

# Explainability and Control for Adaptive E-Learning Systems



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**Maak een aangeraden oefening van hetzelfde hoofdstuk**

Aangeraden  
Oefening 37  
Oefening 26  
Oefening 21

**Maak een aangeraden oefening van hetzelfde hoofdstuk**

Aangeraden  
Oefening 27  
Oefening 48  
Oefening 45

**Maak een aangeraden oefening van hetzelfde hoofdstuk**

Aangeraden  
Oefening 27

**Wisk**

School - Klas opvolgen

Leerlingstracker

Oefeningstracker

Student 1

Student 2

Student 3

Student 4

Student 5

Student 6

Student 7

**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

Solve more exercises on this topic

Return to exercise

**How good do you think you are at mathematics?**

There is no right or wrong answer. You set your answer to find out if it is a good answer for you.

Expert: mathematics is too easy for you.  
Proficient: you are better than average at mathematics.  
Competent: you come average at mathematics.  
Advanced beginner: better exercises are not a problem for you.  
Novice: you still have a hard time understanding mathematics.

Start

**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: Novice

Start exercises

You can do it! Try solving easier exercises, but I believe you can handle slightly more difficult exercises. You can do it!

**Pick a reward and exercise**

Next time you will get 4 new exercises

$8 + X = 25$

Level: **Novice**  
Reward: **1**

$12 + X = 5$

Level: **Novice**  
Reward: **1**

Wat is de hoofdstad van de staat Florida?

Antwoord

Tallahassee

Kwaliteit afielders

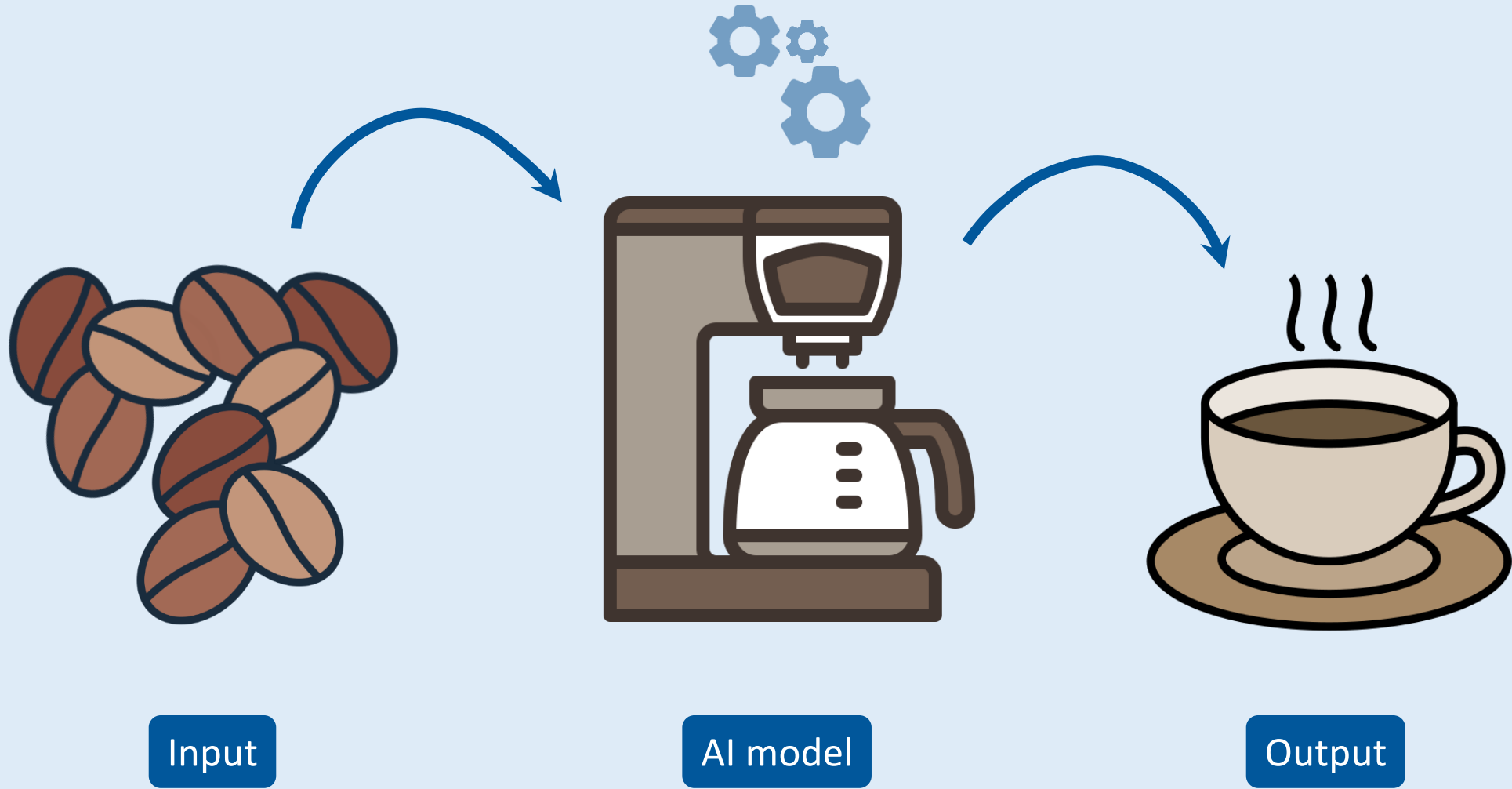
Goed

Laag Gemiddeld Hoog

Goeljkardigheid

Afielders

Miami  
New York  
Los Angeles  
Limburg  
Noorwegen  
Zuidpool





Available exercises



Recommended exercise



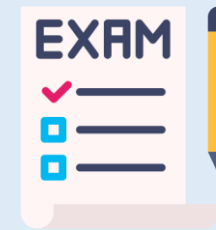
Learner profile



Predicted progress/risk



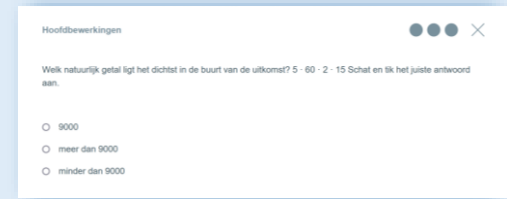
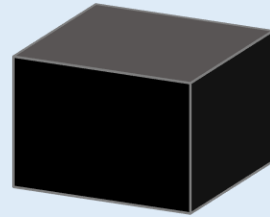
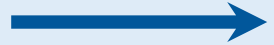
Textual prompt



Exam question



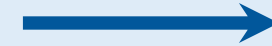
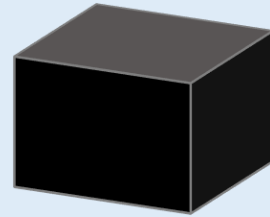
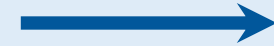
Available exercises



Recommended exercise



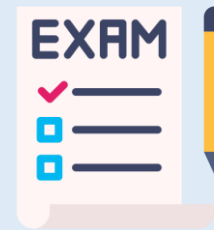
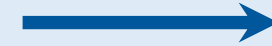
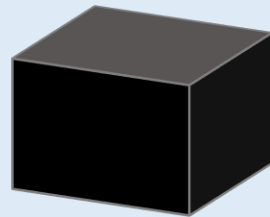
Learner profile



