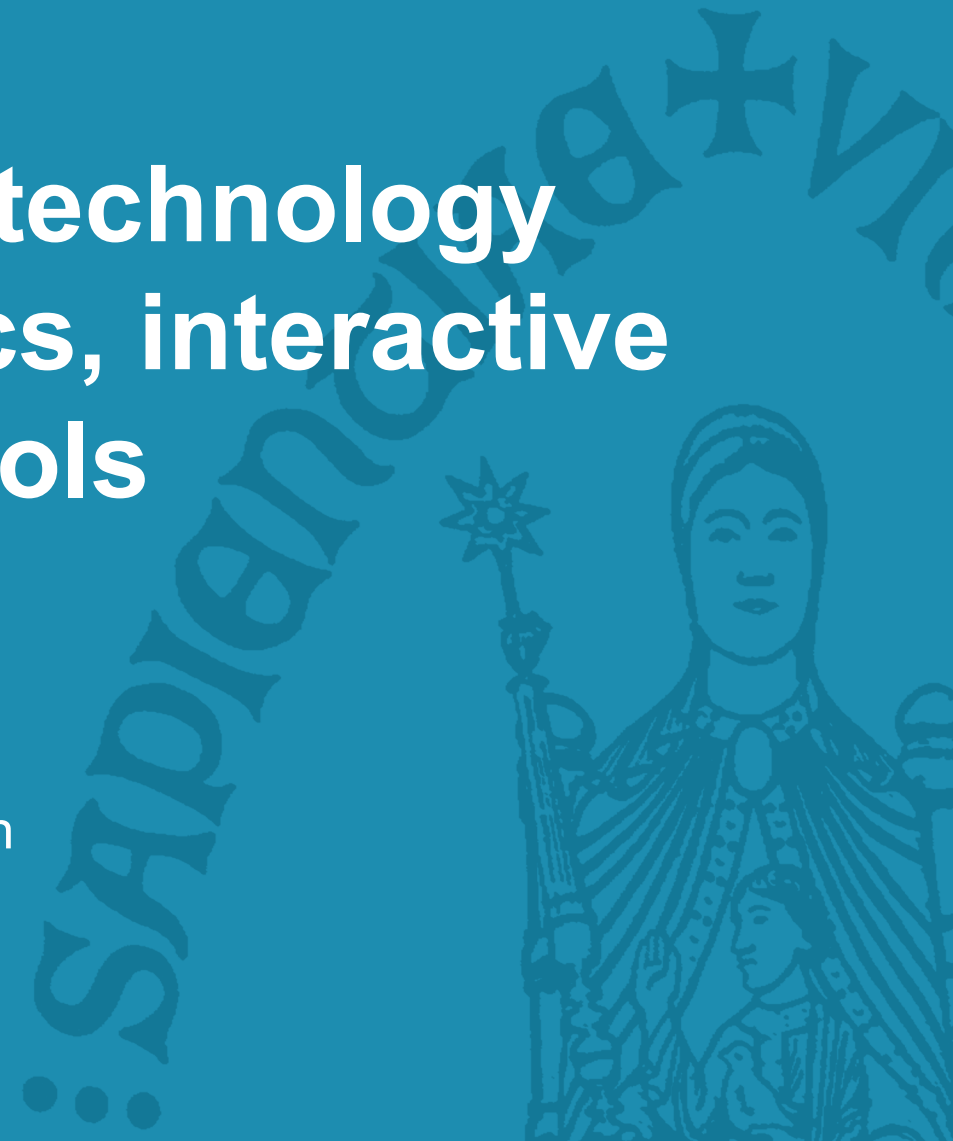


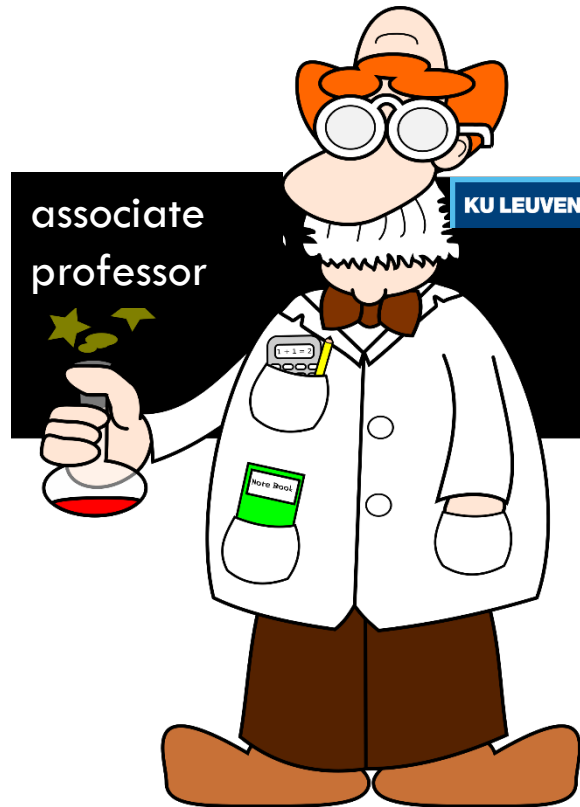
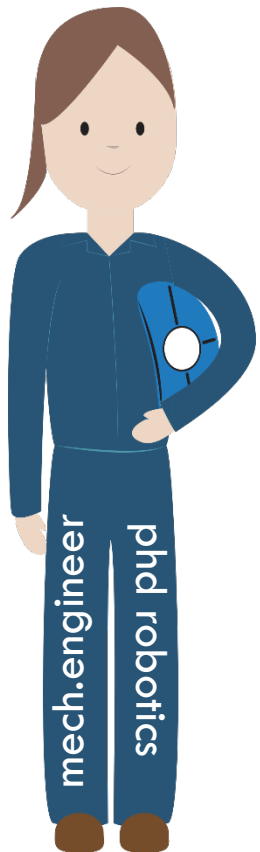
# Research-based educational technology innovations: learning analytics, interactive courseware, and reflection tools

Tinne De Laet

Leuven Engineering and Science Education Center, KU Leuven



# Who am I?



Head Tutorial Services  
Engineering Science KU  
Leuven



# SIG engineering Education research?

## Mission

Create a European community of engineering education researchers in order to contribute with research evidence to the advancement of engineering education.

Specific objectives are :

- to raise awareness of the need of a research approach to the development of engineering education,
- to identify and define the research area of engineering education and the engineering education researchers,
- to support the establishment of engineering education research as a discipline in Europe as a whole as well as regionally,
- to establish and contribute to European research projects,
- to collaborate in the training of PhD students and to establish a European standard for doctoral training for engineering education researchers,
- to influence and strengthen the engineering education research dimension at SEFI annual conferences, and
- to actively support the development of the SEFI journal European Journal of Engineering Education as a platform for

# Current activities and way of working

## Current activities

Workshops

SEFI@Work sessions

doctoral symposium at SEFI

summer school

Want to become a member?

