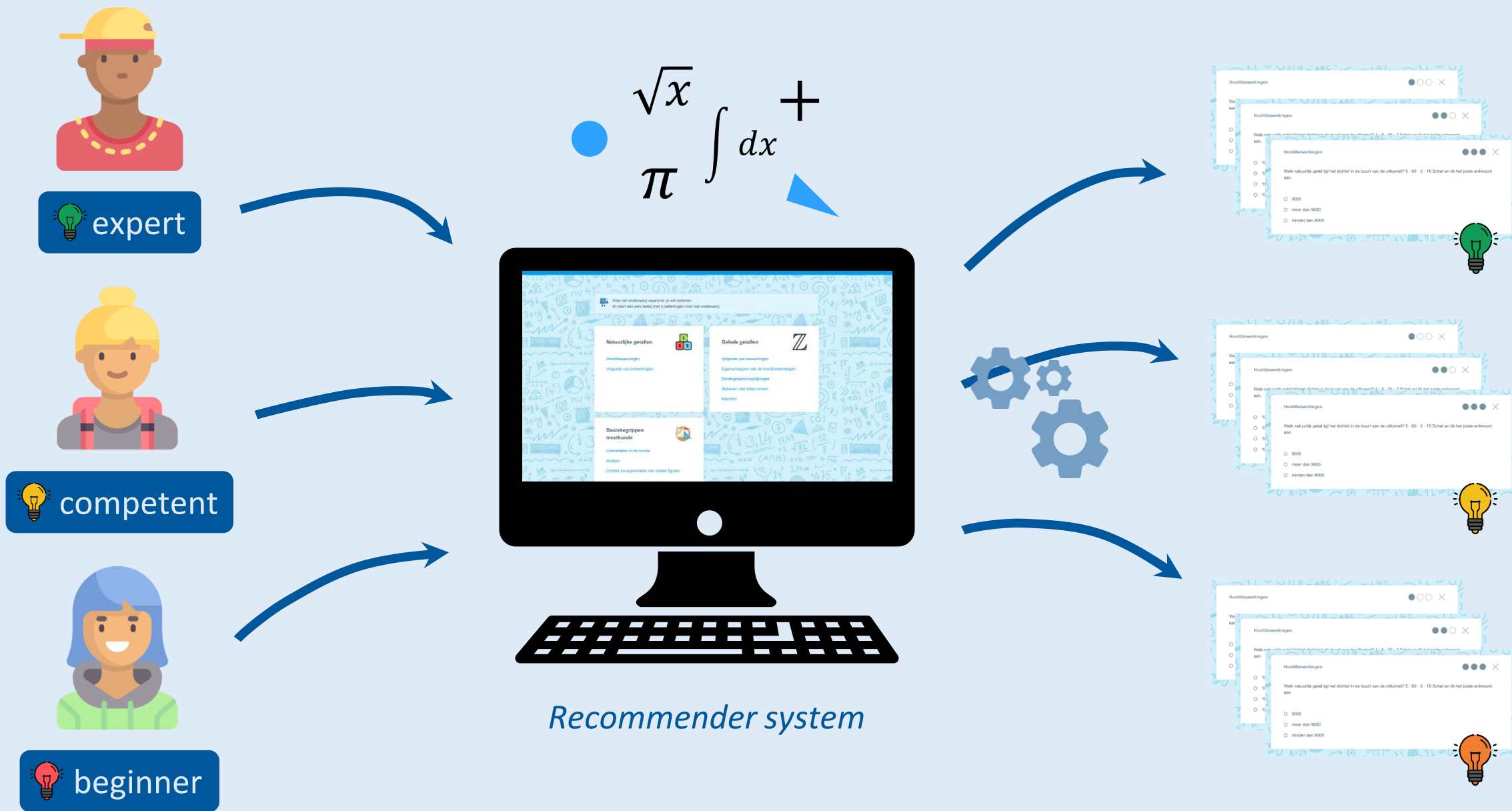


Correct

Top-21

Overslaan

Volgende



Explanations

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New York

Los Angeles

Limburg

Noorwegen

Zuidpool

Kwaliteit afleiders: Goed

Control

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Proficient

Competent

Advanced beginner

Novice

Your level after completion

Your level now

Start exercises

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

$8 + X = 25$

Level: 4.0

Reward: 1

$X - 1 = -14$

Level: 4.0

Reward: 2

$12 + X = 5$

Level: 4.0

Reward: 1

$-8 + X = -24$

Level: 4.0

Reward: 2

Solve a recommended exercise of the same chapter

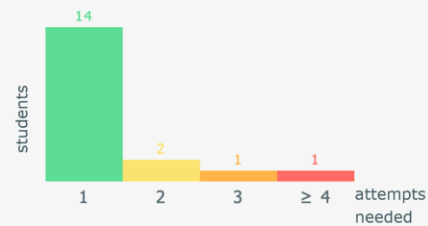
Recommended



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.

Number of attempts fellow students needed to solve exercise 21



Solve exercise 21

... or pick your next exercise yourself

Go to the exercise overview

Textual
explanation

Visual
explanation

Solve a recommended exercise of the same chapter

Recommended



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



Wiski recommends this next exercise



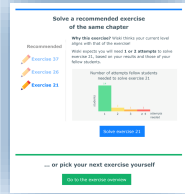
Solve exercise 21

... or pick your next exercise yourself

Go to the exercise overview

No explanation

How was trust in the platform for recommending exercises affected?



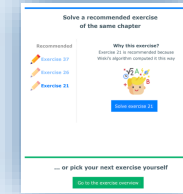
Real vs no explanation

trust increased



trust unchanged

trust decreased



Placebo vs no explanation

trust increased



trust unchanged

trust decreased

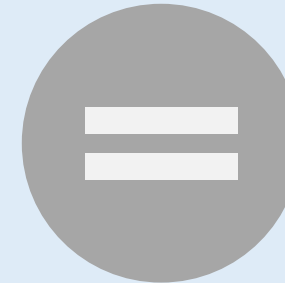
Competence	
Q1	Wiski is like an expert (for example, a teacher) for recommending exercises.
Q2	Wiski has the expertise (knowledge) to estimate my math level.
Q3	Wiski can estimate my math level.
Q4	Wiski understands the difficulty level of math exercises well.
Q5	Wiski takes my math level into account 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

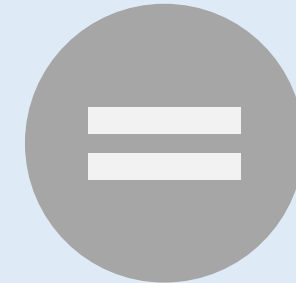
Multidimensional trust

Real vs no explanation

MD trust



1D trust

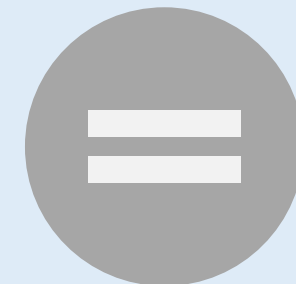


Placebo vs no explanation

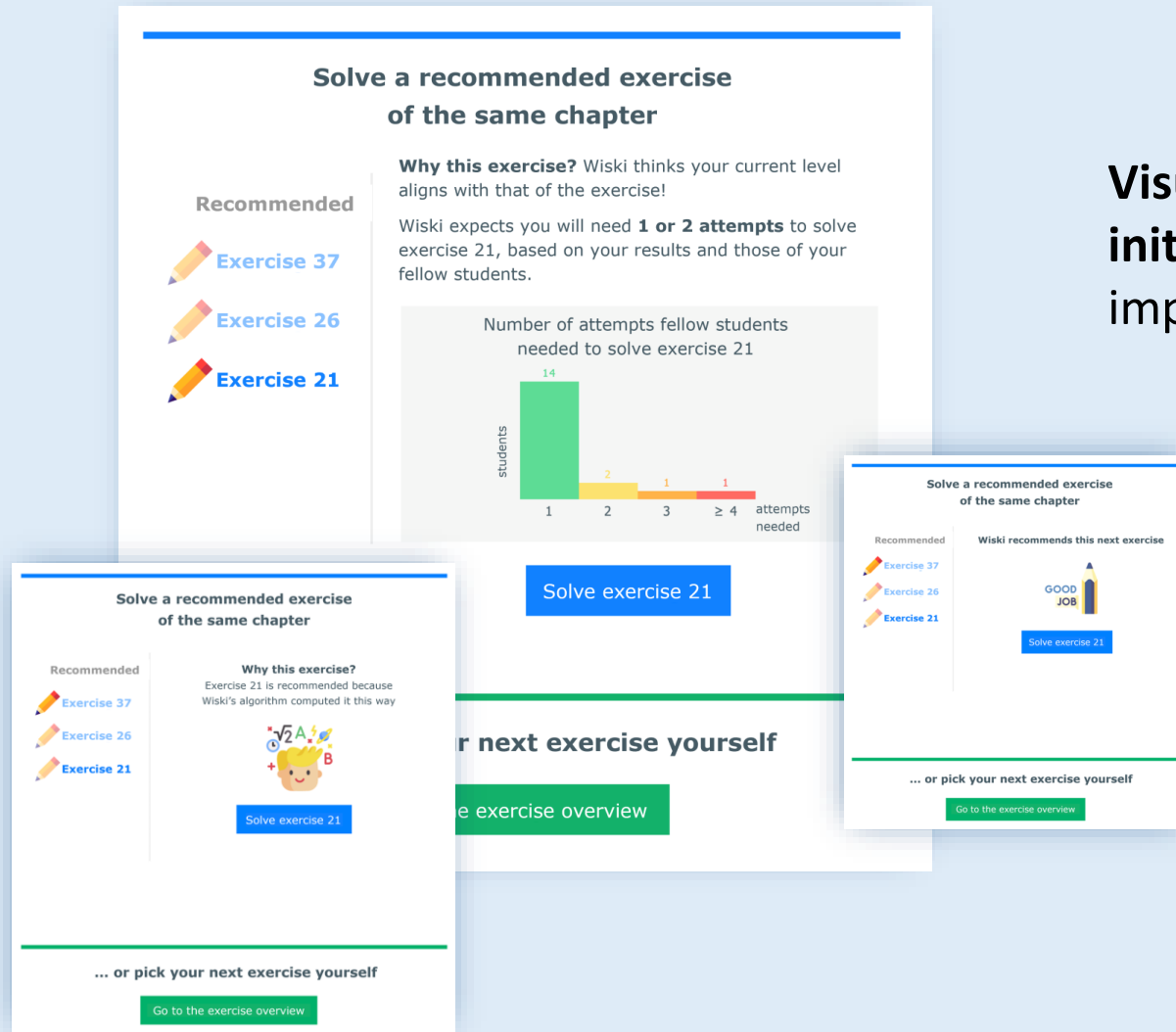
MD trust



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

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.