Predicted progress/risk

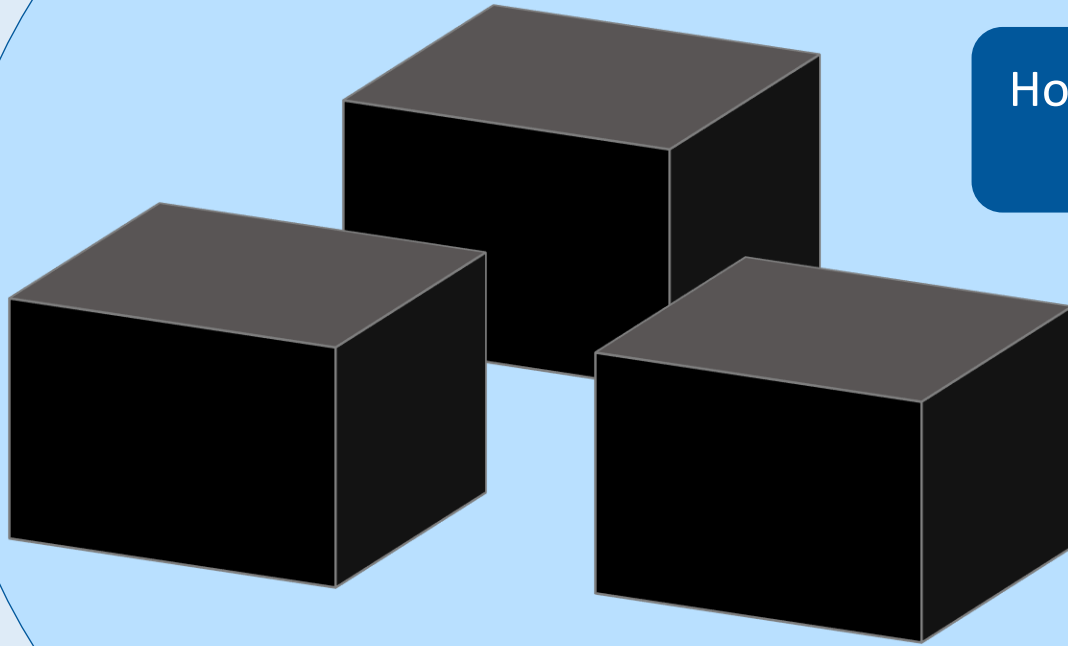


Textual prompt



Exam question

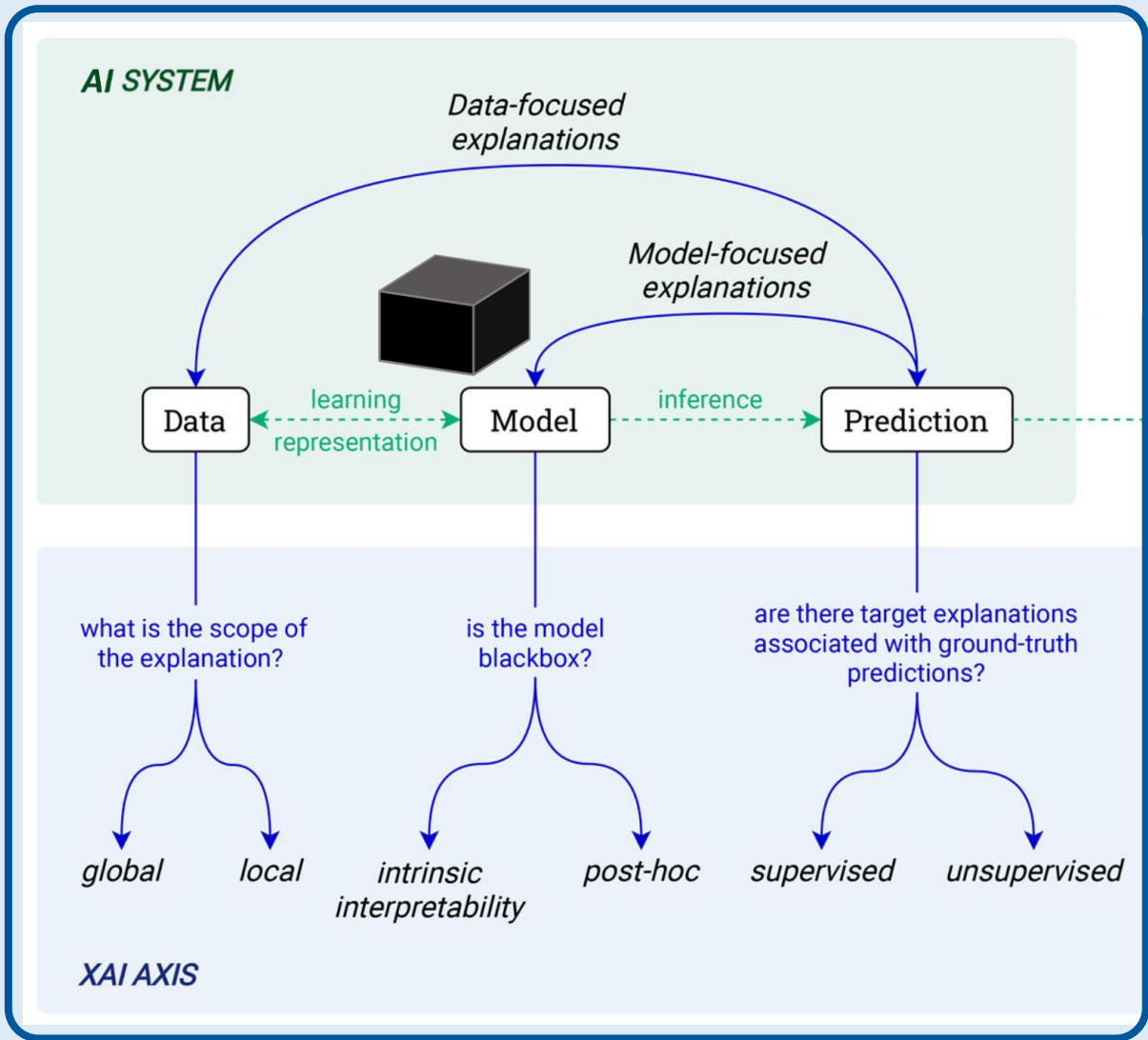
*Explanations*



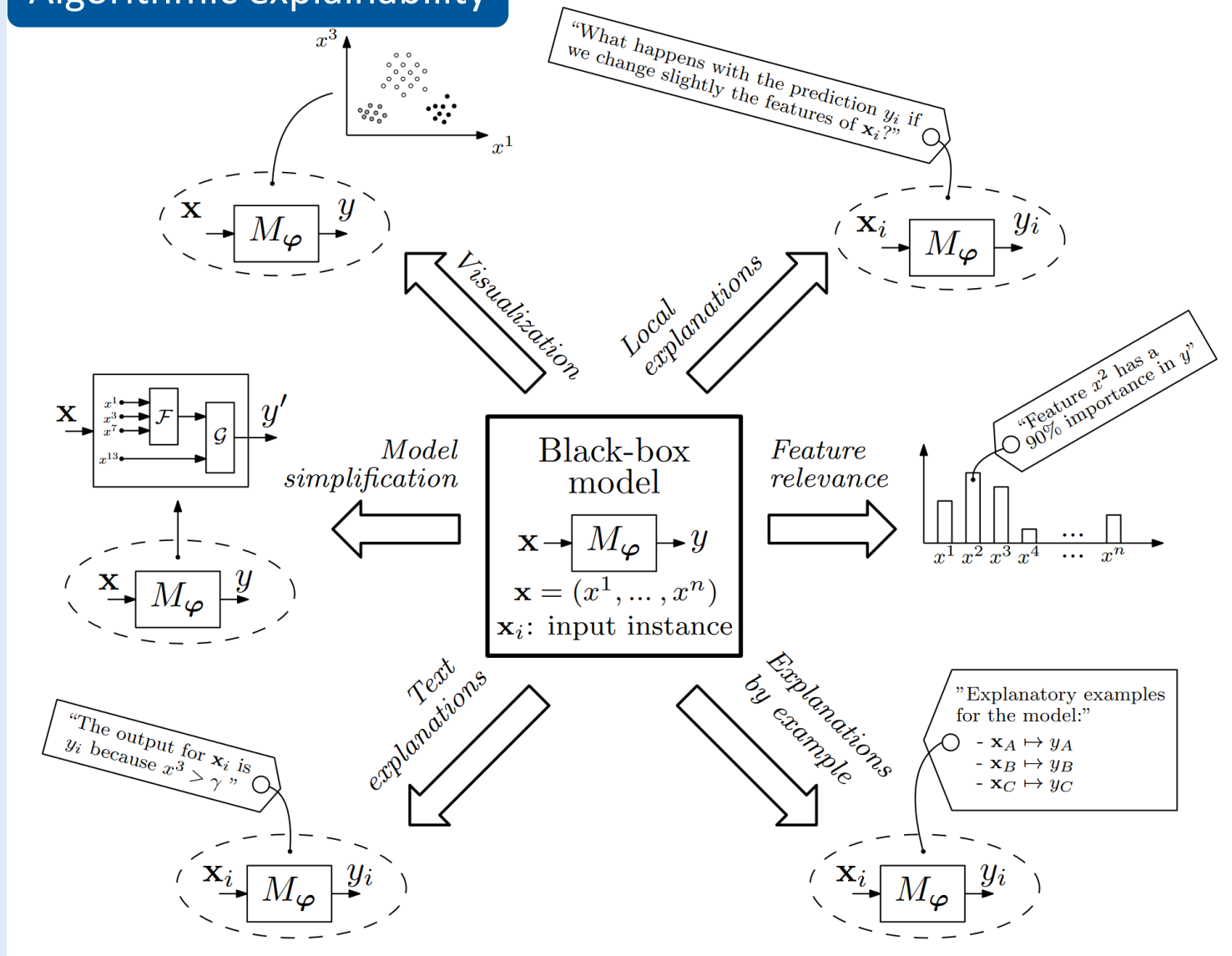
How can we generate explanations for these black boxes?



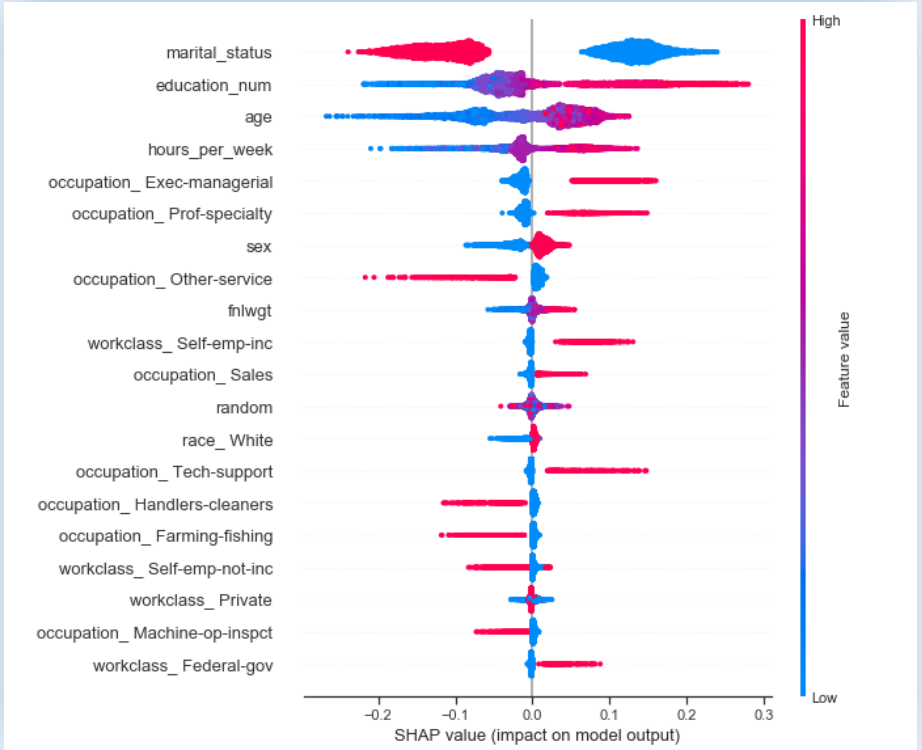
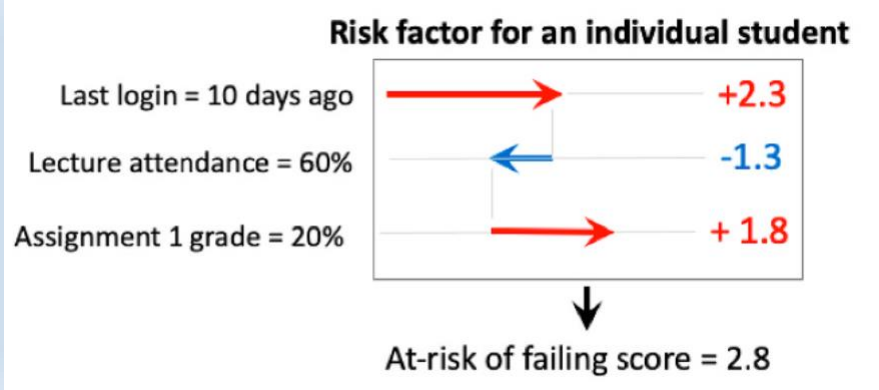
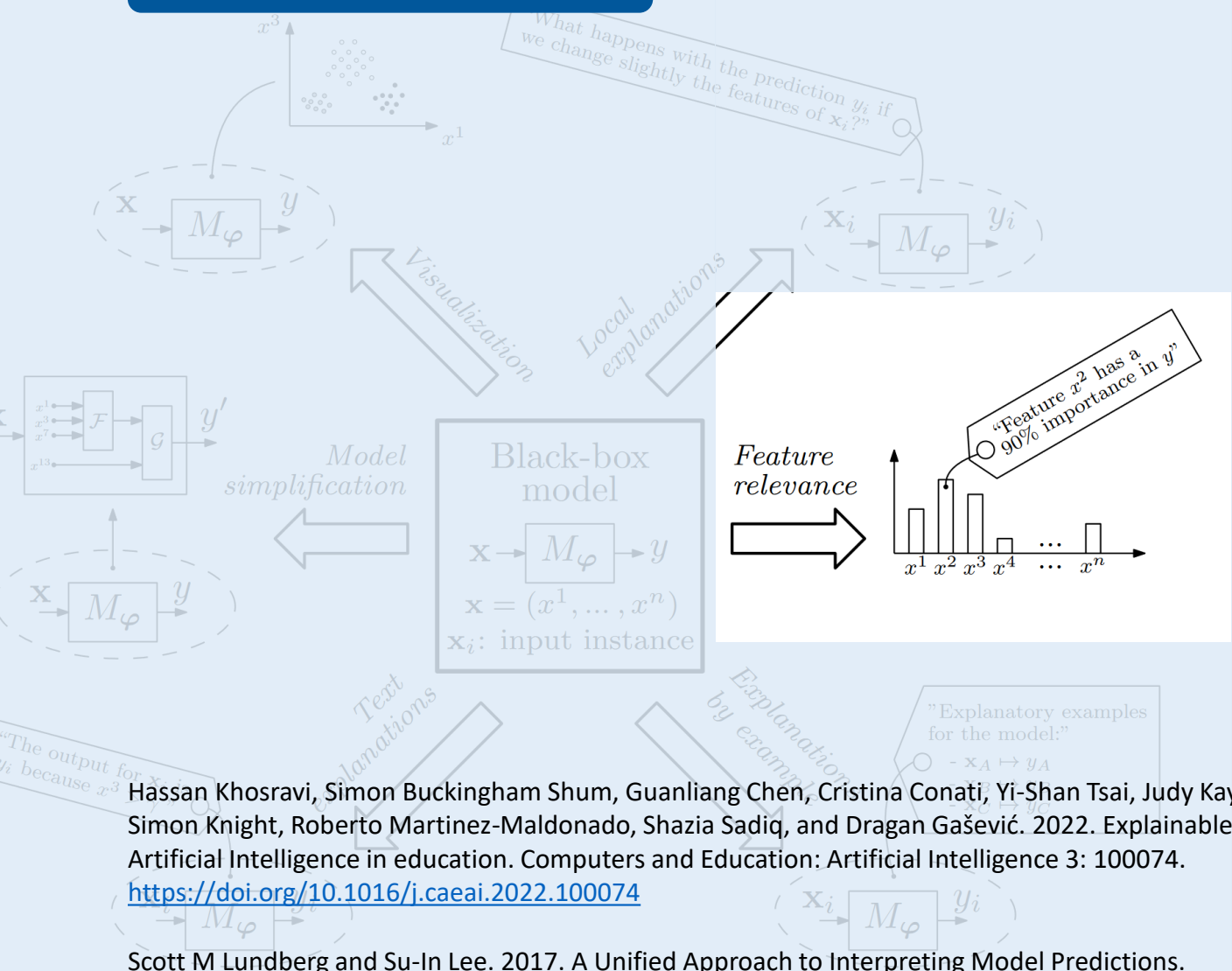
# Algorithmic explainability