Send e-mail to [tinne.delaet@kuleuven.be](mailto:tinne.delaet@kuleuven.be)

Learning Analytics that  
makes sense in practice

# KU LEUVEN

largest university in Belgium, founded 1425

16 faculties → general university

➤ 55 000 students



**no national exam**

secondary schools organize  
own independent exams



**low registration fees**

€922,3  
typically regular full-time  
students, 1 year



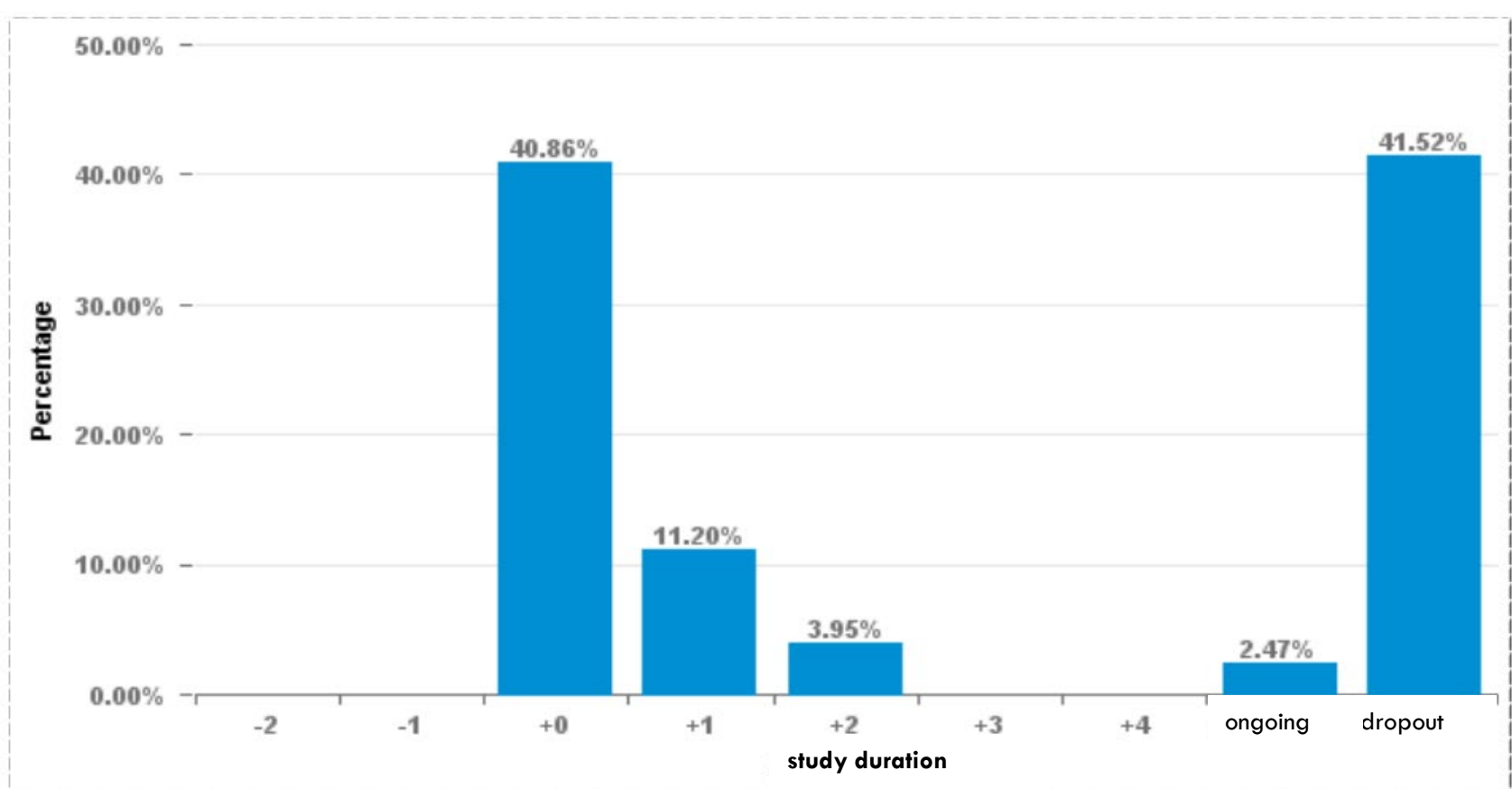
**no selection allowed**

have to accept all students with  
secondary education diploma  
(except Medicine, Dentistry & Performing Arts)



# KU LEUVEN

## How to improve student success??



# Learning Analytics?

*“Learning analytics is about collecting traces that learners leave behind and using those traces to improve learning.”*

*- Erik Duval*





# Learning Dashboards?

*“A dashboard is a visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance.”*

*- Stephen Few*

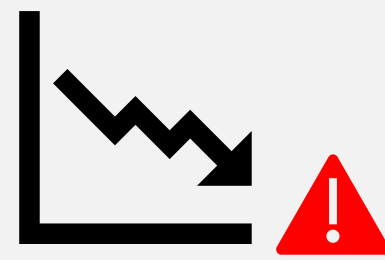
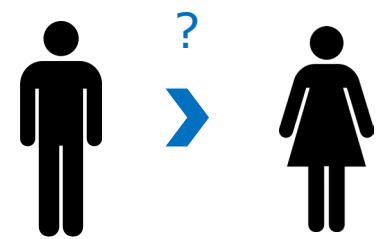


# [!] Feedback must be “actionable”.



Warning!  
Male are 10% less  
likely to be successful.  
You are male.

➤ action?

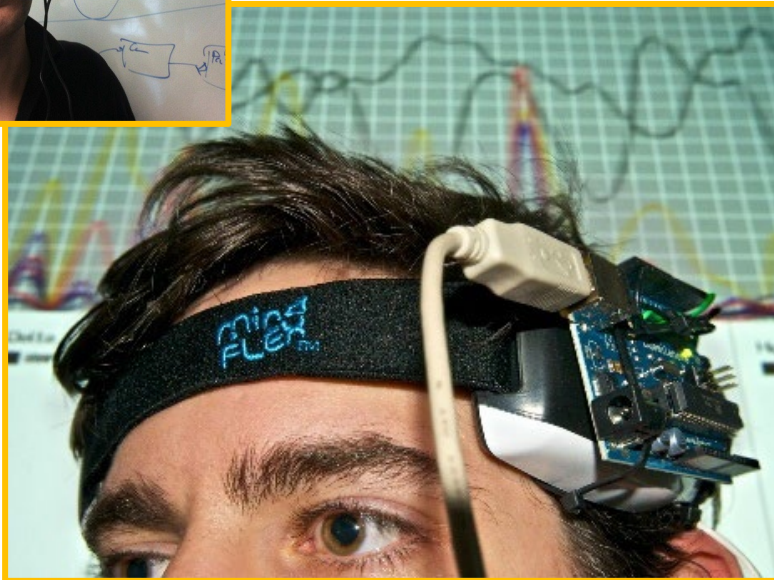
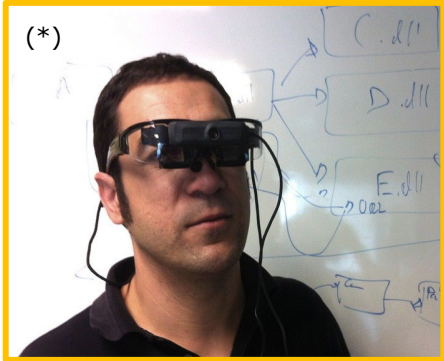


Warning!  
Your online activity is  
lagging behind.