Recommended

- Exercise 37
- Exercise 26
- Exercise 21

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 new goal

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.

Expert

Proficient

Competent

Advanced beginner

Novice

Before series After series After feedback

Solve more exercises on this topic

Return to exercise page

WISKI

School - Klas opvolgen

Levenslijn

Wat is de hoofdstad van de staat Florida?

Antwoord: Tallahassee

Kwaliteit afleiders: Goed

Laag Gemiddeld Hoog

Vraag: Wat is de hoofdstad van de staat Florida?

Antwoord: Tallahassee

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Gelijkwaardigheid

Afleidings

Miami

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Los Angeles

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Zuidpool

Pick a reward and exercise:

Next time you will get 4 new exercises

$8 + X = 25$

Level: $\star\star\star$

Reward: 1

$X - 1 = -14$

Level: $\star\star\star\star$

Reward: 2

$12 + X = 5$

Level: $\star\star\star\star$

Reward: 1

$-8 + X = -24$

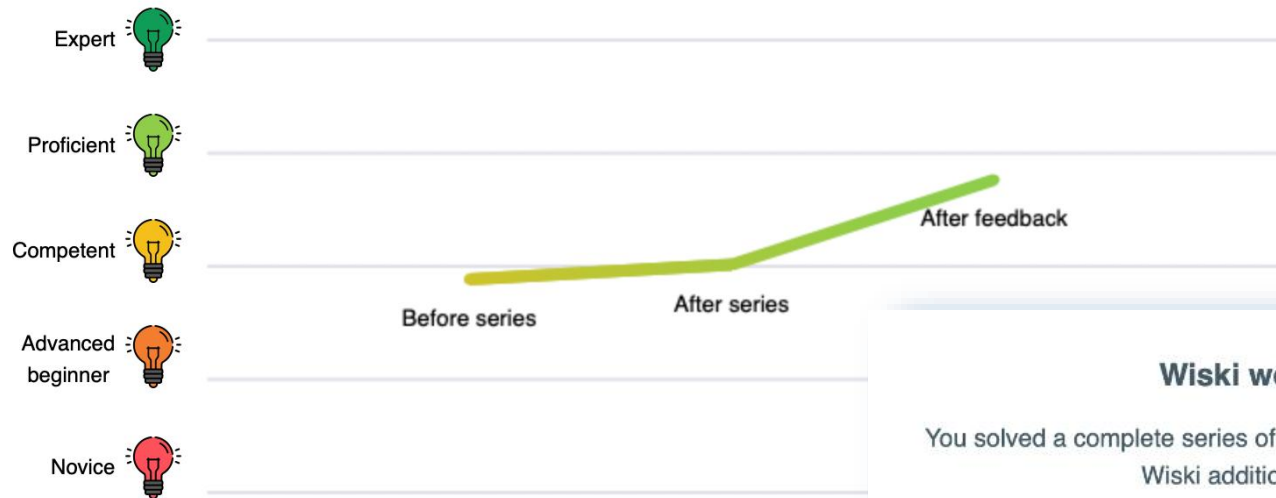
Level: $\star\star\star\star$

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

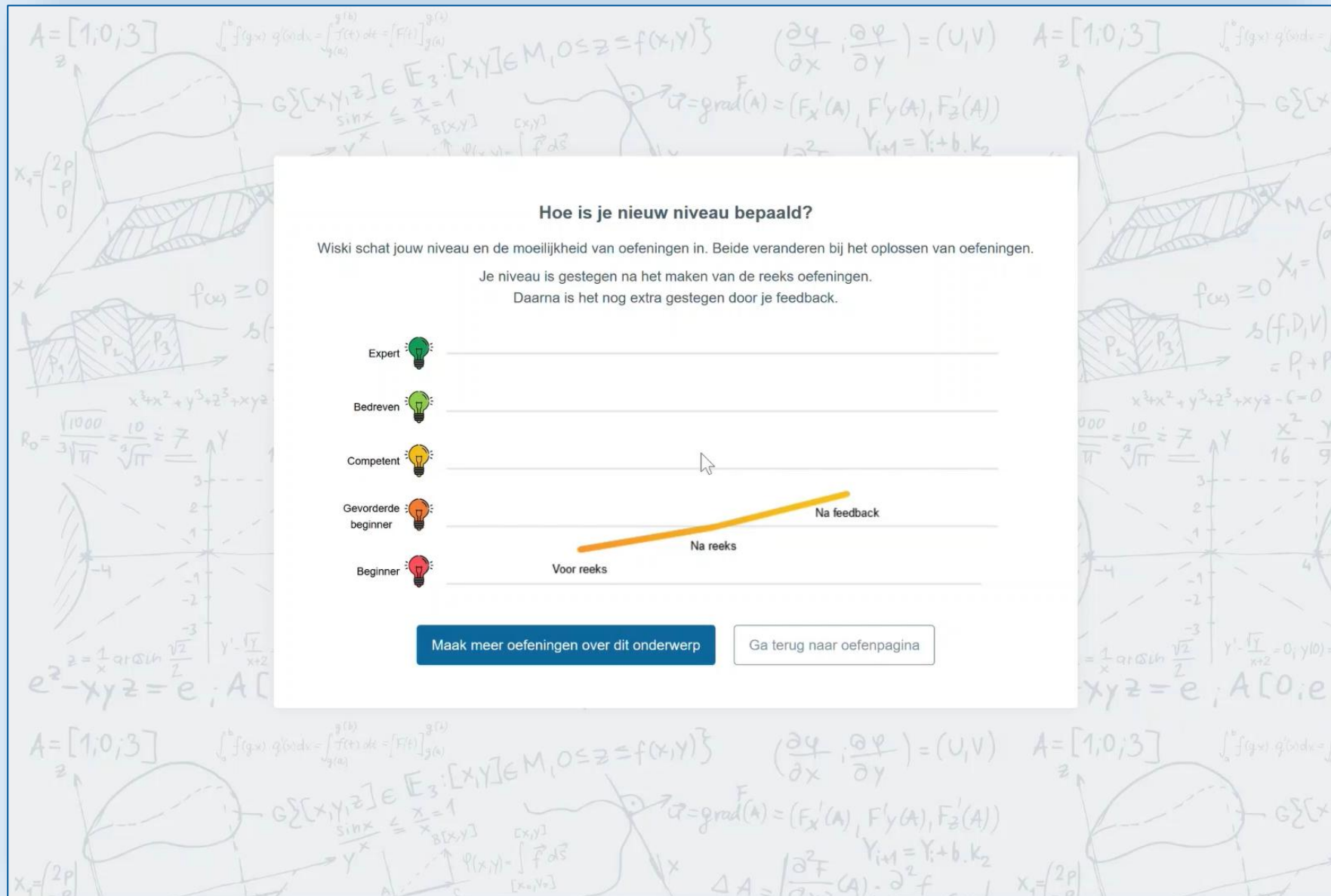
Wiski would like additional information from you

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.

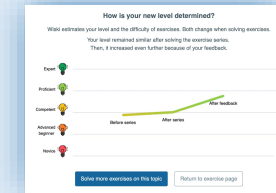
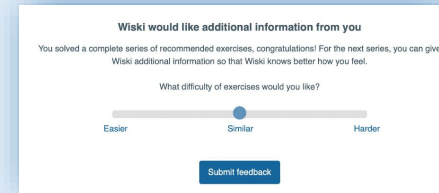
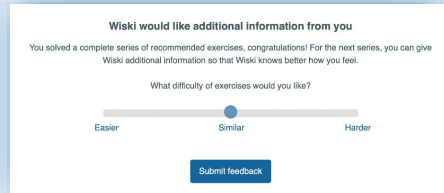
What difficulty of exercises would you like?



Submit feedback



How was trust in the platform for recommending exercises affected?



Control vs no control

trust increased

Control with impact vs no control

trust increased



trust unchanged



trust unchanged

trust decreased

trust decreased

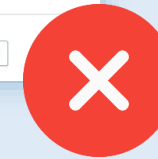
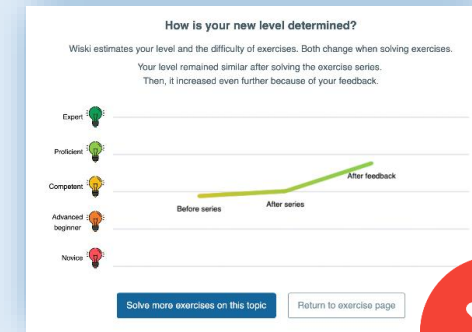
Wiski would like additional information from you

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



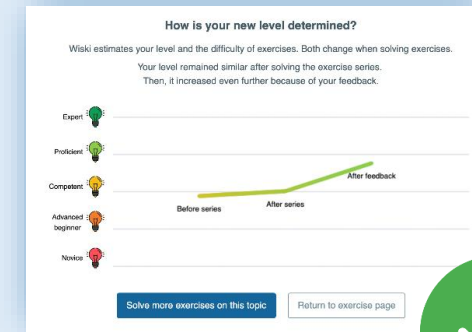
Wiski would like additional information from you