# Algorithmic explainability



# Algorithmic explainability

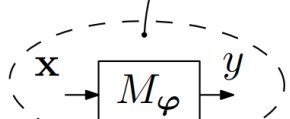
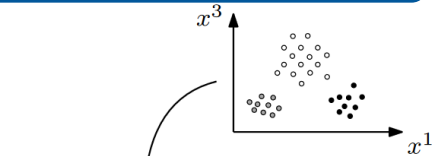


Hassan Khosravi, Simon Buckingham Shum, Guanliang Chen, Cristina Conati, Yi-Shan Tsai, Judy Kay, Simon Knight, Roberto Martinez-Maldonado, Shazia Sadiq, and Dragan Gašević. 2022. Explainable Artificial Intelligence in education. Computers and Education: Artificial Intelligence 3: 100074. <https://doi.org/10.1016/j.caeai.2022.100074>

Scott M Lundberg and Su-In Lee. 2017. A Unified Approach to Interpreting Model Predictions. Advances in Neural Information Processing Systems. <https://proceedings.neurips.cc/paper/2017/file/8a20a8621978632d76c43dfd28b67767-Paper.pdf>

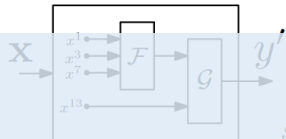


# Algorithmic explainability



Visualization

"What happens when we change slightly"



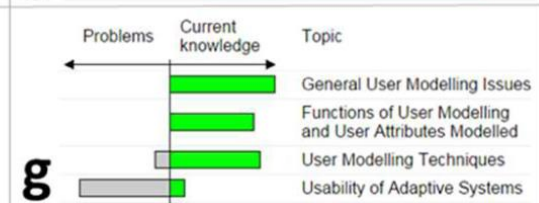
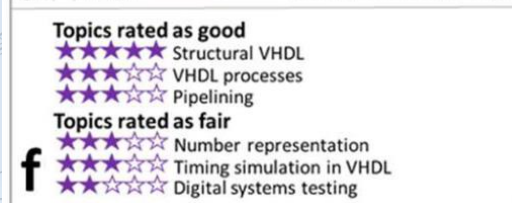
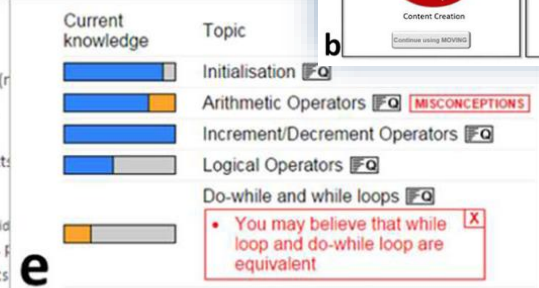
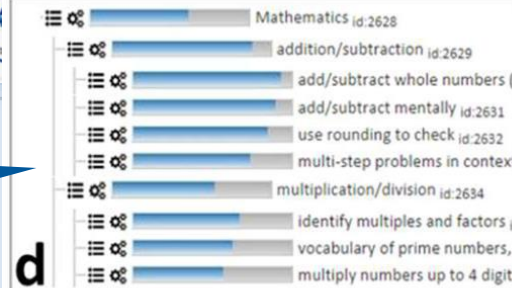
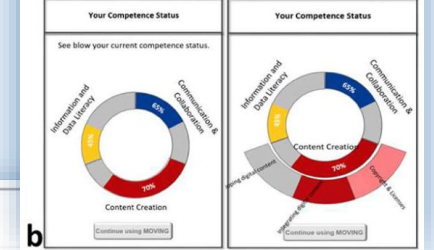
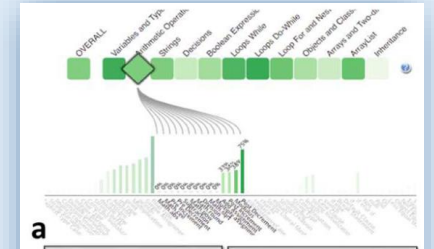
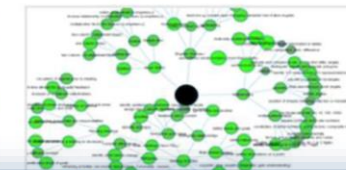
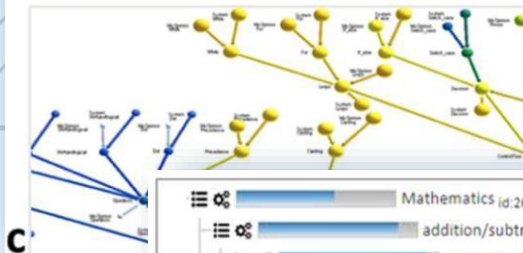
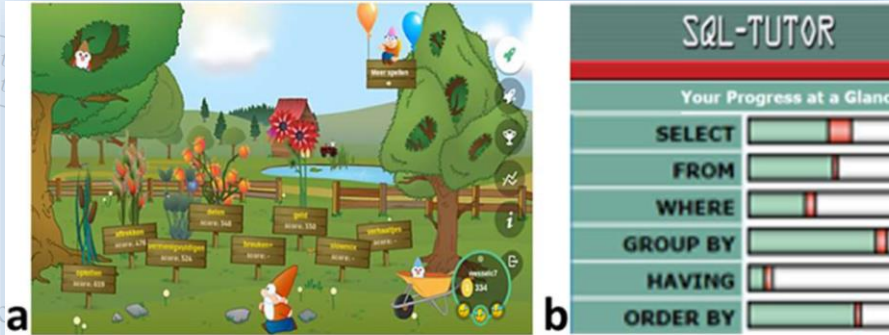
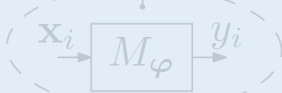
Model simplification