➤ action?



# [!] Start with the available data.

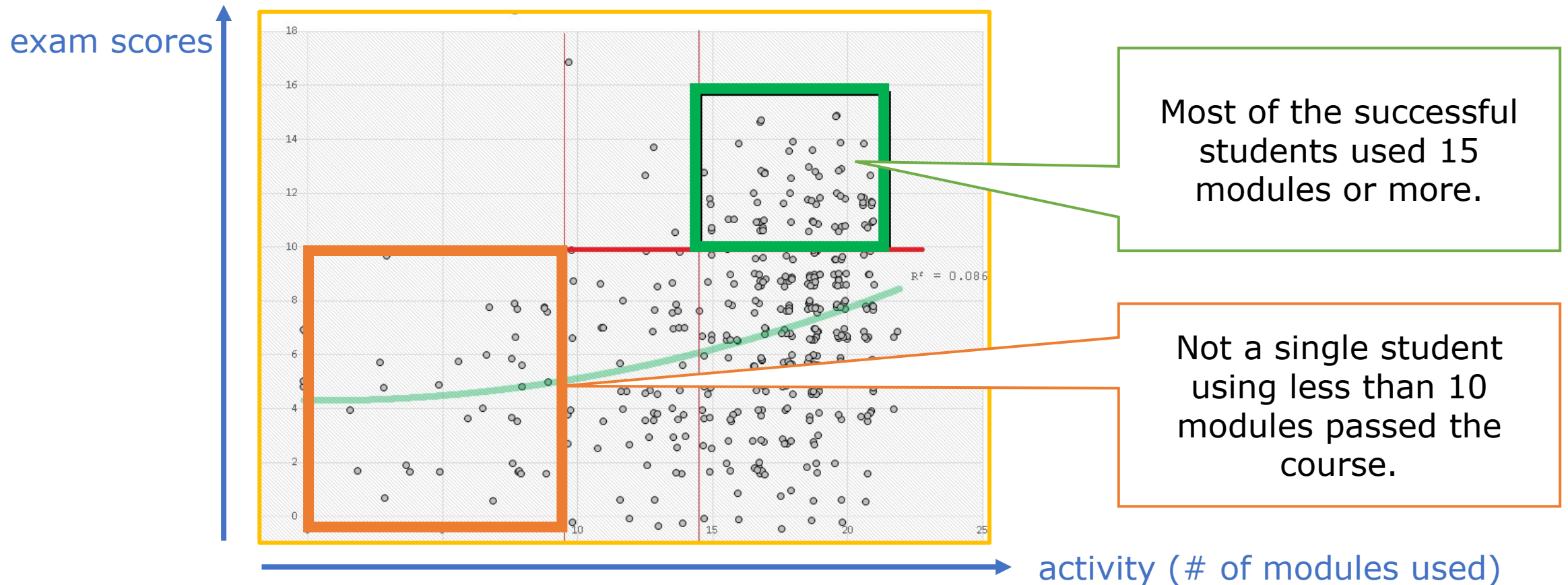


Lots of data may *eventually* become available in the future ...

.... already start with what is available

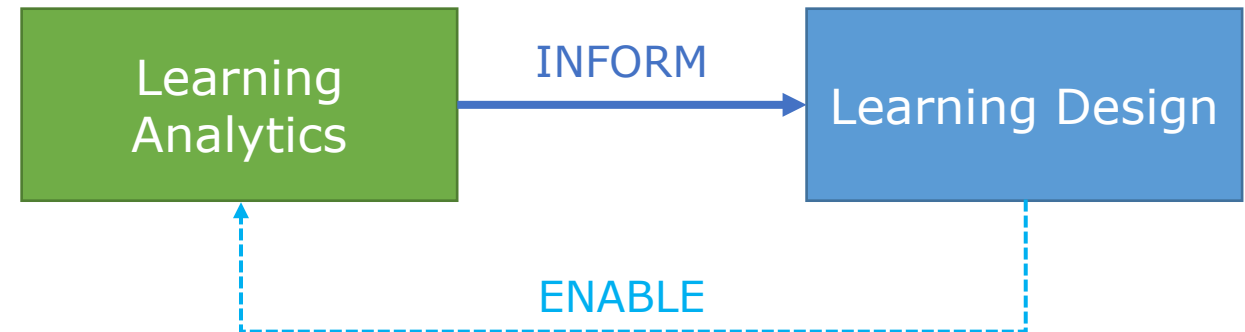
# [!] Not all data is usable.

example data from a course with flipped classroom & blended learning



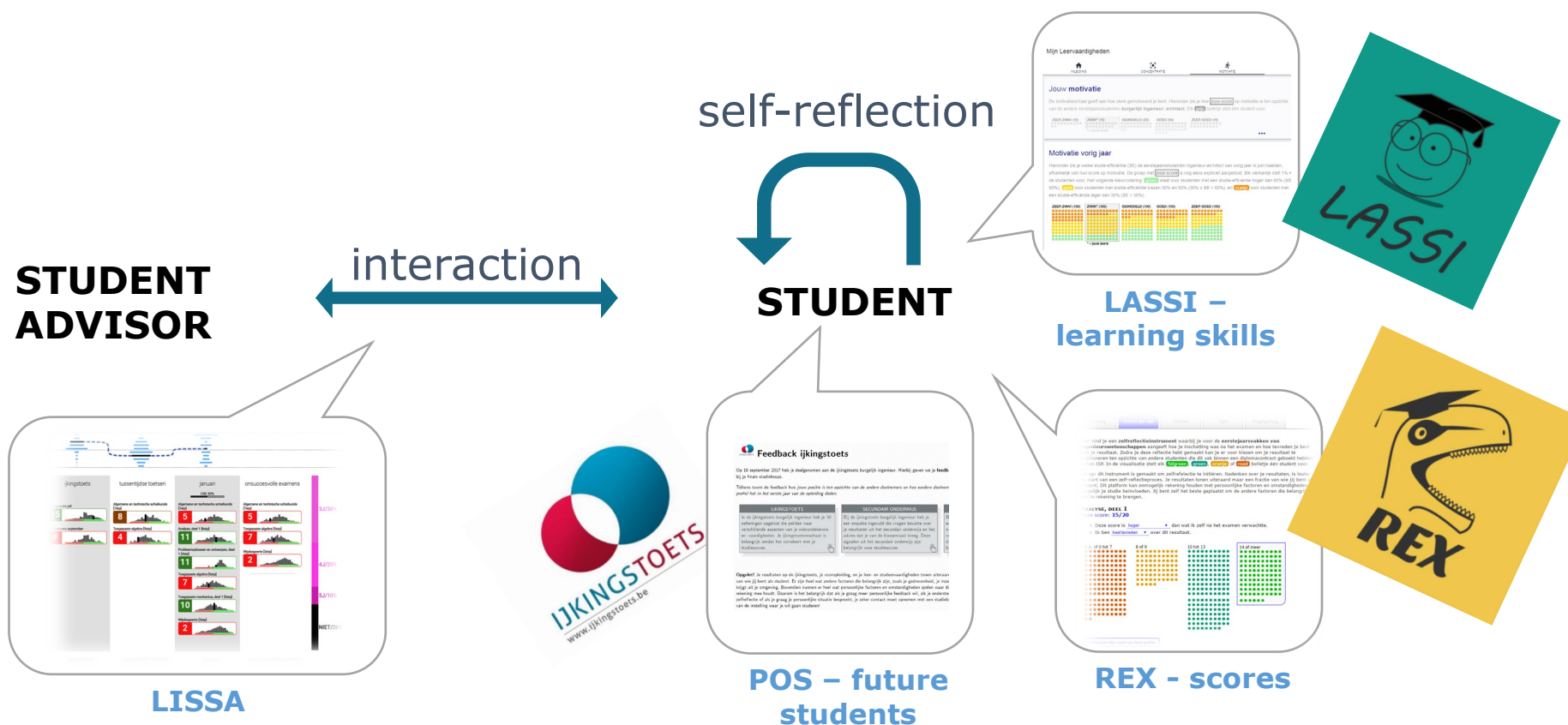
# [!] Keep Learning Analytics in mind when designing learning activities.