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

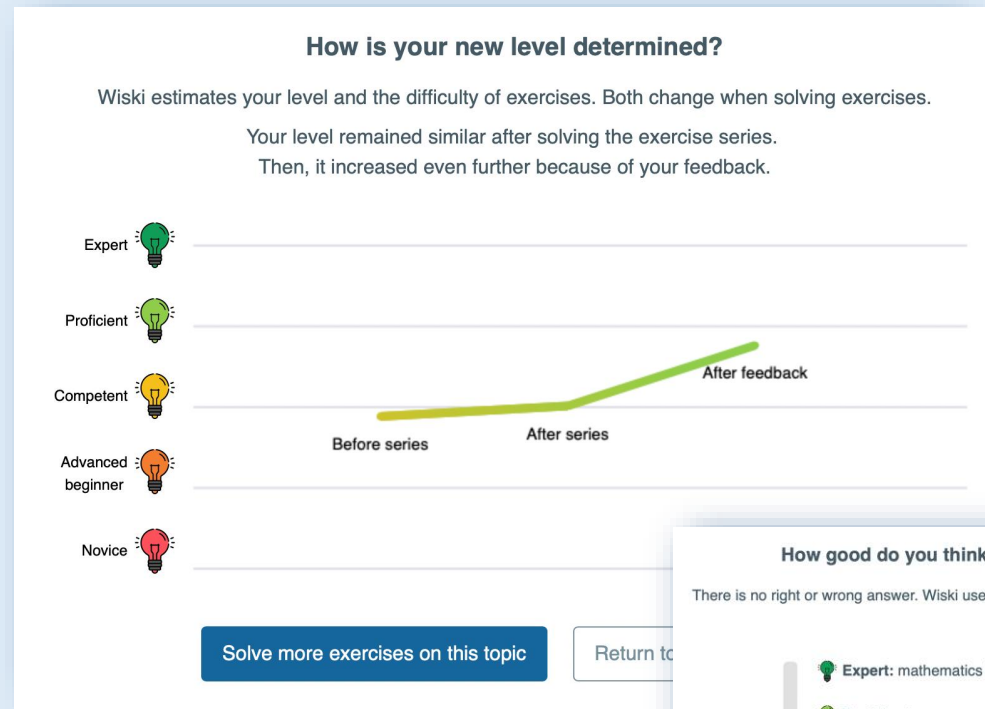


Trust in the platform due to more perceived transparency



Reflection on own mastery and recommendations





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

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.

Recommended

- Exercise 37
- Exercise 26
- Exercise 21

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

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.

Expert

Proficient

Competent

Advanced beginner

Novice

Before series After series After feedback

Solve more exercises on this topic

Return to exercise page

WISKI

School - Klas opvolgen

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Pick a reward and exercise:

Next time you will get 4 new exercises

$8 + X = 25$

Level: $\star\star\star$

Reward: 1

$X - 1 = -14$

Level: $\star\star\star\star$

Reward: 2

$12 + X = 5$

Level: $\star\star\star\star$

Reward: 1

$-8 + X = -24$

Level: $\star\star\star\star$

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 

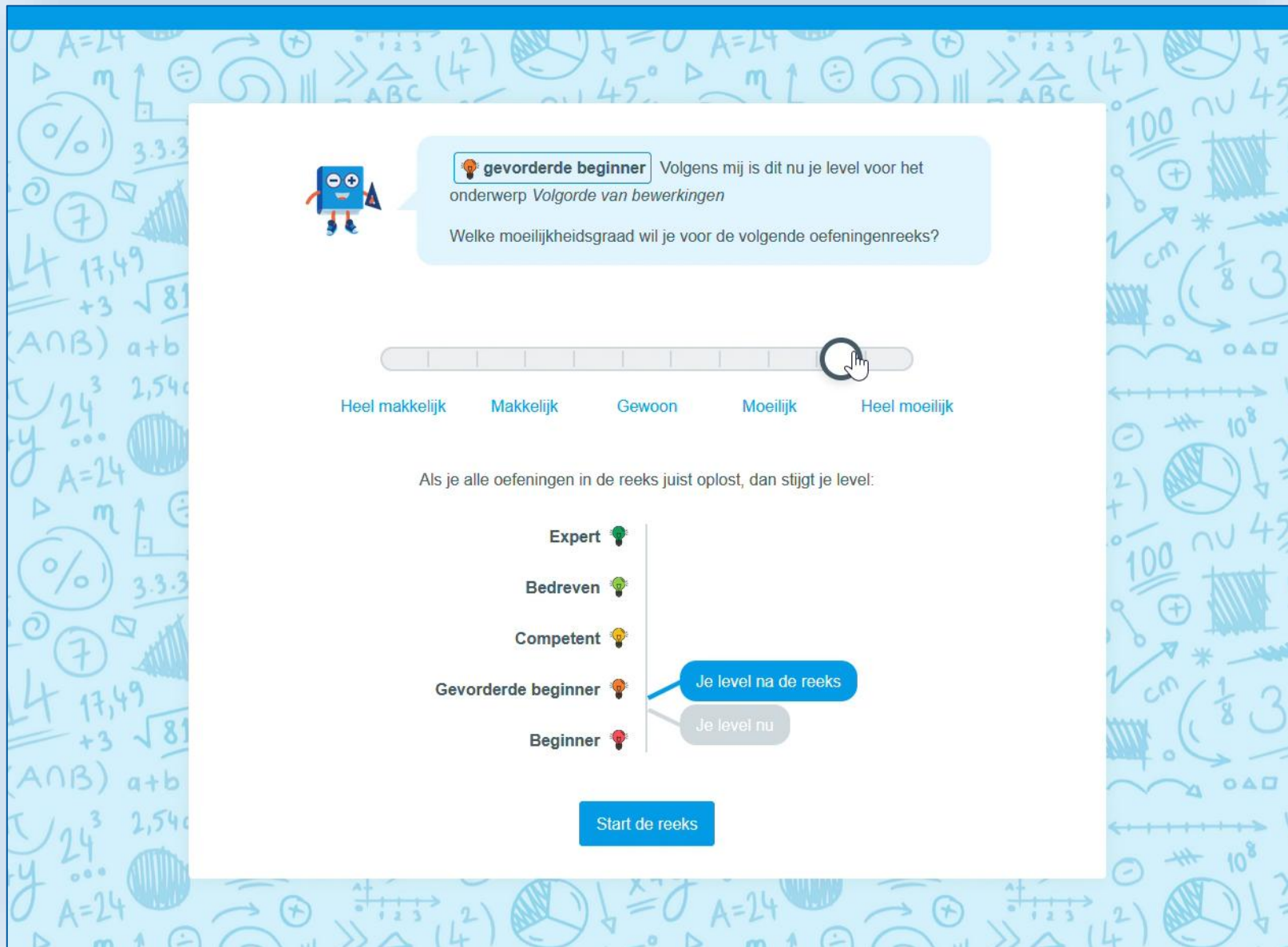
Your level after completion

Your level now

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?



 **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

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

Expert
Proficient
Competent
Advanced beginner
Novice

Your level after completion
What level now

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

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

Expert
Proficient
Competent
Advanced beginner
Novice

Your level after completion
What level now

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 adapted to your mastery level so you can make the most progress. Your mastery level is estimated based on test data you have solved previously. 1. Your level and why Part 1: Easy 2. Exercises most similar to your level Subjects and finite verbs Types of sentences Vowels and consonants 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!			
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	Exercise level	
Exercise 15 Part 1 Subjects and finite verbs	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	Medium	
Exercise 12 Part 1 Subjects and finite verbs	Easy	
Exercise 35 Part 1 Vowels and consonants	Hard	
Exercise 10 Part 1 Subjects and finite verbs	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

Extensive **human-centred design process** with many educational stakeholders!