Black-box model

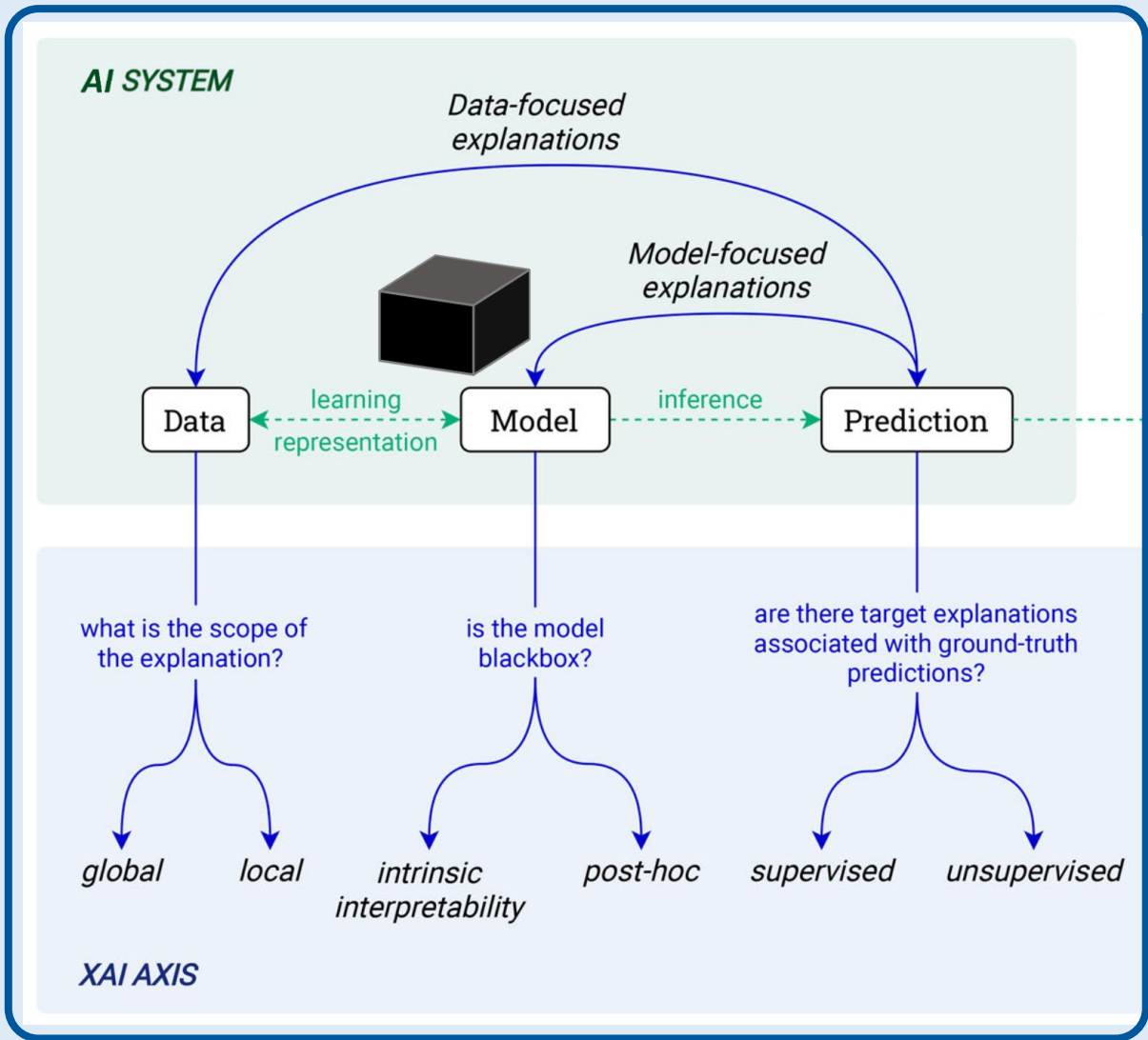


Open learner models often require algorithmic skill estimation

"The output for  $x_i$  is  $y_i$  because  $x^3 > \gamma$ "

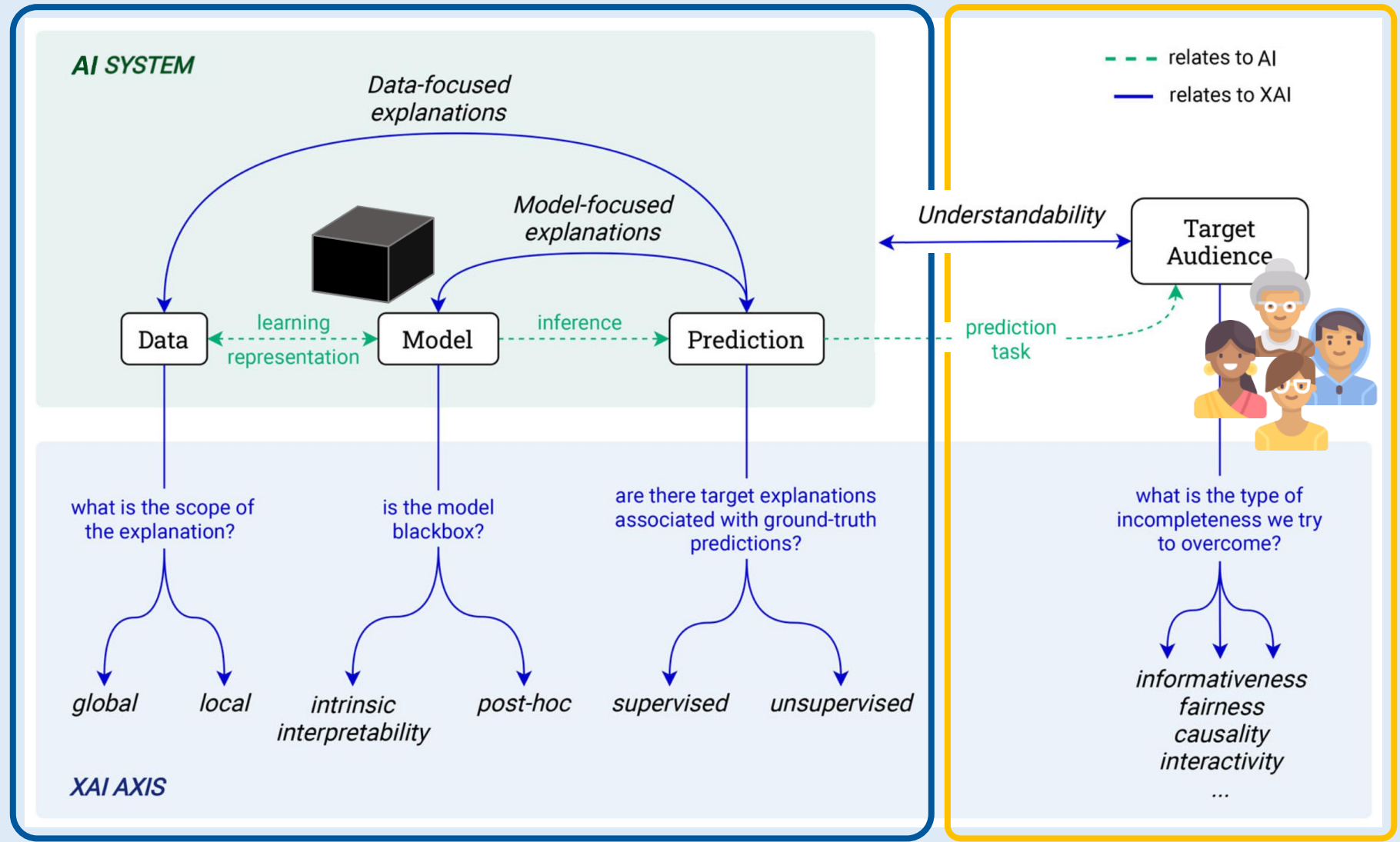


# Algorithmic explainability



# Algorithmic explainability

# Human-centred explainability





## Human-centred explainability

Different people and contexts  
need different explainability solutions

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

# The XAI-ED Framework

## Who are the main stakeholders?

Leainers, 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?

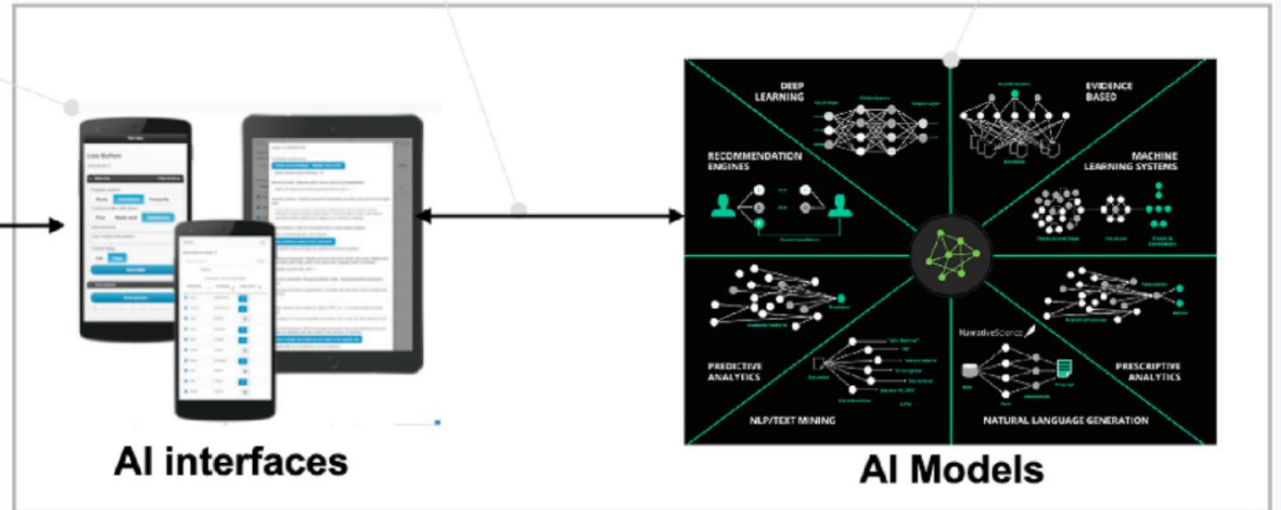
Agency, student-teacher interactions, AI literacy, accountability and trust.

## How can educational AI tools be effectively designed?

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



Users



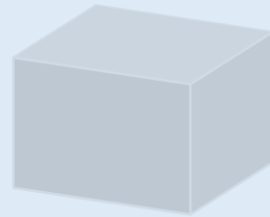
AI interfaces

AI Models

Educational AI systems



Available exercises



Recommended exercise



Learner profile

What if we want to steer the model outputs?