If LA indeed contributes to improved  
learning design...  
... don't make it an afterthought

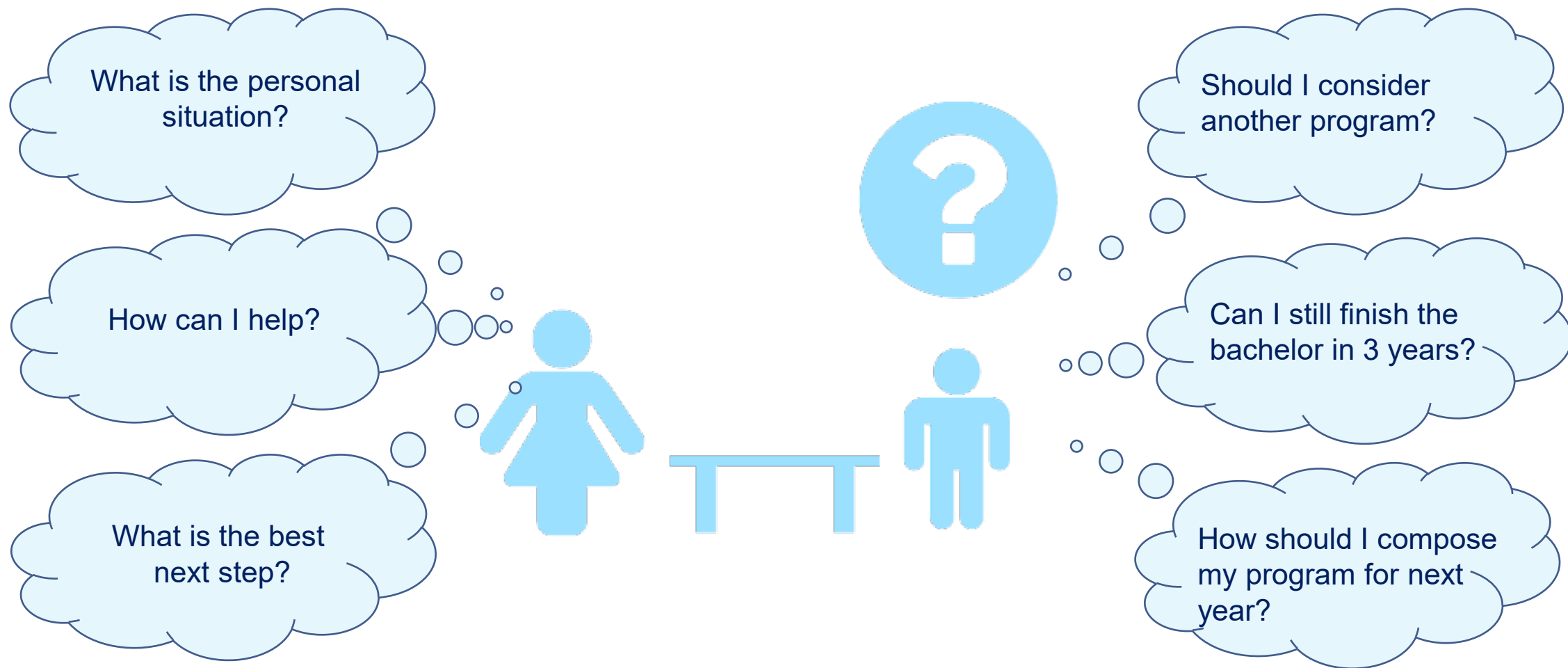




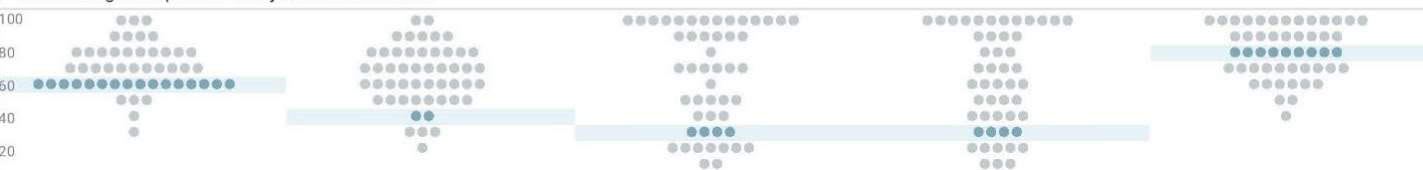
# learning dashboards @KU Leuven



# Student advisor – student conversations on study progress



Positionering ten opzichte van je medestudenten

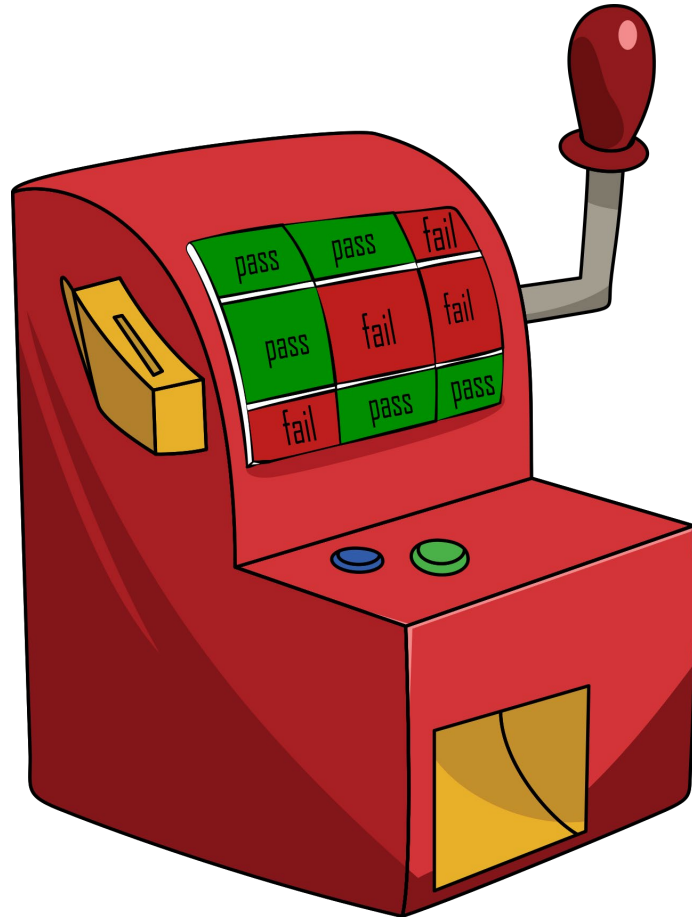


# LISSA dashboard



Charleer S., Vande Moere A., Klerkx J., Verbert K., De Laet T. (2017). Learning Analytics Dashboards to Support Adviser-Student Dialogue. In IEEE Transactions on Learning Technology

[!] Wording matters.



73% chance of success



73% of students of earlier  
cohorts with the same  
study efficiency obtained  
the bachelor degree

# Evaluation – interviews student advisors

*“I can talk about what to do with the results, instead of each time looking for the data and puzzling it together.”*

*“A student changed her study method in June and could now see it paid off.”*