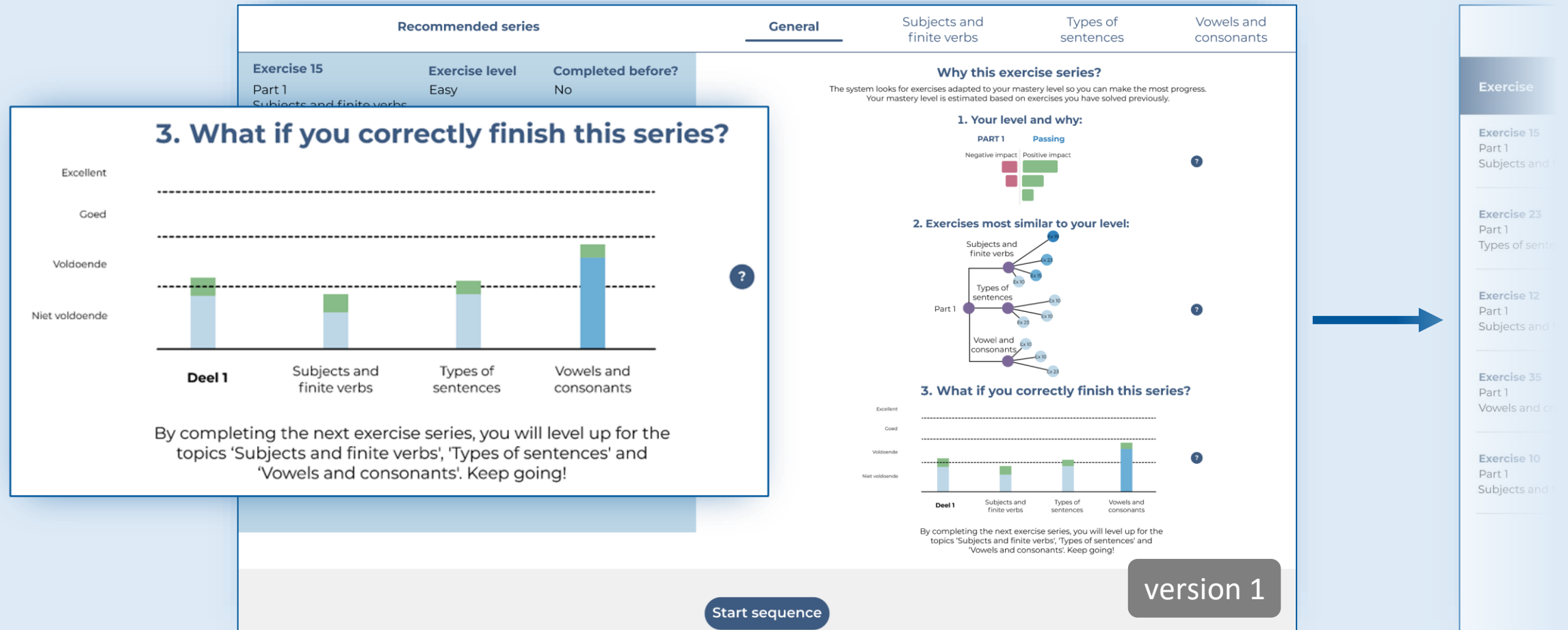


Study 1: Group Discussion

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



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

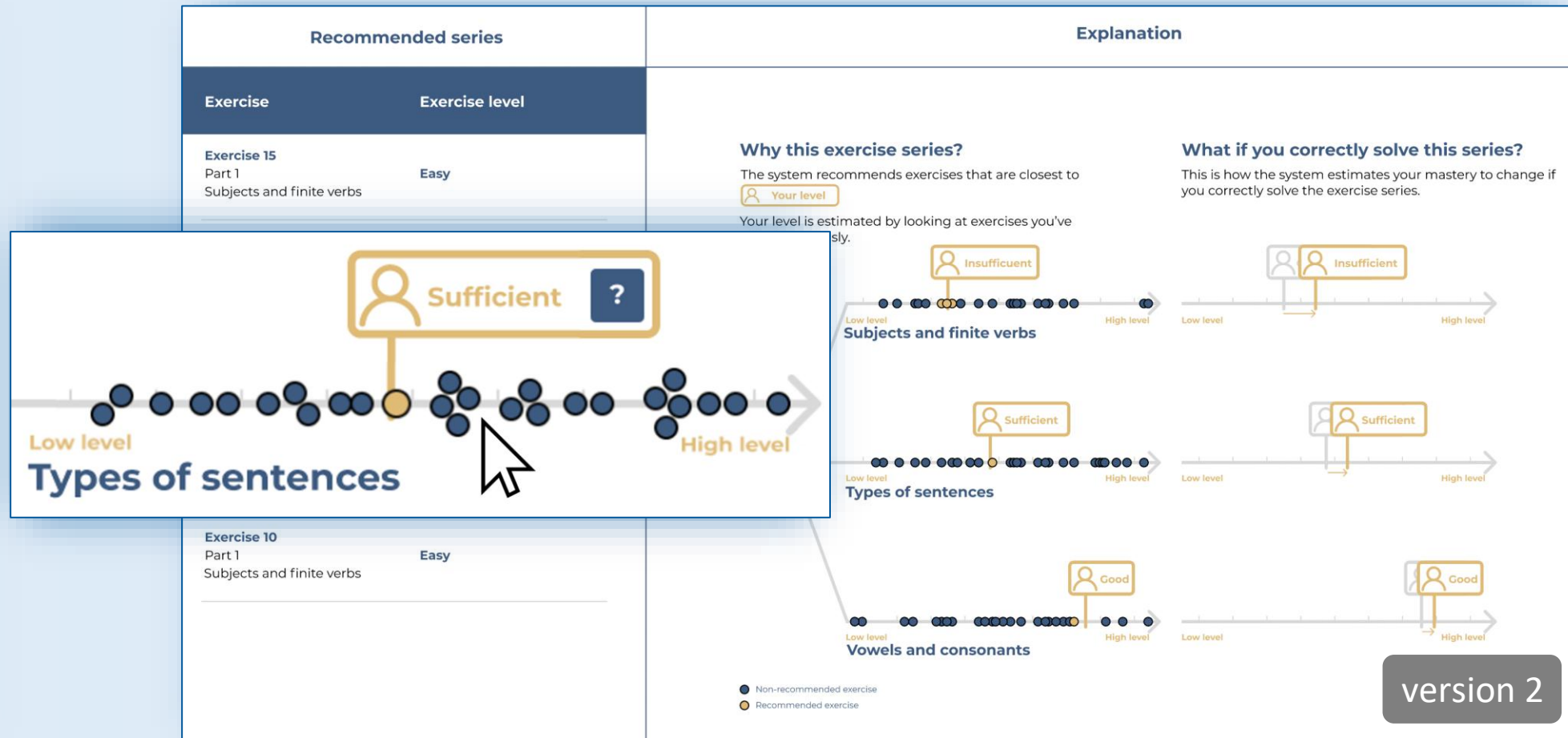


Study 2: Think-Aloud Studies

- 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

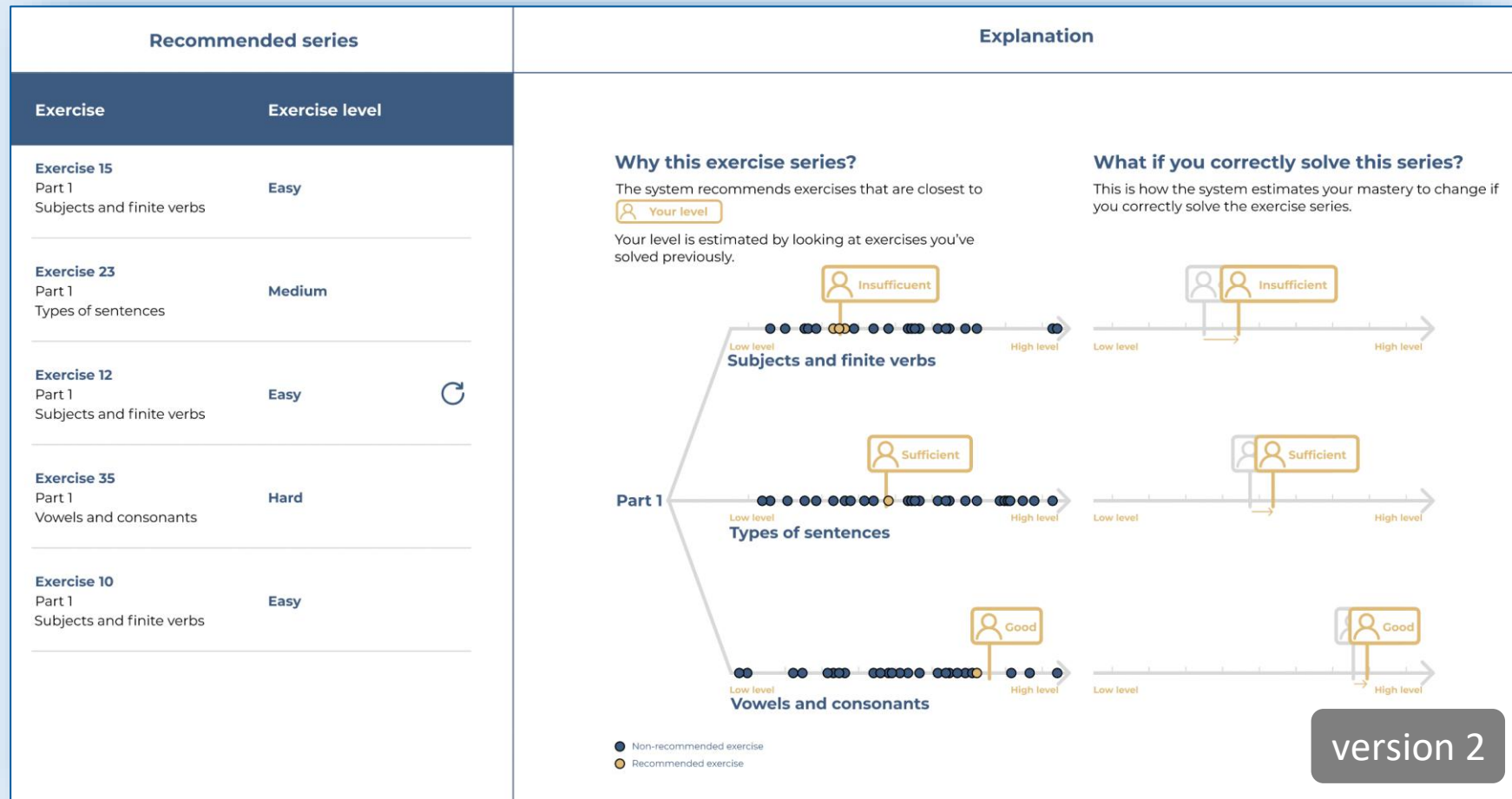


Study 3: Focus Groups

- 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

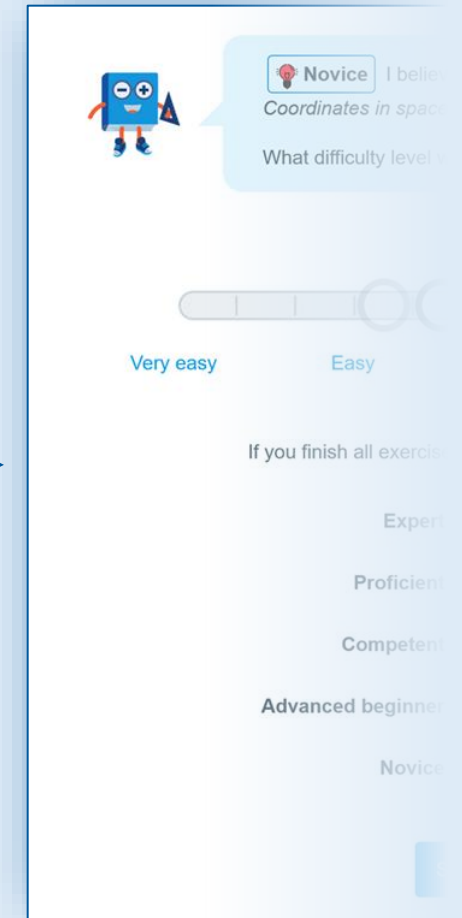
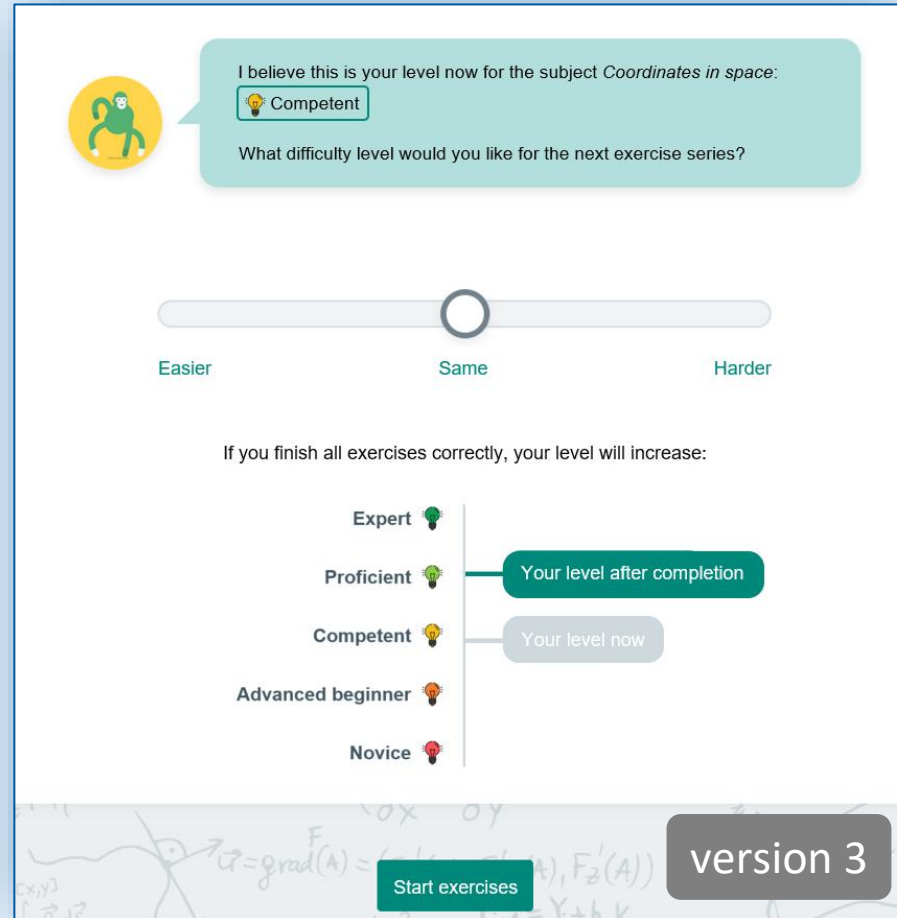
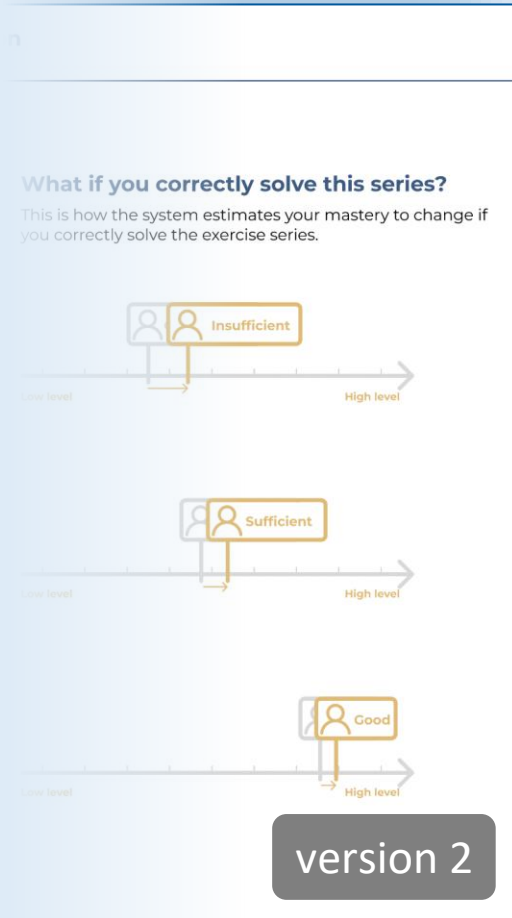


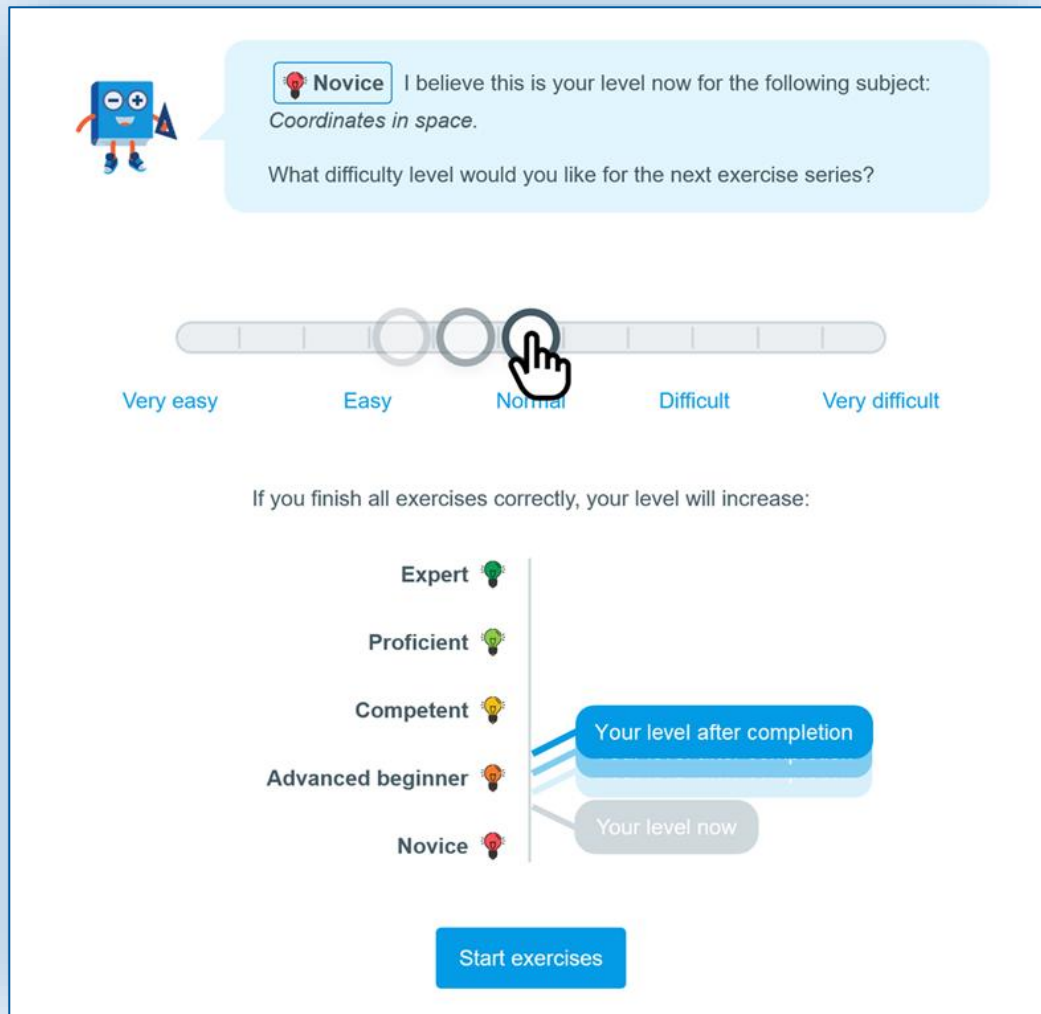
Study 4: Think-Aloud Studies

- 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**

Some of your reflections

can XAI tools be designed in ways that don't just increase transparency, but actually **nurture reflection** and reduce performative responses? - [REDACTED]