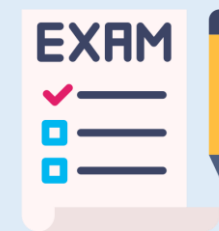


Predicted progress/risk

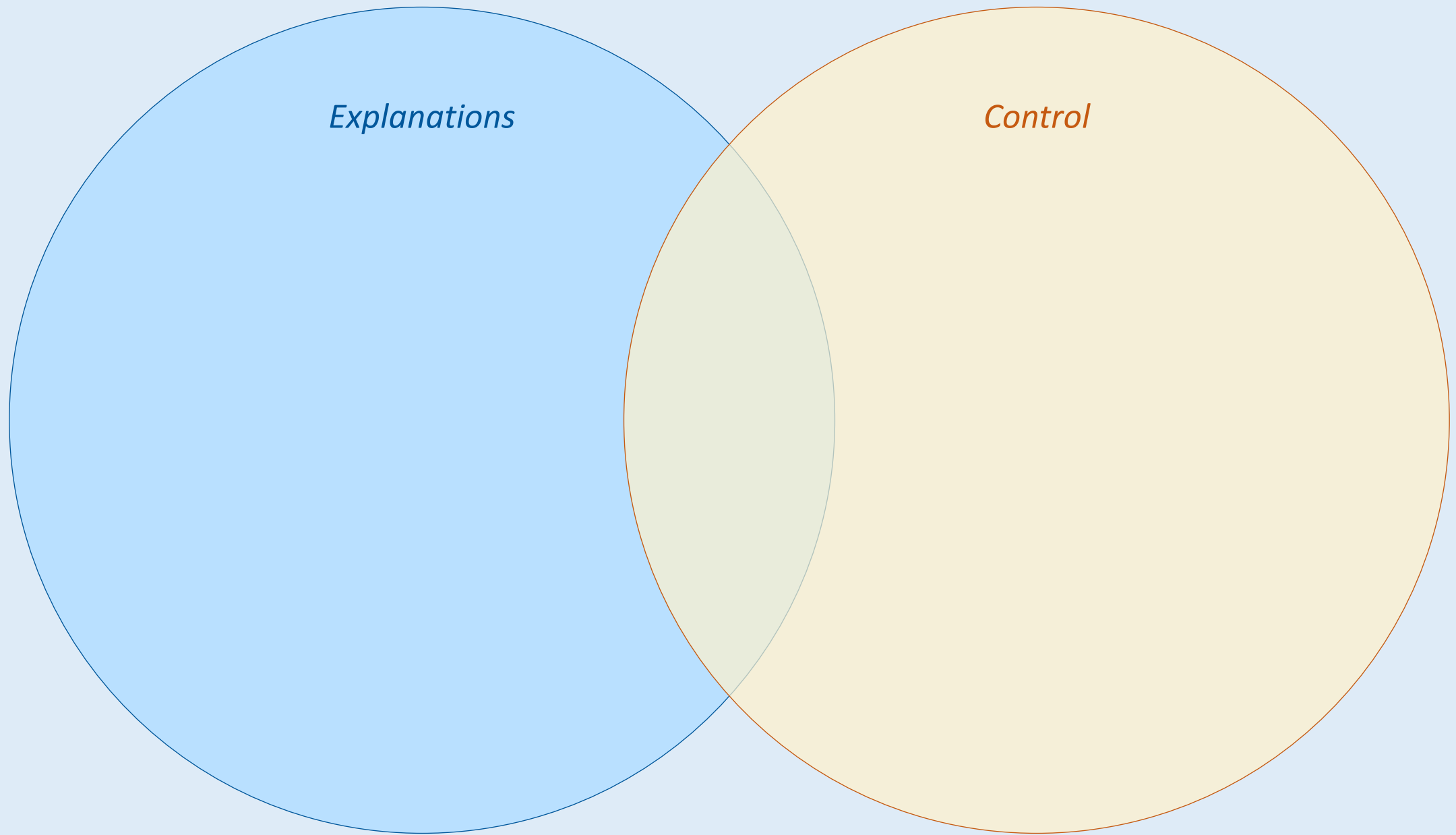
Adapt



Textual prompt



Exam question



# Explanations

**Maak een aangeraden oefening van hetzelfde hoofdstuk**

**Aangeraden**

- Oefening 37
- Oefening 26
- Oefening 21

**Maak een aangeraden oefening van hetzelfde hoofdstuk**

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

Wiski verwacht dat je **1 of 2 pogingen** nodig 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

**Maak oefening 21**

**Maak zelf je volgende oefening**

**Naar het oefeningenoverzicht**

**WISKI**

School - Klas opvolgen

Leertijdschema

Wat is de hoofdstad van de staat Florida?

Antwoord: Tallahassee

Kwaliteit afleiders: Goed

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

**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**

**How good do you think you are at mathematics?**

Expert: mathematics is too easy for you.  
Proficient: you know better than average on math topics.  
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.

**Sum**

**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



# WISKI

personalised maths practice with AI

### 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** Volgens mij is dit nu je level voor het onderwerp Hoofdbewerkingen

Welke moeilijkheidsgraad wil je voor de volgende oefeningensreeks?

Heer makkelijk Makkelijk Gewoon Moeiijk Heer moeiijk

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

- Expert
- Bedreven
- Competent
- Gevorderde beginner
- Beginner

**Je level is de reeks**

**Start de reeks**

Op volgorde van Hoog naar laag

nummer	Verwachte moeilijkheidsgraad voor jou
Oefening 43	Makkelijk
Oefening 42	Competent
Oefening 41	Makkelijk
Oefening 40	Moeiijk
Oefening 39	Competent
Oefening 38	Makkelijk
Oefening 37	Makkelijk
Oefening 36	Makkelijk
Oefening 35	Makkelijk
Oefening 34	Makkelijk

### WISKI

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

**Punten**

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

**Puntenklassement**

Vergelijk je puntentotaal met dat van anderen op een 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

Hoofdbewerkingen

**Gefeliciteerd Pri(s)ma resultaat!**

Maak een oefening correct om een challenge voor de volgende reeks te krijgen

**Volgzaam**

### WISKI

Oefenen

Kies het onderwerp waarover 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
  - Hoeken
  - Omrek en oppervlakte van vlakke figuren

### WISKI

Oefenen Helpen Oefeningen overzicht

**Badge Vooruitgang**

**Challenge Badges**

**Badge Overzicht**

Delen van oplossingen (2/4)

Mededestudenten helpen (1/2)

Hang in behouden badges

**Deelwoord 2 vragen van een medeleerling** 2/5

**Reeds behaalde badges**

**Verwachte moeilijkheidsgraad voor jou** 2/5

### How is your new level determined?

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

Expert

Proficient

Competent

Advanced beginner

Novice

Volgorde van bewerkingen



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

- 0
- 144
- 72
- 144



**Correct**

Top-zl

Overslaan

Volgende 



expert

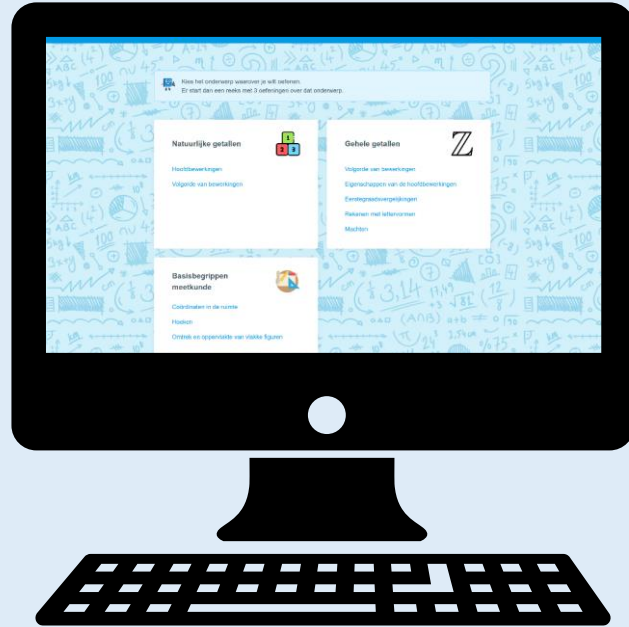


competent

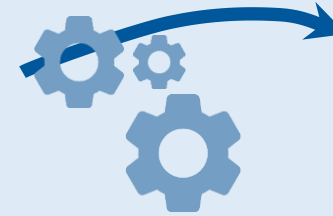


beginner

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



Recommender system





## Maak een aangeraden oefening van hetzelfde hoofdstuk

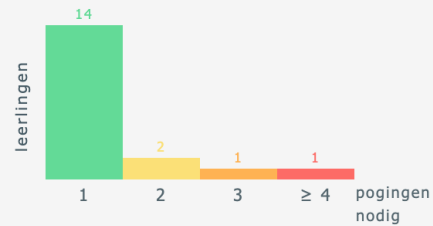
### Aangeraden

-  Oefening 37
-  Oefening 26
-  Oefening 21

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

Wiski verwacht dat je **1 of 2 pogingen** nodig gaat hebben om oefening 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



Maak oefening 21

... of kies zelf je volgende oefening

Naar het oefeningenoverzicht

Textual explanation

Visual explanation

## Maak een aangeraden oefening van hetzelfde hoofdstuk

- Aangeraden
-  Oefening 27
  -  Oefening 40
  -  Oefening 45

**Waarom deze oefening?**  
Oefening 27 is aangeraden omdat het algoritme van Wiski dat zo heeft berekend.



Maak oefening 27

... of kies zelf je volgende oefening

Naar het oefeningenoverzicht

Placebo explanation

## Maak een aangeraden oefening van hetzelfde hoofdstuk

- Aangeraden
-  Oefening 27
  -  Oefening 40
  -  Oefening 45

Wiski raadt de volgende oefening aan



Maak oefening 27

... of kies zelf je volgende oefening

Naar het oefeningenoverzicht

No explanation

## Questionnaire on trust

### 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

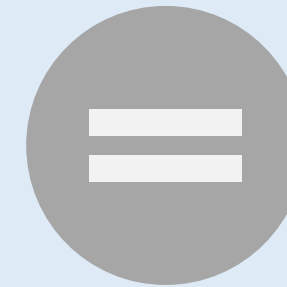
Multidimensional trust

## Effects on trust

Placebo explanations



1D trust



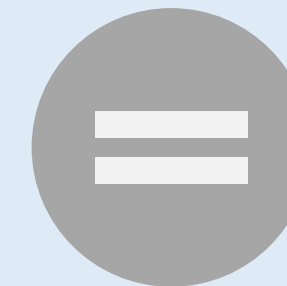
MD trust



Real explanations



1D trust



MD trust



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

### Maak een aangeraden oefening van hetzelfde hoofdstuk

**Aangeraden**

- Oefening 37
- Oefening 26
- Oefening 21

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

Wiski verwacht dat je **1 of 2 pogingen** nodig gaat hebben om oefening 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

pogingen nodig	leerlingen
1	14
2	2
3	1
≥ 4	1

Maak oefening 21

### Maak een aangeraden oefening van hetzelfde hoofdstuk

**Aangeraden**

- Oefening 27
- Oefening 40
- Oefening 45

**Wiski raadt de volgende oefening aan**

GOOD JOB

Maak oefening 27

... of kies zelf je volgende oefening

Naar het oefeningenoverzicht

Wiski raadt je volgende oefening

Naar het oefeningenoverzicht

### Maak een aangeraden oefening van hetzelfde hoofdstuk

**Aangeraden**

- Oefening 27
- Oefening 40
- Oefening 45

**Waarom deze oefening?** Oefening 27 is aangeraden omdat het algoritme van Wiski dat zo heeft berekend.

Maak oefening 27

... of kies zelf je volgende oefening

Naar het oefeningenoverzicht

# Explanations

**Maak een aangeraden oefening van hetzelfde hoofdstuk**

**Aangeraden**

- Oefening 37
- Oefening 26
- Oefening 21

**Maak een aangeraden oefening van hetzelfde hoofdstuk**

**Maak oefening 21**

... of kies zelf je volgende oefening

[Naar het oefeningenoverzicht](#)

**WISKI**

School - Klas volgen

Leertijdoverzicht

Antwoord

Tallahassee

Kwaliteit afleiders

Goed

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

Vraag: Wat is de hoofdstad van de staat Florida?

Antwoord: Tallahassee

Gelijkwaardigheid

Afleidings

Miami

New York

Los Angeles

Limburg

Noorwegen

Zuidpool

# 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

**How good do you think you are at mathematics?**

Expert: mathematics is too easy for you.

Proficient: you know better than average on mathematics.

Competent: you know average on mathematics.

Advanced beginner: basic exercises are not a problem for you.

Novice: you often have a hard time understanding mathematics.

Sum

**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



**Hoe is je nieuw niveau bepaald?**

Wiski schat jouw niveau en de moeilijkheid van oefeningen in. Beide veranderen bij het oplossen van oefeningen.

Je niveau is gestegen na het maken van de reeks oefeningen.  
Daarna is het nog extra gestegen door je feedback.