## LISSA supports a personal dialogue.

- ✓ the level of usage depends on the experience and style of the student advisors
  - ✓ fact-based evidence at the side
  - ✓ narrative thread
- ✓ key moments and student path help to reconstruct personal track

*“It’s like a main thread guiding the conversation.”*

*“I can focus on the student’s personal path, rather than on the facts.”*

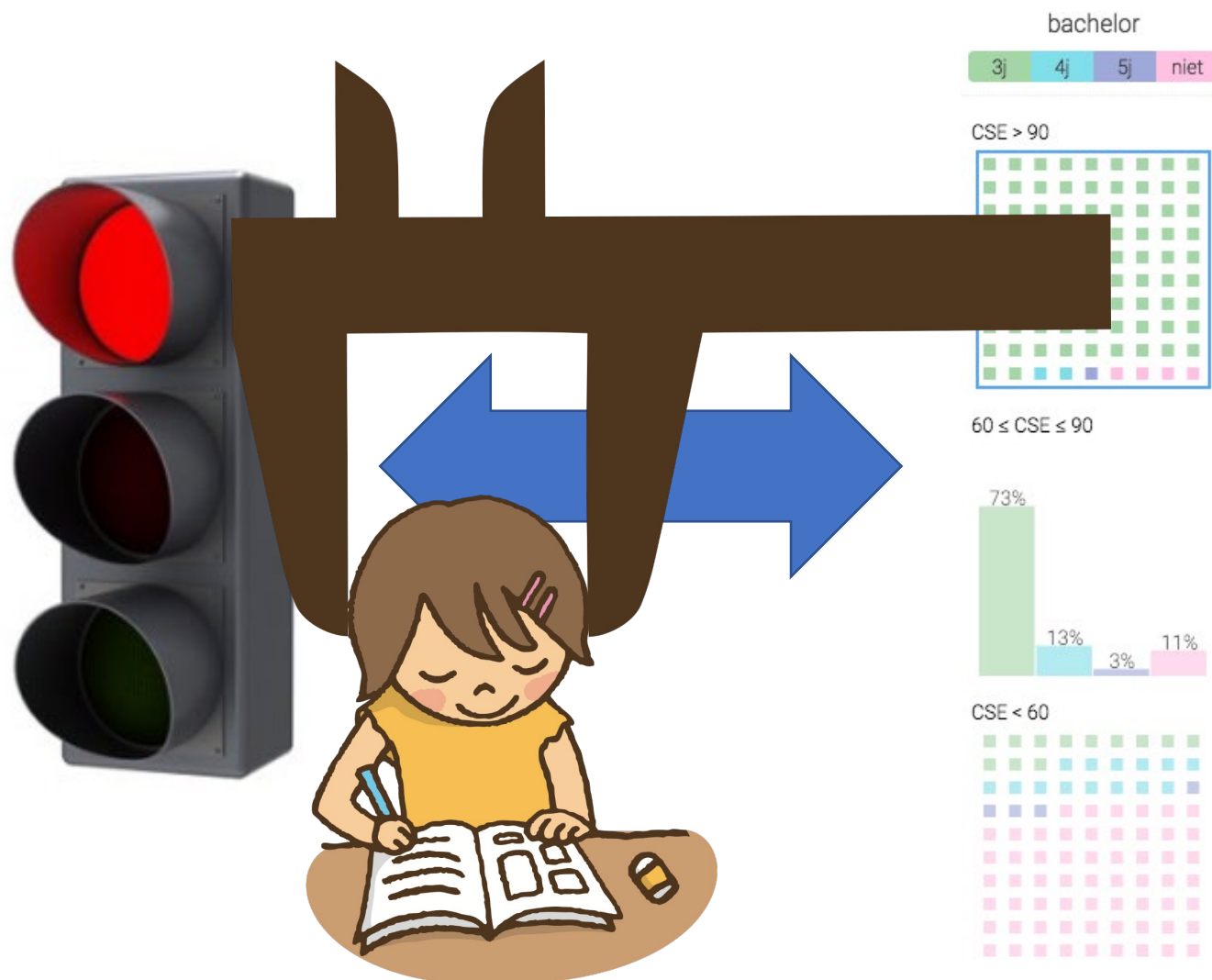
*“Now, I can blame the dashboard and focus on collaboratively looking for the next step to take.”*

*“Students don’t know where to look during the conversation, and avoid eye contact. The dashboard provides them a point of focus”.*

*“When students see the numbers, they are surprised, but now they believe me. Before, I used my gut feeling, now I feel more certain of what I say as well”.*



# [!] Do not oversimplify. Show uncertainty.



- reality is complex
- measurement is limited
- individual circumstances
- need for nuance
- trigger reflection