In a world where students increasingly use tools like ChatGPT or adaptive learning platforms, how do we teach them to **critically evaluate AI output**? - [REDACTED]

it's not just about explaining what the AI did, it's also about **why it matters for learning** - [REDACTED]

tension between explainability and **cognitive overload**. Sometimes I feel like we treat explainability as if "more is always better" but as the paper admits, bad or incomplete explanations can actually harm learning. - [REDACTED]



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
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Novice

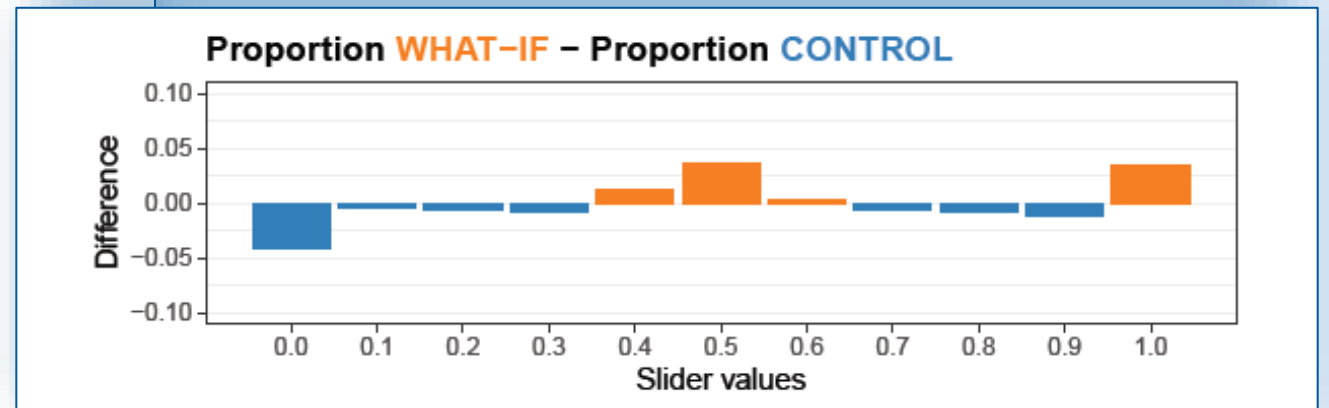
Your level after completion

Your level now

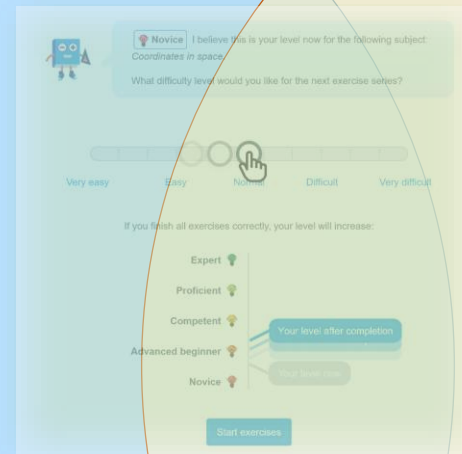
Start exercises

PRELIMINARY RESULTS!