Expert 


---

Bedreven 


---

Competent 


---

Gevorderde beginner 


---

Beginner 


---

Voor reeks

Na reeks

Na feedback

Maak meer oefeningen over dit onderwerp

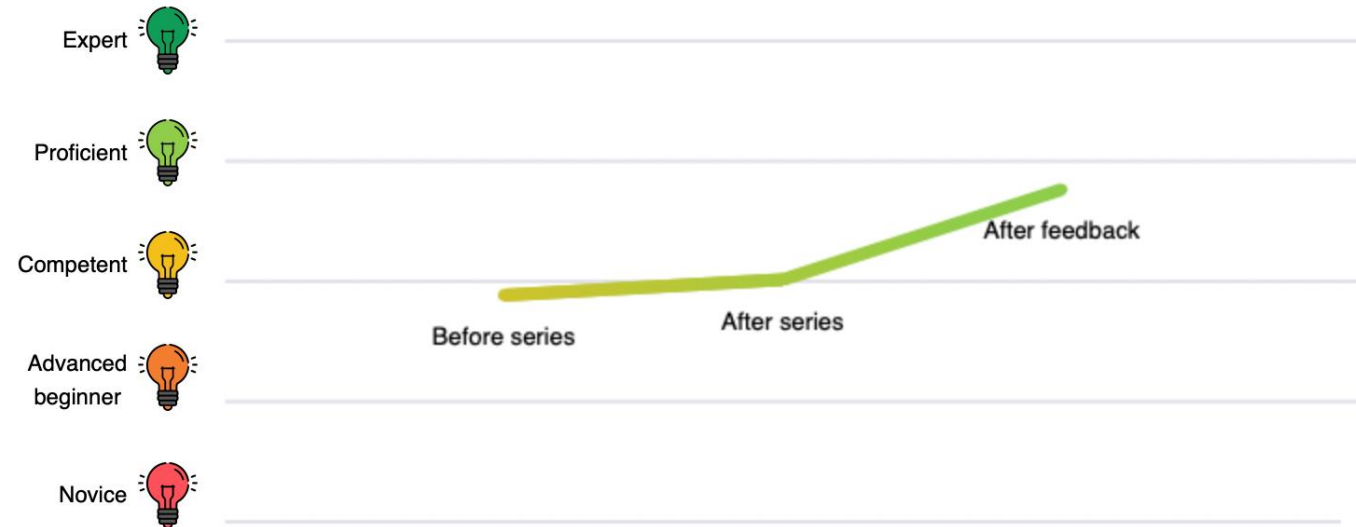
Ga terug naar oefenpagina

## 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

## Final questionnaire: control

### Control

- Q18 I feel in control of telling Wiski what I want.
- Q19 I don't feel in control of telling Wiski what I want.
- Q20 I don't feel in control of specifying and changing my preferences.
- Q21 Wiski seems to control my decision process rather than I do.

### Preference elicitation

- Q22 Wiski provides an adequate way for me to express my preferences.
- Q23 I found it easy to tell Wiski about my preferences.
- Q24 It is easy to learn to tell Wiski what I like.
- Q25 It required too much effort to tell Wiski what I like.

### Preference revision

- Q26 Wiski provides an adequate way for me to revise my preferences.
- Q27 I found it easy to make Wiski recommend different things.
- Q28 It is easy to train Wiski to update my preferences.
- Q29 I found it easy to alter the recommended exercises.
- Q30 It is easy for me to inform Wiski if I dislike/like recommended exercises.
- Q31 It is easy for me to get a new set of recommended exercises.

7-point Likert-type questions + open comments

## Final questionnaire: trust

### Competence

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

### Benevolence

- Q6 Wiski prioritises that I improve in maths.
- Q7 Wiski recommends exercises so that I improve in maths.
- Q8 Wiski wants to estimate my maths 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 maths exercises.

### Intention to return

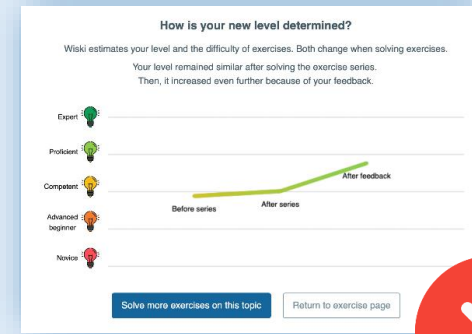
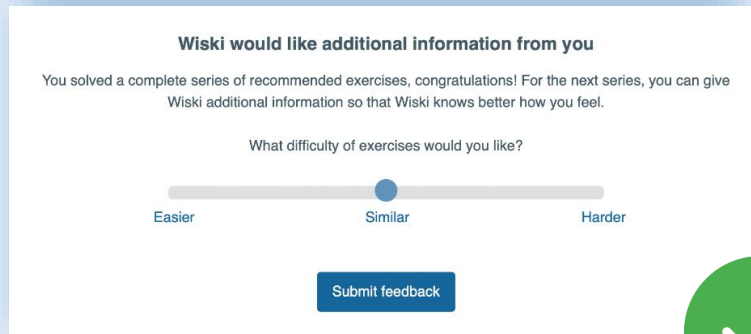
- Q13 If I want to solve maths exercises again, I will choose Wiski.
- Q14 If I want to be recommended maths exercises again, I will choose Wiski.

### Transparency

- Q15 I understood why the exercises were recommended.
- Q16 Wiski helps me understand why the exercises were recommended.
- Q17 Wiski explains why the exercises are recommended.

Trusting beliefs

Multidimensional trust

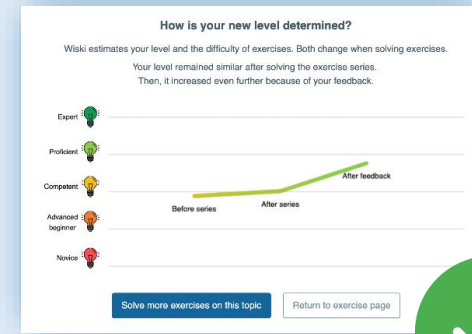
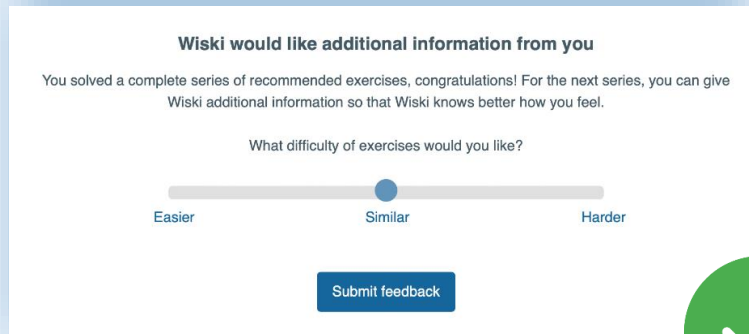


Trust in the platform

Reflection on own mastery

Reflection on recommendations





Trust in the platform

Perceived transparency

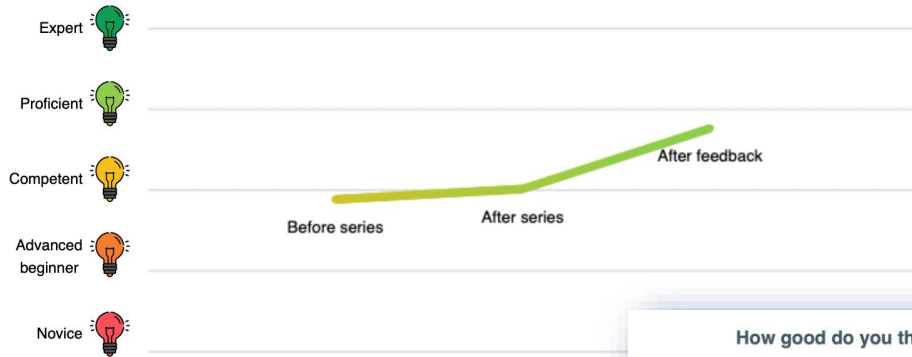
Reflection



### 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

### 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 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

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

# Explanations

**Maak een aangeraden oefening van hetzelfde hoofdstuk**

**Aangeraden**

- Oefening 37
- Oefening 26
- Oefening 21

**Maak een aangeraden oefening van hetzelfde hoofdstuk**

**Maak oefening 21**

**... of kies zelf je volgende oefening**

**Naar het oefeningenoverzicht**

**WISKI**

School - Klas opvolgen

Leertijdoverzicht

Antwoord

Tallahassee

Kwaliteit afleiders

Goed

Laag Gemiddeld Hoog

**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**

Vraag: Wat is de hoofdstad van de staat Florida?

Antwoord: Tallahassee

Gelijkwaardigheid

Afleidingsvragen

Miami  
New York  
Los Angeles  
Limburg  
Noorwegen  
Zuidpool

# 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

How good do you think you are in mathematics?

Expert: mathematics is too easy for you.  
Proficient: you are better than average in mathematics.  
Competent: you were average in mathematics.  
Advanced beginner: basic exercises are a challenge for you.  
Novice: you often have a hard time understanding mathematics.

**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



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

Welke moeilijkheidsgraad wil je voor de volgende oefeningenreeks?

Heel makkelijk    Makkelijk    Gewoon    Moeilijk    Heel moeilijk

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

- Expert
- Bedreven
- Competent
- Gevorderde beginner **Je level na de reeks**
- Beginner Je level nu

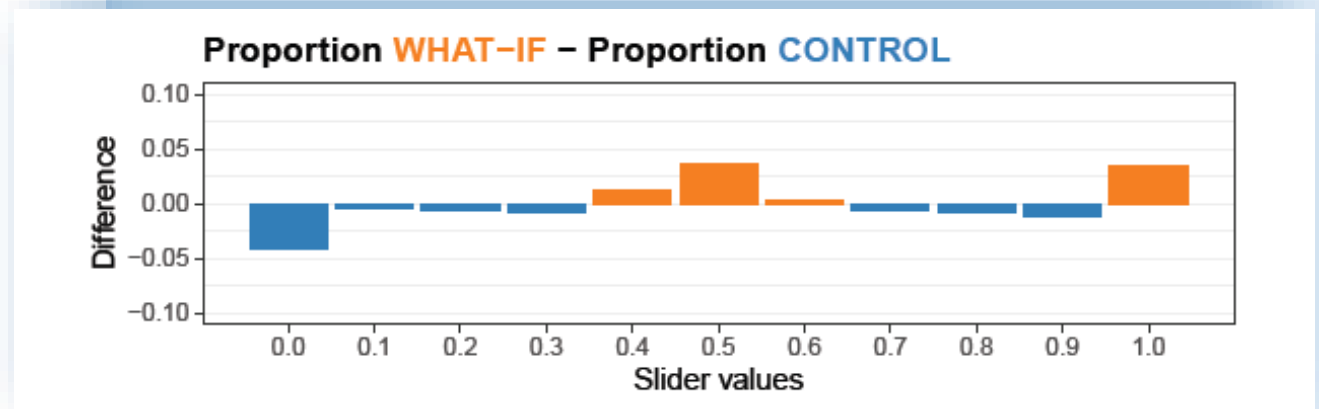
Start de reeks


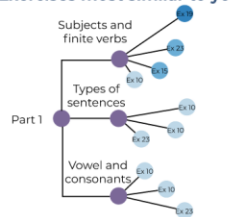
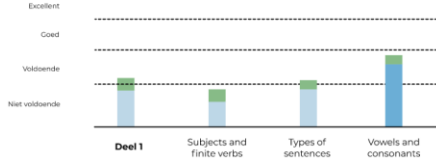
Impact on level if series is solved correctly



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

The screenshot shows a user interface for selecting a difficulty level. A blue robot character is on the left. A speech bubble from a 'Novice' level (indicated by a red lightbulb icon) says: "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?". Below this is a horizontal slider with five segments labeled 'Very easy', 'Easy', 'Normal', 'Difficult', and 'Very difficult'. A hand cursor is pointing to the 'Normal' segment. Below the slider, text says: "If you finish all exercises correctly, your level will increase:". To the right is a vertical progression chart with five levels: 'Expert' (green lightbulb), 'Proficient' (green lightbulb), 'Competent' (yellow lightbulb), 'Advanced beginner' (orange lightbulb), and 'Novice' (red lightbulb). A blue callout box labeled 'Your level after completion' points to the 'Advanced beginner' level, and a grey callout box labeled 'Your level now' points to the 'Novice' level. A blue button labeled 'Start exercises' is at the bottom.