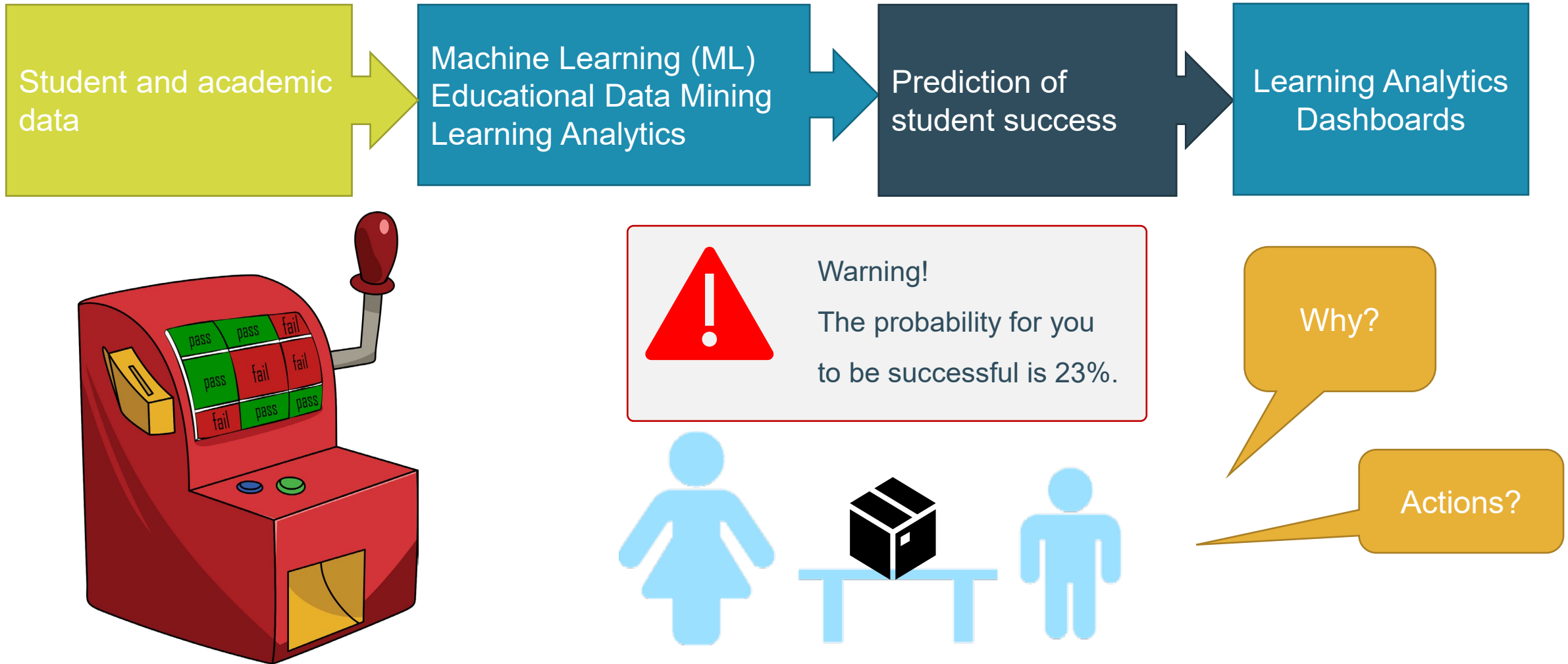
# [!] Context matters!



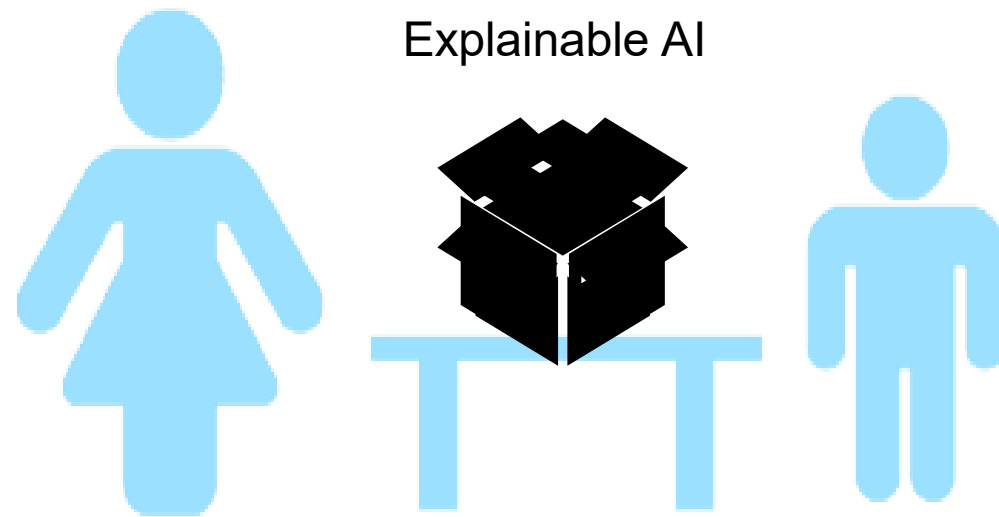
- available data
- national and institutional regulations and culture
- educational vision
- educational system, size of population ..
- ...

**Don't just copy existing solutions!**

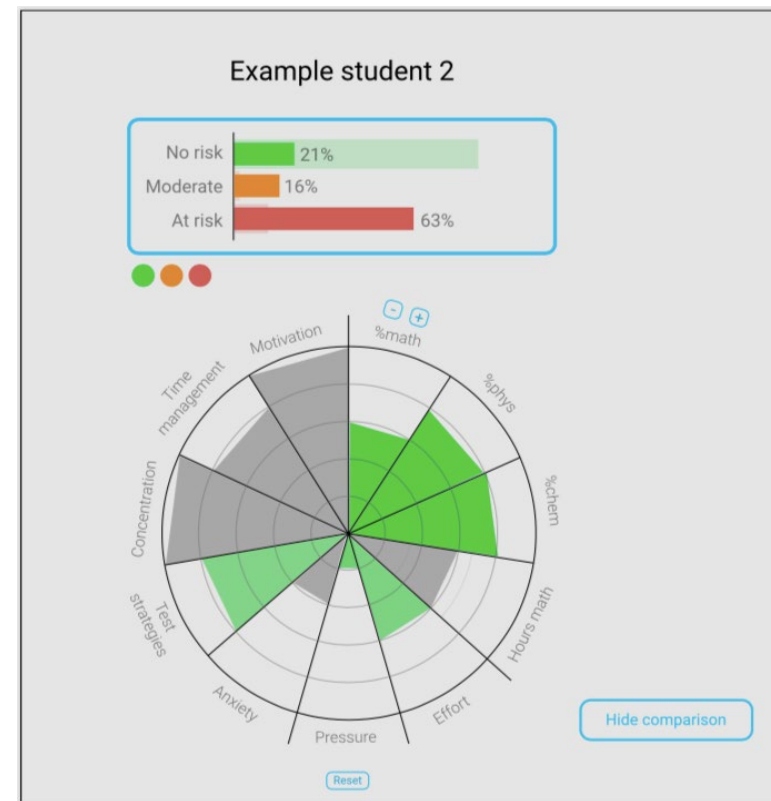
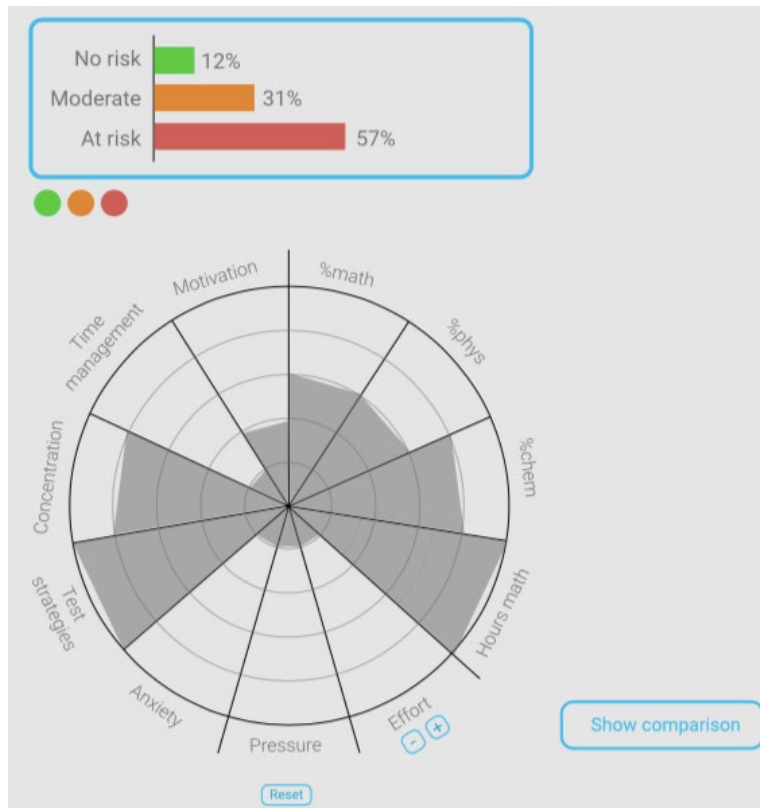
# Explainable AI for academic advising