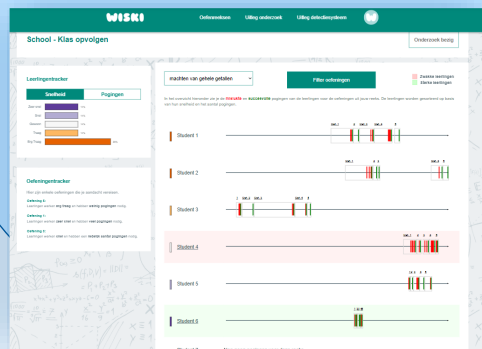
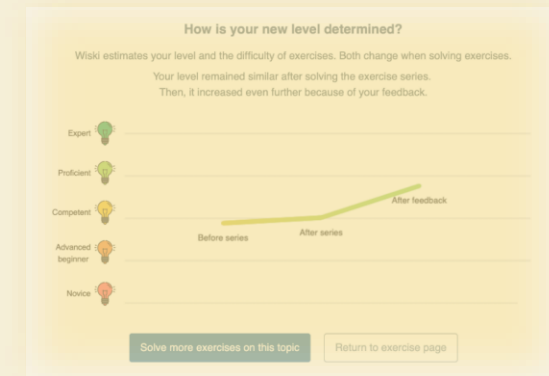
***What-if* explanations can encourage teenagers to try harder exercises, but do not necessarily affect initial trust, metacognition, motivation, or performance**



Explanations



Control



Vraag

Wat is de hoofdstad van de staat Florida?

Antwoord

Tallahassee

Kwaliteit afleiders

Goed

Laag Gemiddeld Hoog

Geïktaardheid

Affleider Vragen

Affleider Vragen

Miami

New York

Los Angeles

...

Limburg

Noorwegen

Zuidpool

←

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

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.

Recommended

- Exercise 37
- Exercise 26
- Exercise 21

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

[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](#)

WISKI

School - Klas opvolgen

Levenslijn

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Kwaliteit afleiders

Goed

Vraag: Wat is de hoofdstad van de staat Florida?

Antwoord: Tallahassee

Gelijkwaardigheid

Afleidings

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

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

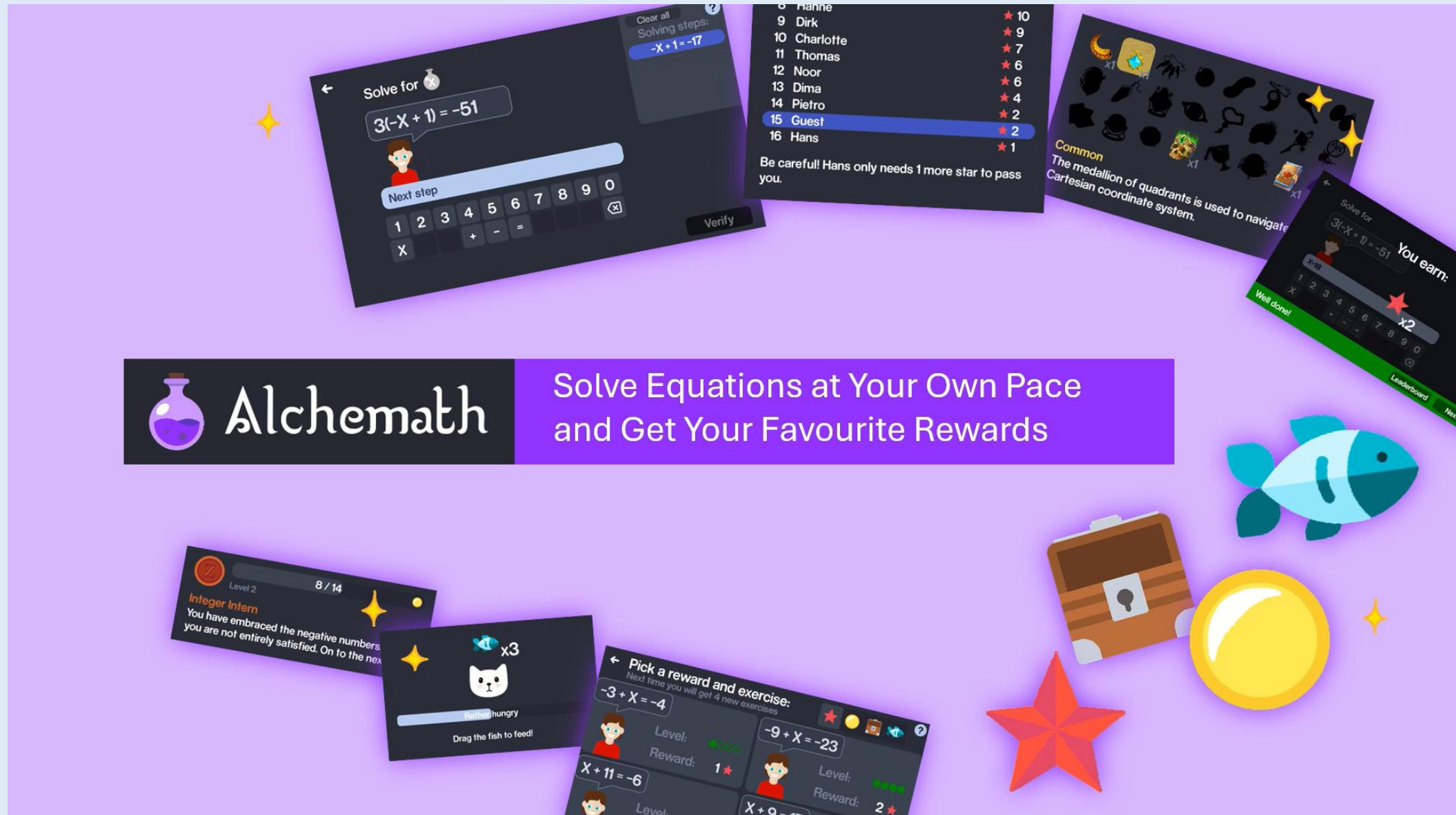
$8 + X = 25$ Level: ●●●●○ Reward: 1 ●	$X - 1 = -14$ Level: ●●●●● Reward: 2 ●●
$12 + X = 5$ Level: ●●●●○ Reward: 1 ●	$-8 + X = -24$ Level: ●●●●○ Reward: 2 ●●

← 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 ●

Simple control:
choose among
recommendations



Explanations

Solve a recommended exercise of the same chapter

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.

Recommended

- Exercise 37
- Exercise 26
- Exercise 21

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

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.

Expert

Proficient

Competent

Advanced beginner

Novice

Before series | After series | After feedback

Solve more exercises on this topic

Return to exercise page

WISKI

School - Klas volgen

Leerstofoverzicht

Wat is de hoofdstad van de staat Florida?

Antwoord: Tallahassee

Kwaliteit afleiders: Goed

Laag | Gemiddeld | Hoog

Student 1

Student 2

Student 3

Student 4

Student 5

Student 6

Student 7

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

$12 + X = 5$

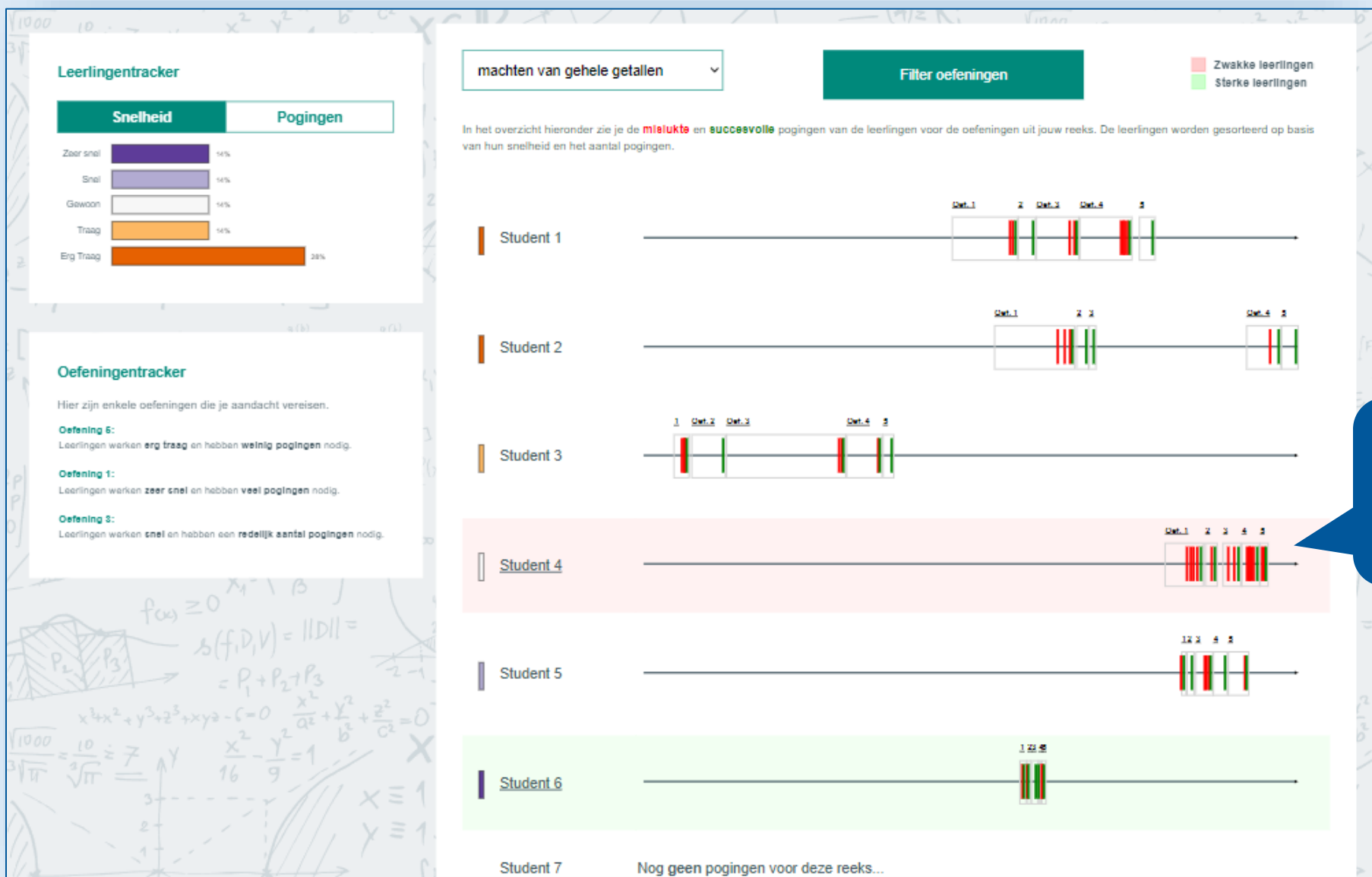
Level: ★★★★

Reward: 1

$-8 + X = -24$

Level: ★★★★

Reward: 2

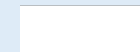


Visualise data used for automated outlier detection

Some of your reflections

I think AI can be useful when paired with **expert oversight** - [REDACTED]