Recommended series			General	Subjects and finite verbs	Types of sentences	Vowels and consonants
<b>Exercise 15</b> Part 1 Subjects and finite verbs	<b>Exercise level</b> Easy	<b>Completed before?</b> No	<p><b>Why this exercise series?</b></p> <p>The system looks for exercises adapted to your mastery level so you can make the most progress. Your mastery level is estimated based on exercises you have solved previously.</p> <p><b>1. Your level and why:</b></p> <p>PART 1    <b>Passing</b></p> <p>Negative impact    Positive impact</p>  <p><b>2. Exercises most similar to your level:</b></p>  <p><b>3. What if you correctly finish this series?</b></p>  <p>Excellent Goed Voldoende Niet voldoende</p> <p>Deel 1    Subjects and finite verbs    Types of sentences    Vowels and consonants</p> <p>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!</p>			
<b>Exercise 23</b> Part 1 Types of sentences	<b>Exercise level</b> Easy	<b>Completed before?</b> No				
<b>Exercise 12</b> Part 1 Subjects and finite verbs	<b>Exercise level</b> Easy	<b>Completed before?</b> No				
<b>Exercise 35</b> Part 1 Vowels and consonants	<b>Exercise level</b> Easy	<b>Completed before?</b> No				
<b>Exercise 10</b> Part 1 Types of sentences	<b>Exercise level</b> Easy	<b>Completed before?</b> No				

**Start sequence**



Exercise
Exercise 15 Part 1 Subjects and finite verbs
Exercise 23 Part 1 Types of sentences
Exercise 12 Part 1 Subjects and finite verbs
Exercise 35 Part 1 Vowels and consonants
Exercise 10 Part 1 Subjects and finite verbs



Group discussions with teachers and people developing educational technologies

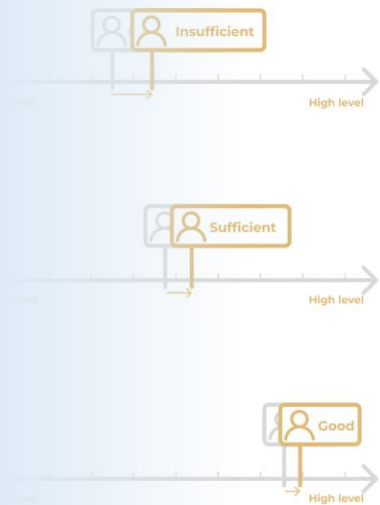
Recommended series		Explanation
Exercise	Exercise level	
Exercise 15 Part 1 Subjects and finite verbs	Easy	<p><b>Why this exercise series?</b> The system recommends exercises that are closest to <b>Your level</b>. Your level is estimated by looking at exercises you've solved previously.</p> <p><b>What if you correctly solve this series?</b> This is how the system estimates your mastery to change if you correctly solve the exercise series.</p> <p>● Non-recommended exercise ● Recommended exercise</p>
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	



Focus groups with teachers and educational experts  
Think-aloud sessions with adolescents

### What if you correctly solve this series?

How is how the system estimates your mastery to change if you correctly solve the exercise series.



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?



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



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

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



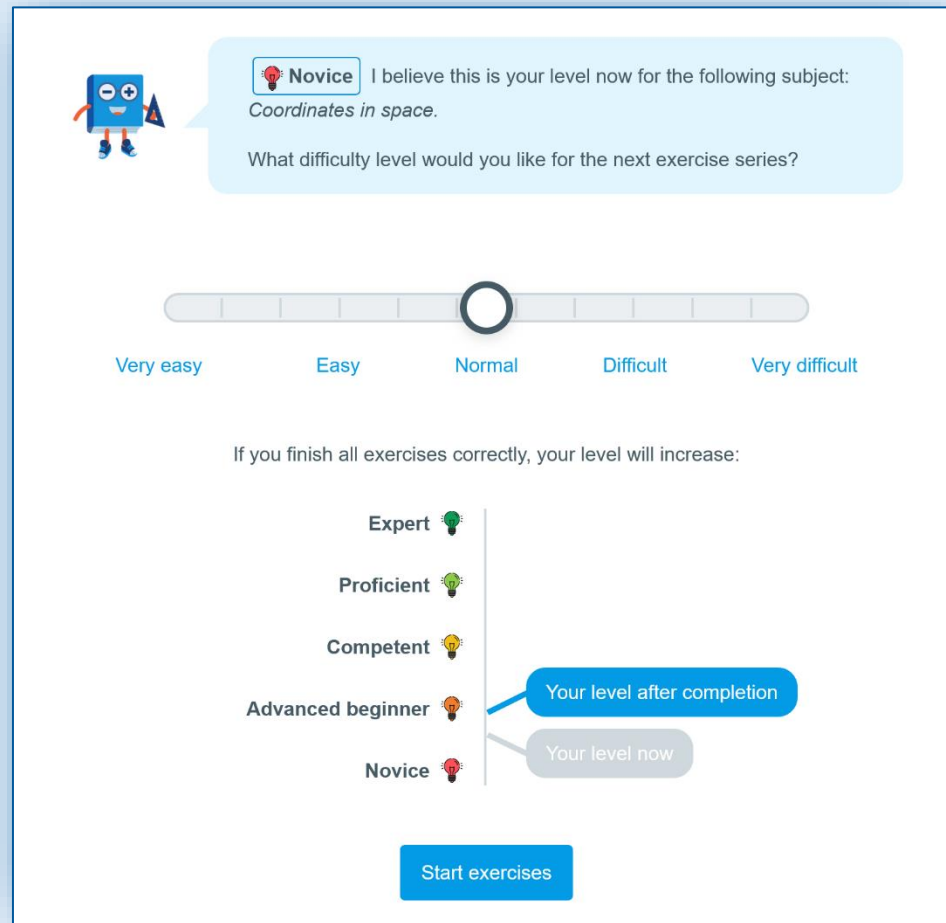
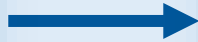
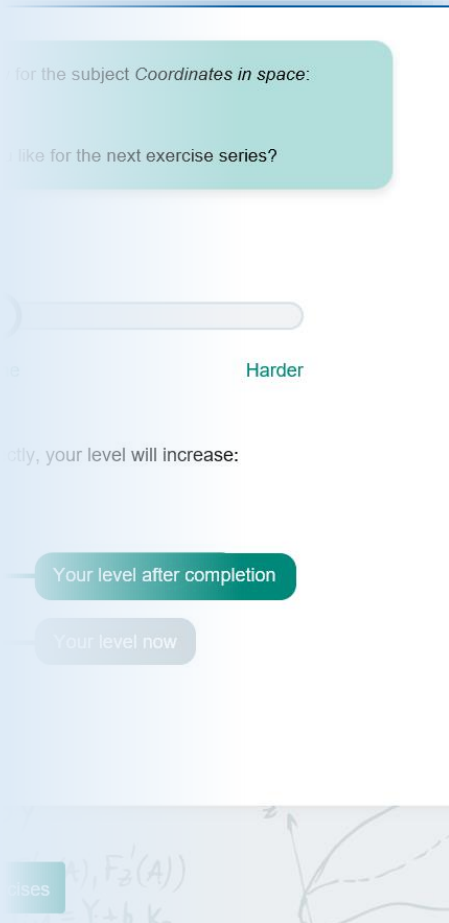
If you finish all exercises correctly, your level will increase:

- Expert
- Proficient
- Competent
- Advanced beginner
- Novice

Start



## More think-aloud sessions with adolescents



Final prototype for evaluation!

# Explanations

**Maak een aangeraden oefening van hetzelfde hoofdstuk**

**Aangeraden**

- Oefening 37
- Oefening 26
- Oefening 21

**Maak een aangeraden oefening van hetzelfde hoofdstuk**

**Maak oefening 21**

... of kies zelf je volgende oefening

**Naar het oefeningenoverzicht**

**WISKI**

School - Klas opvolgen

**Leerstofoverzicht**

Hoofdstuk	Program
Hoofdstuk 1	Program 1
Hoofdstuk 2	Program 2
Hoofdstuk 3	Program 3
Hoofdstuk 4	Program 4
Hoofdstuk 5	Program 5
Hoofdstuk 6	Program 6
Hoofdstuk 7	Program 7

**Deelnameoverzicht**

Wat zijn de resultaten van de leerlingen?

Deelnameoverzicht van de leerlingen op de oefeningen van het hoofdstuk 1 van de leerstof. De leerlingen worden gerangschikt op basis van hun aantal correcte antwoorden.

Hoofdstuk 1

Hoofdstuk 2

Hoofdstuk 3

Hoofdstuk 4

Hoofdstuk 5

Hoofdstuk 6

Hoofdstuk 7

Hoog geen programma voor deze serie.

**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**

**Vraag**

Wat is de hoofdstad van de staat Florida?

**Antwoord**

Tallahassee

**Kwaliteit afleiders**

Goed

Laag Gemiddeld Hoog

**Gelijkwaardigheid**

Afleidingsvragen

**Afleidingsvragen**

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

# 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**

**How good do you think you are at mathematics?**

There is no right or wrong answer. What does your answer tell you about your level?

- Expert: mathematics is too easy for you.
- Proficient: you are better than average in mathematics.
- Competent: you are average in mathematics.
- Advanced beginner: you are better than average in mathematics.
- Novice: you often have a hard time understanding mathematics.