**Goal** = bring predictive models for student success to advising practice by incorporating them in Learning Analytics Dashboards



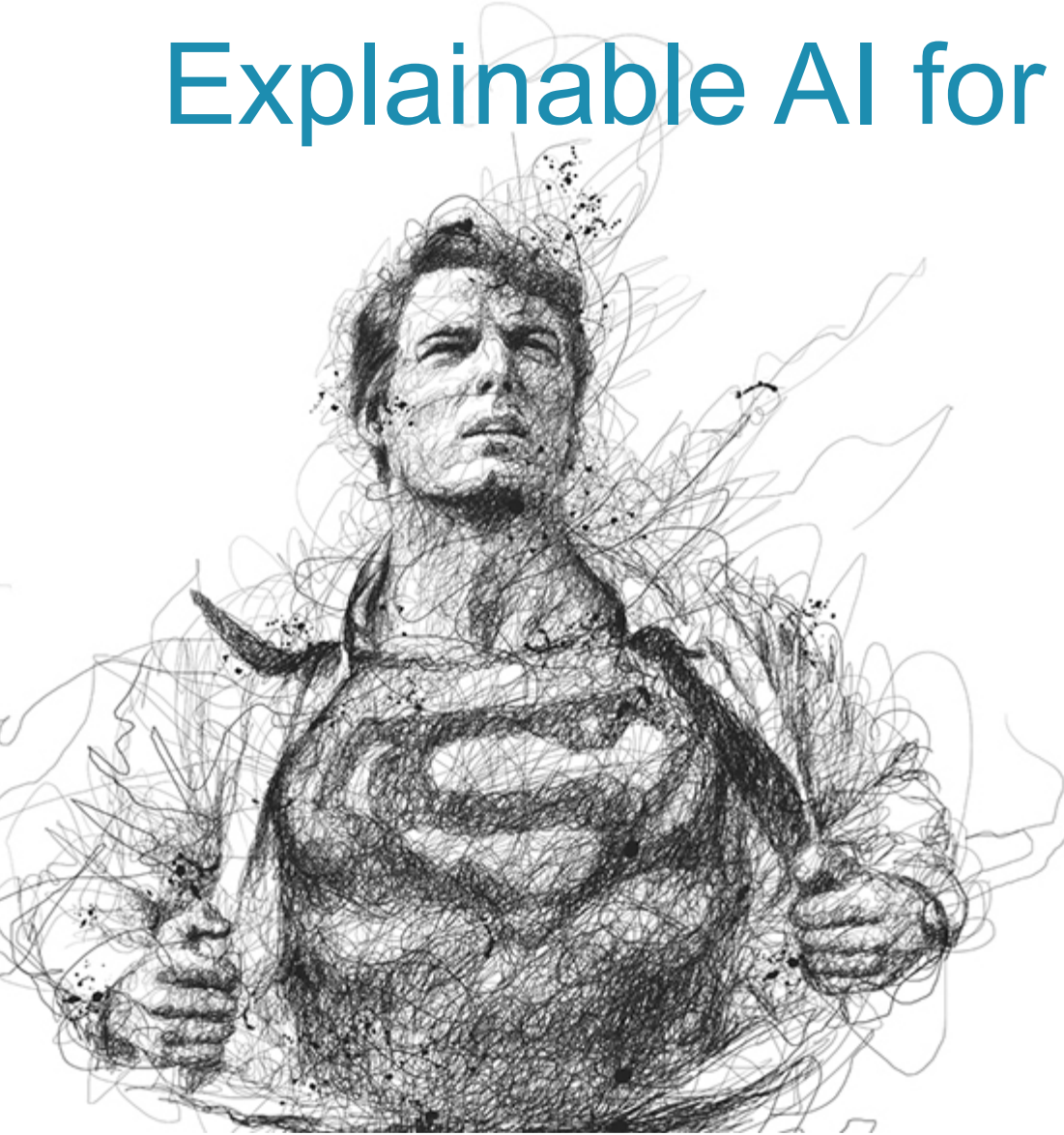
# Interactive and Explainable Advising Dashboard



<https://bit.ly/2YOAGFP>



# Explainable AI for academic advising



## Conclusion: Interactive explainers

- .... can help bring predictive models do advising practice
- ... contribute to awareness and reflection
- ... help to better understand black-box prediction model, and match or contrast mental model to the prediction model
- ... enforce mistrust in case of conflict with mental model
- ... risk for cognitive overload

## Future work

- Actual advising practice
- Real impact of explainers on utility, understanding, and trust

# Interactive courseware

# Interactive courseware – a side step



<https://bit.ly/3Bvqnpk>

# The Disciplinary Learning Companion

The Impact of Disciplinary and Topic-Specific Reflection on Students' Metacognitive Abilities and Academic Achievement

# Metacognition (Flavell, 1979, 2002)

**Metacognition** is students' **knowledge about their processes of cognition** and **the ability to control and monitor those processes** as a function of the feedback received via outcomes of learning.