It also made me think about the social and emotional side of explainability. ... **do teachers feel empowered or undermined** when AI suggests feedback or flags student behavior? - [REDACTED]



Explanations

Solve a recommended exercise of the same chapter

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

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Recommended

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- Exercise 21

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[Solve exercise 21](#)

... or pick your next exercise yourself

[Go to the exercise overview](#)

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Your level after completion

[Start exercises](#)

Control

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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](#)

WISKI

School - Klas opvolgen

Levenslijn

Wat is de hoofdstad van de staat Florida?

Antwoord

Tallahassee

Kwaliteit afleiders

Goed

Vraag

Wat is de hoofdstad van de staat Florida?

Antwoord

Tallahassee

Kwaliteit afleiders

Goed

Laag | Gemiddeld | Hoog

Gelijkaardigheid

Afleidingsvragen

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

Pick a reward and exercise:

Next time you will get 4 new exercises

$8 + X = 25$ | $X - 1 = -14$

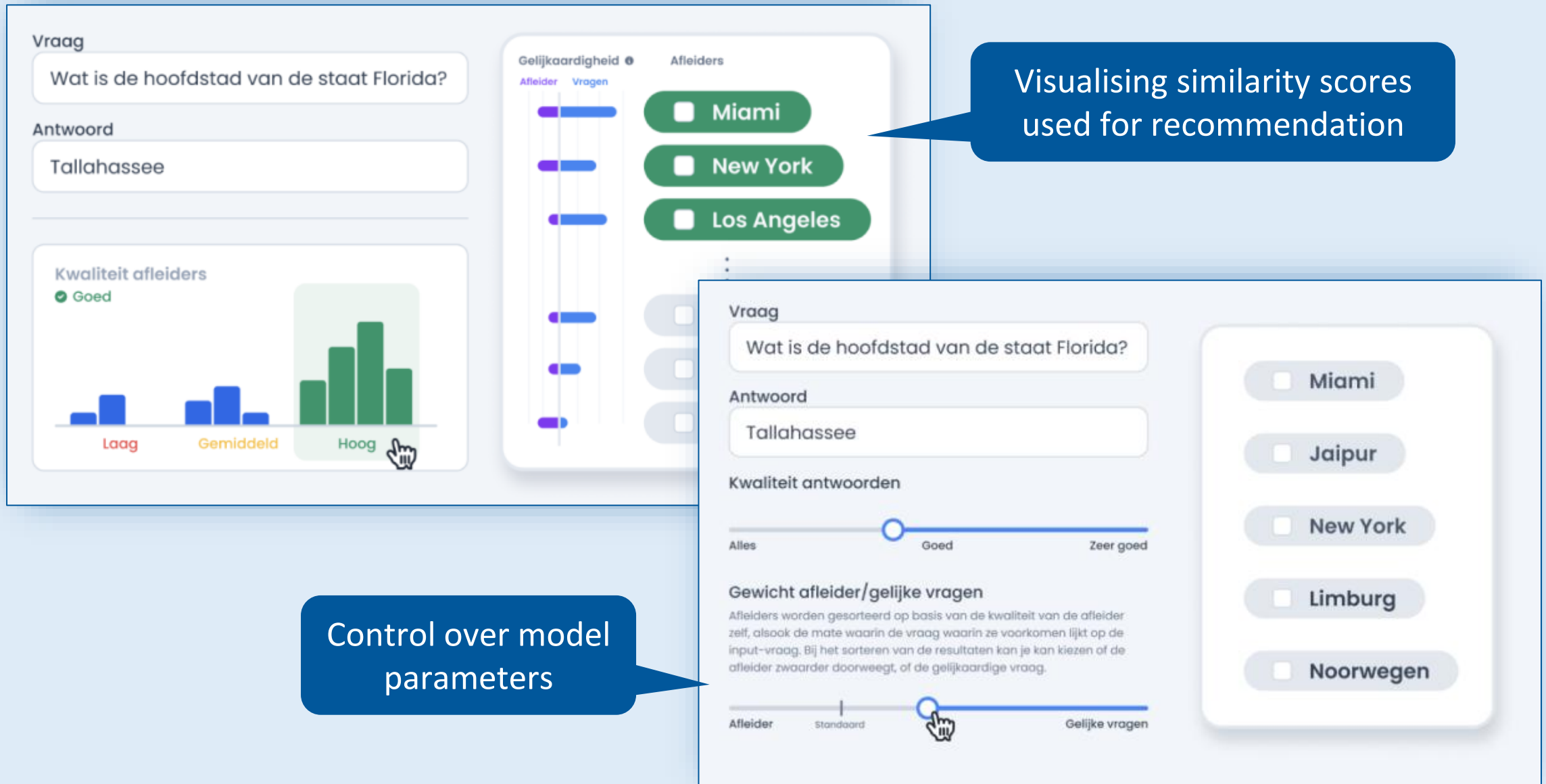
Level: **Goed** | Level: **Goed**

Reward: **1** | Reward: **2**

$12 + X = 5$ | $-8 + X = -24$

Level: **Goed** | Level: **Goed**

Reward: **1** | Reward: **2**



Explanations

Solve a recommended exercise of the same chapter

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

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Number of attempts fellow students needed to solve exercise 21

Solve exercise 21

... or pick your next exercise yourself

Go to the exercise overview

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Expert
Proficient
Competent
Advanced beginner
Novice

Your level after completion
Your level now

Start exercises

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

WISKI

School - Klas volgen

Leerstofoverzicht

Studenten van gehele school

Alle oefeningen

Deelnemers

Overzicht van de klas

Student 1

Student 2

Student 3

Student 4

Student 5

Student 6

Student 7

Vraag

Wat is de hoofdstad van de staat Florida?

Antwoord

Tallahassee

Kwaliteit afleiders

Goed

Laag Gemiddeld Hoog

Gelijkaardigheid

Afleidings vragen

Miami

New York

Los Angeles

Limburg

Noorwegen

Zuidpool

Pick a reward and exercise:

Next time you will get 4 new exercises

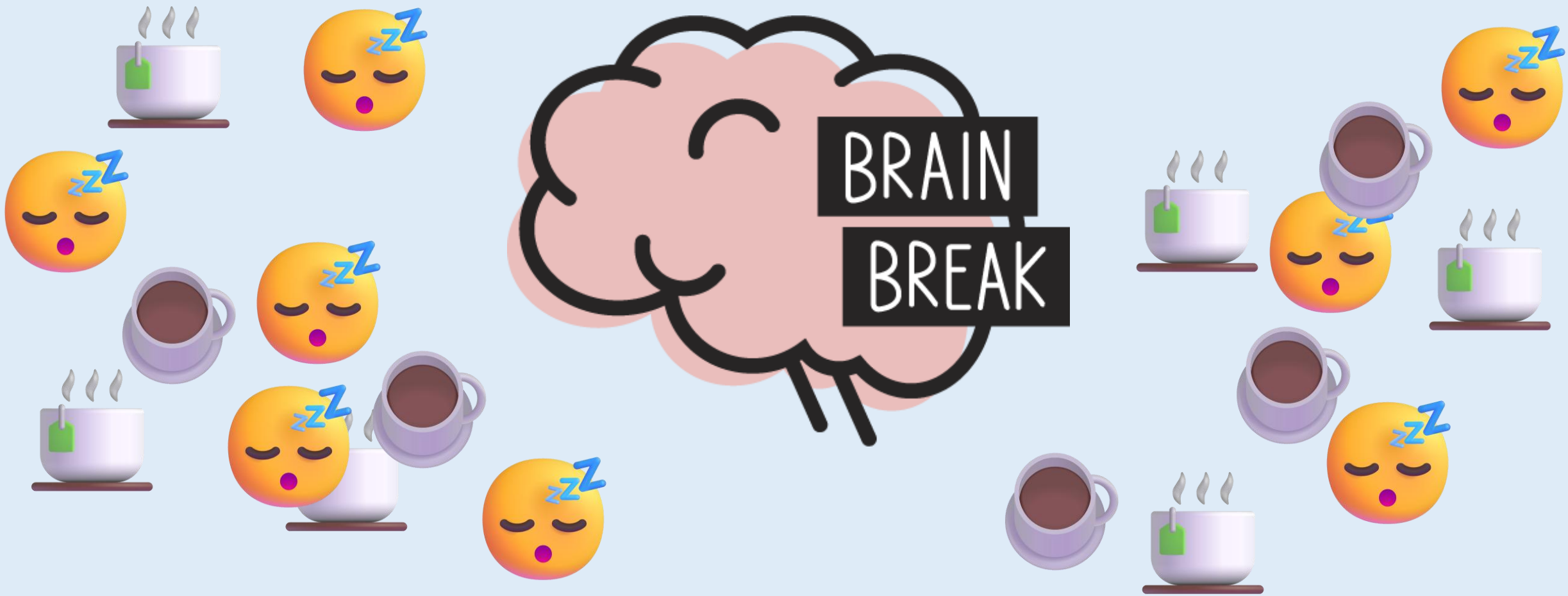
$8 + X = 25$ Level: Reward: 1

$X - 1 = -14$ Level: Reward: 2

$12 + X = 5$ Level: Reward: 1

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





I Presentation (45 min.)