**Save**

**Pick a reward and exercise:**

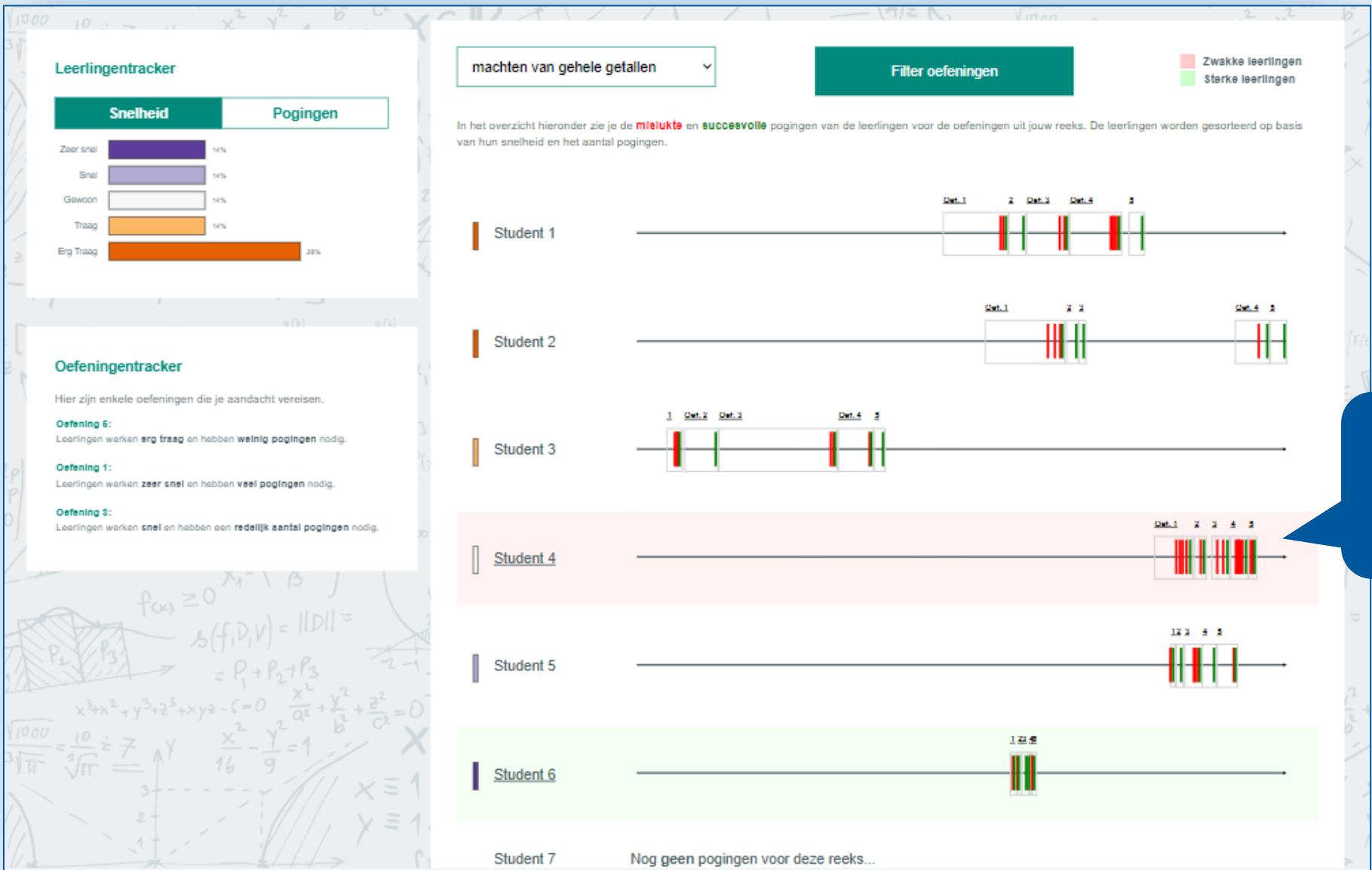
Next time you will get 4 new exercises

**8 + X = 25** Level: **Goed** Reward: 1

**X - 1 = -14** Level: **Goed** Reward: 2

**12 + X = 5** Level: **Goed** Reward: 1

**-8 + X = -24** Level: **Goed** Reward: 2



# Explanations

**Maak een aangeraden oefening van hetzelfde hoofdstuk**

**Aangeraden**

- Oefening 37
- Oefening 26
- Oefening 21

**Maak een aangeraden oefening van hetzelfde hoofdstuk**

**Waarom deze oefening?**  
Oefening 21 is aangeraden omdat het algoritme van Wiskit dat je heeft bevestigd.

**Waarom deze oefening?**  
Wiskit denkt dat jouw huidige niveau past bij dat van deze oefening!  
Wiskit 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

Maak oefening 21

... of kies zelf je volgende oefening

Naar het oefeningenoverzicht

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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Your level after completion

Start exercises

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**How is your new level determined?**

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How good do you think you are at mathematics?

- Expert: mathematics made its master for you.
- Proficient: you know better than anyone in your class.
- Competent: you score average on most exercises.
- Advanced beginner: you know enough to solve most problems for you.
- Novice: you often have a hard time understanding mathematics.

Solve more exercises on this topic Return to exercise page

**WISKI**

School - Klas opvolgen

Leertijdschaker

Maak een aangeraden oefening van hetzelfde hoofdstuk

Deelresultaten

Deelresultaten

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

Gelijkwaardigheid

Afleidingsvragen

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

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

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

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

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

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



Vraag  
Wat is de hoofdstad van de staat Florida?

Antwoord  
Tallahassee

Kwaliteit afleiders  
Goed

Laag Gemiddeld Hoog

Gelijkaardigheid • Afleiders

Afleid. Vragen

- Miami
- New York
- Los Angeles

Visualising similarity scores used for recommendation

Control over model parameters

Vraag  
Wat is de hoofdstad van de staat Florida?

Antwoord  
Tallahassee

Kwaliteit antwoorden

Alles ————— Goed ————— Zeer goed

Gewicht afleider/gelijke vragen

Afleid. ————— standaard ————— Gelijke vragen

- Miami
- Jaipur
- New York
- Limburg
- Noorwegen

# Explanations

**Maak een aangeraden oefening van hetzelfde hoofdstuk**

**Aangeraden**

- Oefening 37
- Oefening 26
- Oefening 21

**Maak een aangeraden oefening van hetzelfde hoofdstuk**

**Waarom deze oefening?**  
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**Waarom deze oefening?**  
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Aantal pogingen medeleerlingen nodig hadden om oefening 21 juist op te lossen

Maak oefening 21

... of kies zelf je volgende oefening

Naar het oefeningenoverzicht

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?**

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How good do you think you are at mathematics?

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- Proficient: you know better than anyone in your class.
- Competent: you were average in your class.
- Advanced beginner: you know more than most in your class.
- Novice: you often have a hard time understanding mathematics.

Solve more exercises on this topic | Return to exercise page

**WISKI**

School - Klas opvolgen

Leertijdschema

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

Afleidingsvragen





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

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

$8 + X = 25$ Level: <span style="color: green;">●●●○○</span> Reward: 1 <span style="color: gold;">●</span>	$X - 1 = -14$ Level: <span style="color: green;">●●●●●</span> Reward: 2 <span style="color: gold;">●</span>
$12 + X = 5$ Level: <span style="color: green;">●●●○○</span> Reward: 1 <span style="color: gold;">●</span>	$-8 + X = -24$ Level: <span style="color: green;">●●●●●</span> Reward: 2 <span style="color: gold;">●</span>

← 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

**Maak een aangeraden oefening van hetzelfde hoofdstuk**

**Aangeraden**

- Oefening 37
- Oefening 26
- Oefening 21

**Maak een aangeraden oefening van hetzelfde hoofdstuk**

**Waarom deze oefening?**  
Oefening 21 is aangeraden omdat het algoritme van Wiskit dat je heeft bevestigd.

**Waarom deze oefening?**  
Wiskit denkt dat jouw huidige niveau past bij dat van deze oefening!  
Wiskit 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

Maak oefening 21

... of kies zelf je volgende oefening

Naar het oefeningenoverzicht

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

Start exercises

# Control

**How is your new level determined?**

Wiskit 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.

How good do you think you are at mathematics?

- Expert: mathematics made its master for you.
- Proficient: you know better than anyone in your class.
- Competent: you know enough to teach others.
- Advanced beginner: you know enough to solve problems for you.
- Novice: you still have a hard time understanding mathematics.

Solve more exercises on this topic | Return to exercise page

**WISKI**

School - Klas opvolgen

Leertijdschema

Hoofdstuk	Pogingen
Hoofdstuk 1	10
Hoofdstuk 2	15
Hoofdstuk 3	20
Hoofdstuk 4	25
Hoofdstuk 5	30

Deelnameoverzicht

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

Gelijkwaardigheid

Afleidingsvragen

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

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

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



# Explainability and Control for Adaptive E-Learning Systems

AIED RECIFE 2024



Jeroen Ooge  
jeroenooge.be



**Maak een aangeraden oefening van hetzelfde hoofdstuk**

Aangeraden  
Oefening 37  
Oefening 26  
Oefening 21

**Maak een aangeraden oefening van hetzelfde hoofdstuk**

Aangeraden  
Oefening 27  
Oefening 48  
Oefening 45

**Maak een aangeraden oefening van hetzelfde hoofdstuk**

Aangeraden  
Oefening 27

**Wiskunde**

School - Klas opvolgen

Leerlingstracker

Oefeningstracker

maakt van gehele punten

Filter oefeningen

Er zijn nog geen oefeningen toegevoegd aan de lijst.

Stapel 1

Stapel 2

Stapel 3

Stapel 4

Stapel 5

Stapel 6

Stapel 7

Trag geen pogingen voor deze wiskunde.

**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

**How good do you think you are at mathematics?**

There is no right or wrong answer. You set your answer to find out if it is a good answer for you.

Expert: mathematics is like no second for you.  
Proficient: you are better than average at mathematics.  
Competent: you come average at mathematics.  
Advanced beginner: better exercises are not a problem for you.  
Novice: you still have a hard time understanding mathematics.

Start

**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: Novice

Start exercises

You can do it! You can do it! You can do it! You can do it!

**Pick a reward and exercise**

Next time you will get 4 new exercises

$8 + X = 25$

Level: **Novice**

Reward: **1**

$12 + X = 5$

Level: **Novice**

Reward: **1**

Wat is de hoofdstad van de staat Florida?

Antwoord

Tallahassee

Kwaliteit afielders

Goed

Laag Gemiddeld Hoog

Goed

Afielders

Miami

New York

Los Angeles

Limburg

Noorwegen

Zuidpool