Transparent and Controllable AI Systems for Education: From Designing to Evaluating with Educational Stakeholders

II Interactive exercise (30 min.)

Make your intelligent educational system more transparent and controllable

Interactive exercise: Make your intelligent educational system more transparent and controllable

2

Who are the main stakeholders?

Leaners, parents, teachers, technologists, educational researchers, educational admins and policy makers

6

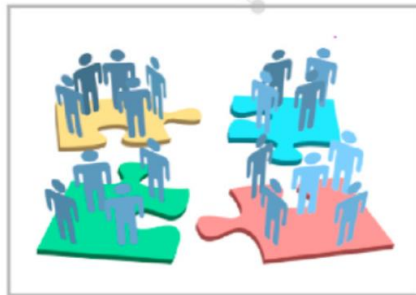
What potential *pitfalls* need to be considered?

Needless use of complex models, inaccurate or incomplete, explanations, misconceptions, promoting misbehavior.

1

What are the main *benefits*?

Agency, student-teacher interactions, AI literacy, accountability and trust.



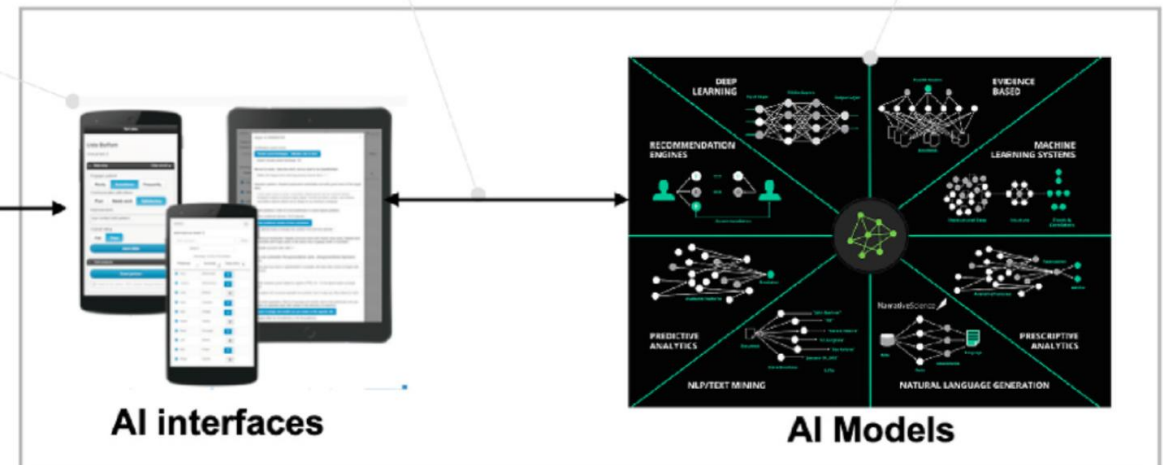
Users

How can educational AI tools be effective *designed*?
Using user experiences, theory driven design, centered design, participatory and co-design, HCI and interaction design.

The XAI-ED Framework

What *approaches* are used for presenting explanations?
Globally self explaining like feature relevance or example based; locally self explaining like comparison based or counterfactual examples.

What AI *models* are commonly used?
General additive models, decision trees, rule-based models, clustering and natural language processing.



Educational AI systems

Interactive exercise: Make your intelligent educational system more transparent and controllable

- 1 Why:** How does the system support education?
What are the main goals?
Agency, student-teachers, AI literacy, accountability
- 2 Who:** What is the target audience and who is involved?
Who are the main stakeholders?
Learners, parents, teachers, technologists, educational researchers, educational admins and policy makers
- 3 Context:** What is specific or important for your system?
- 4 Transparency:** Which explanations can be integrated in the system?
- 5 Control:** How can control be integrated in the system?
- 6 Why not:** What are potential pitfalls or dangers?
What potential pitfalls?
Needless use of complex or incomplete, explanations promoting

Step 1: Describe your intelligent educational system

1 **Why:** How does the system support education?

What are the main *benefits*?
Agency, student-teacher interactions,
AI literacy, accountability and trust.

Teaching

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

2 **Who:** What is the target audience and who is involved?

Who are the main *stakeholders*?
Learners, parents, teachers,
technologists, educational
researchers, educational
admins and policy makers

Student performance

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

3 **Context:** What is specific or important for your system?

Step 2: Make your system more transparent and controllable

4 **Transparency:** Which explanations can be integrated in the system?

5 **Control:** How can control be integrated in the system?

6 **Why not:** What are potential pitfalls or dangers?

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...?

What potential *pitfalls* need to be considered?

Needless use of complex models, inaccurate or incomplete, explanations, misconceptions, promoting misbehavior.

Step 3: Pitch your discussed ideas in 1 min. 💪

General project topics

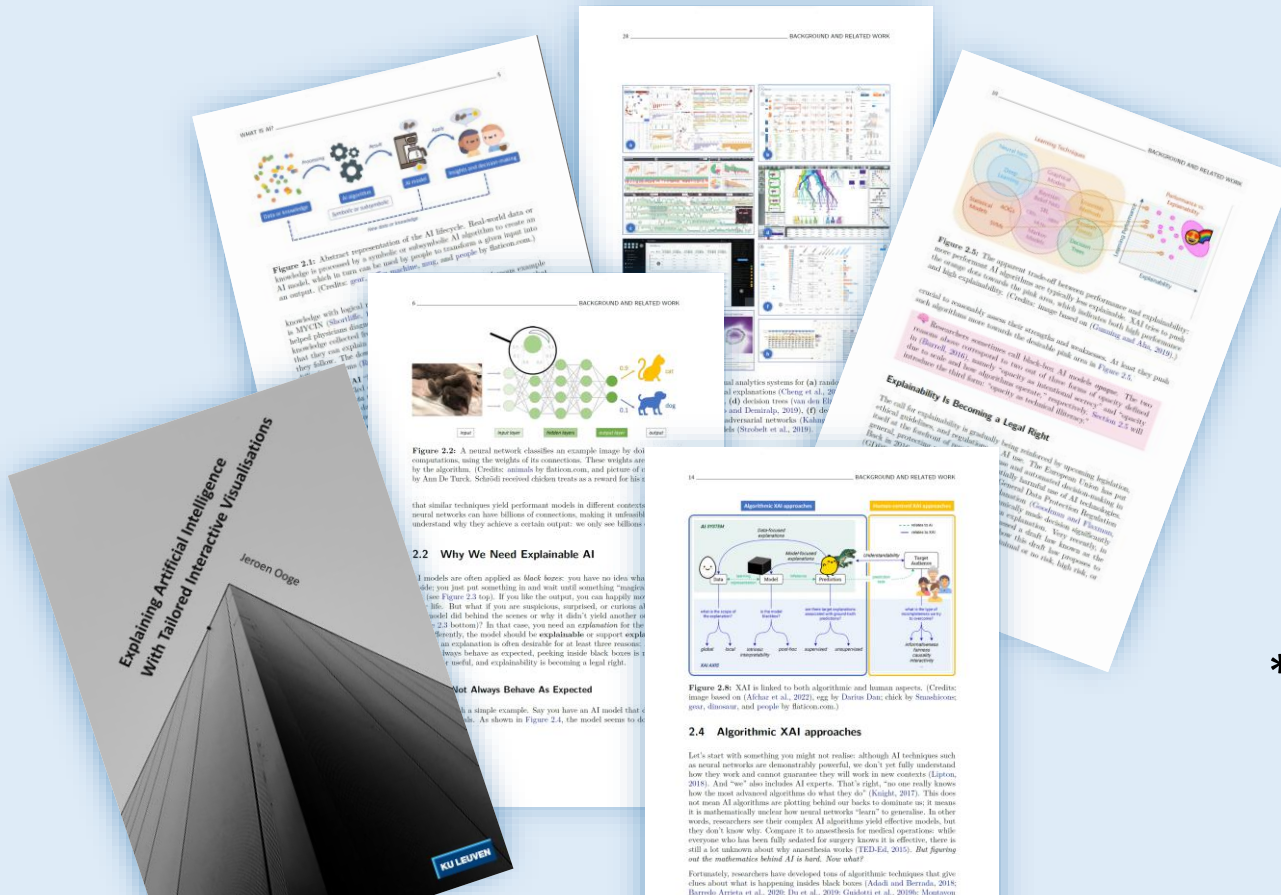
Programming, math, science
Language learning
Literacy (AI, reading, media)
Other (music, soft skills, ...)

- 1 **Why:** How does the system support education?
- 2 **Who:** What is the target audience and who is involved?
- 3 **Context:** What is specific or important for your system?
- 4 **Transparency:** Which explanations can be integrated in the system?
- 5 **Control:** How can control be integrated in the system?
- 6 **Why not:** What are potential pitfalls or dangers?



WAAAH, I want to learn
more about human-
centred explainable AI!

Check out jeroenooge.be and reach out to collaborate*!



* *researchers*: involve me in projects
teachers: participate in studies, exchange ideas

Transparent and Controllable AI Systems for Education

From Designing to Evaluating with Educational Stakeholders



Jeroen Ooge
jeroenooge.be



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Expert
Proficient
Competent
Advanced beginner

Before series
After series
After feedback

Maak een aangeraden oefening van hetzelfde hoofdstuk

Aangeraden
Oefening 37
Oefening 26
Oefening 21

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 21 juist te maken, gebaseerd op de resultaten van jou en je medeleerlingen.

Aantal pogingen medeleerlingen nodig hadden om oefening 21 juist op te lossen

1 2 3 4 pogingen nodig

Maak oefening 21

... of kies zelf je volgende oefening

Naar het oefeningenoverzicht

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

School - Klas opvolgen

WISKI

stad van de staat Florida?

Geleekardigheid

Afbeelders

Miami
New York
Los Angeles
Lombard
Noorwegen
Zuidpool