## Metacognitive knowledge

- about persons: own and others' cognition
- about tasks: nature of information and task demands
- about strategies: learning and problem solving strategies

## Metacognitive skills

- planning: selecting strategies, allocating resources
- monitoring: ongoing awareness and assessment of comprehension, performance and progress
- controlling: managing and changing strategies as a result of monitoring
- evaluating: reviewing and assessing learning products



# Role of metacognition in problem solving

## **Correlation between problem solving and metacognition (Schoenfeld, 2007)**

- Expert problem solvers spend relatively more time on metacognitive activities than novices
- Monitoring solving process → pursuing interesting paths, abandoning unfruitful paths

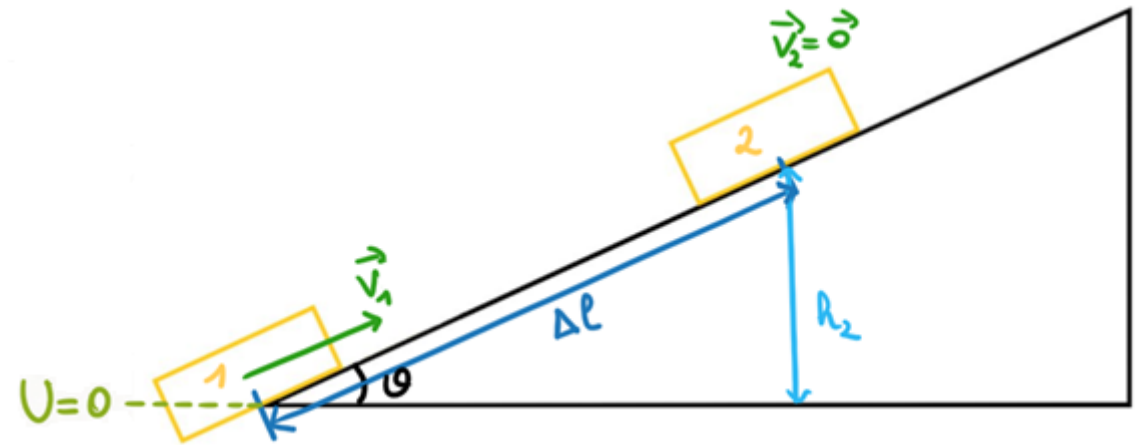
## **Metacognition promotes transfer (Berardi-Coletta, 1995; Kapa, 2007)**

# Disciplinary Learning Companion

## Goal

Trigger metacognition in problem solving by asking discipline-specific reflection questions

→ Focus on physics (Newtonian mechanics)



# Disciplinary Learning Companion: concept



Exercise session



Extra problem  
(homework)



**Disciplinary Learning Companion (DLC):**

Reflection module about extra problem



**Self-confidence:** How confident are you about your solution strategy?



**Content-specific reflection questions:** Questions about content of problem and solution strategy

- strategy plan
- concepts
- mathematical model
- computations
- interpretation



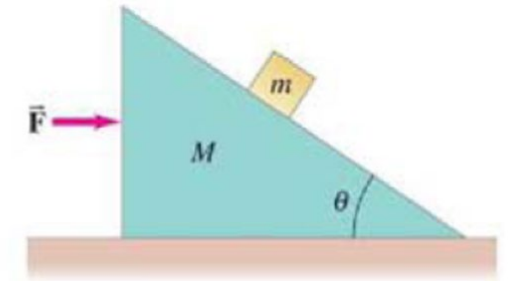
**Points of attention:** What did you learn and want to take with you to next exercise session?

## Instructions

Solve **exercise P.55 of chapter 4**. Compare your solution step-by-step with the model solution in this reflection module. Do this with a critical point of view. The **13 reflection questions** in this module will help you with this. At the end of the module, you can download the complete model solution.

The goal of this reflection module is to learn you how to reflect upon your own solution strategy. It should become a habit to do this.

(III) A small block of mass  $m$  rests on the sloping side of a triangular block of mass  $M$  which itself rests on a horizontal table as shown in Fig. 4-47. Assuming all surfaces are frictionless, determine the magnitude of the force  $\vec{F}$  that must be applied to  $M$  so that  $m$  remains in a fixed position relative to  $M$  (that is,  $m$  doesn't move on the incline). [Hint: Take  $x$  and  $y$  axes horizontal and vertical.]



**FIGURE 4-47**  
Problem 55.

## 1. Strategy plan

Do you recognize the following steps in your strategy plan?

- Identifying relevant concepts
  - Make a sketch.
  - Identify net force, acceleration and Newton's second law as relevant concepts.
- Constructing mathematical model
  - Choose coordinate system.
  - Apply Newton's second law to block  $m$ .
  - Apply Newton's second law on block  $M$ .
- Doing computations
  - Determining magnitude of acceleration  $\vec{a}$  from the equations.
  - Determining magnitude of force  $\vec{F}$  from the equations.
- Interpretation of answer
  - Checking answer by considering limiting cases.

- ☐ Yes, all steps.
- ☒ Some of these steps, but not all of them.
- ☐ None of these steps.
- ☐ I took other steps.
- ☐ I didn't have an (explicit) strategy plan.
- ☐ I don't know.

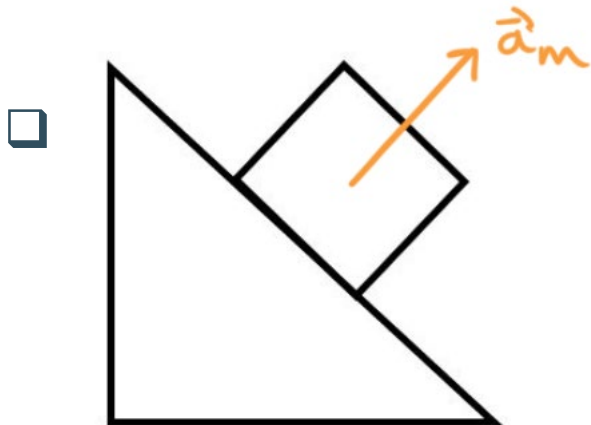
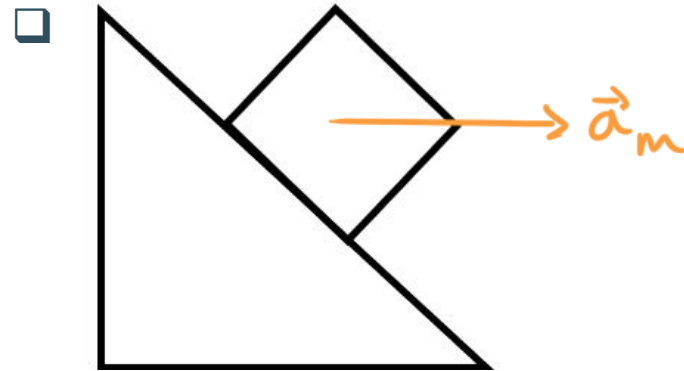
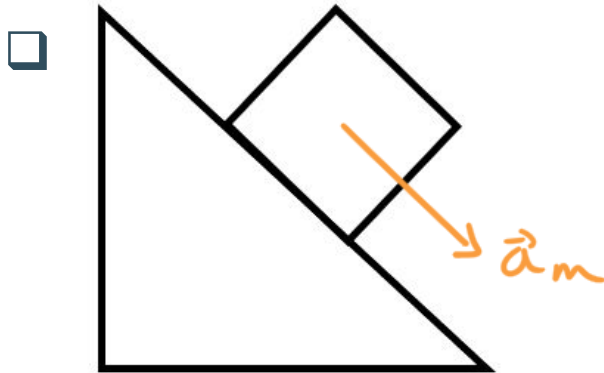
### Feedback

Did you maybe take some of these steps unconsciously?

Have a look at your solution again and try to make explicit which steps you take.

## 2. Concepts

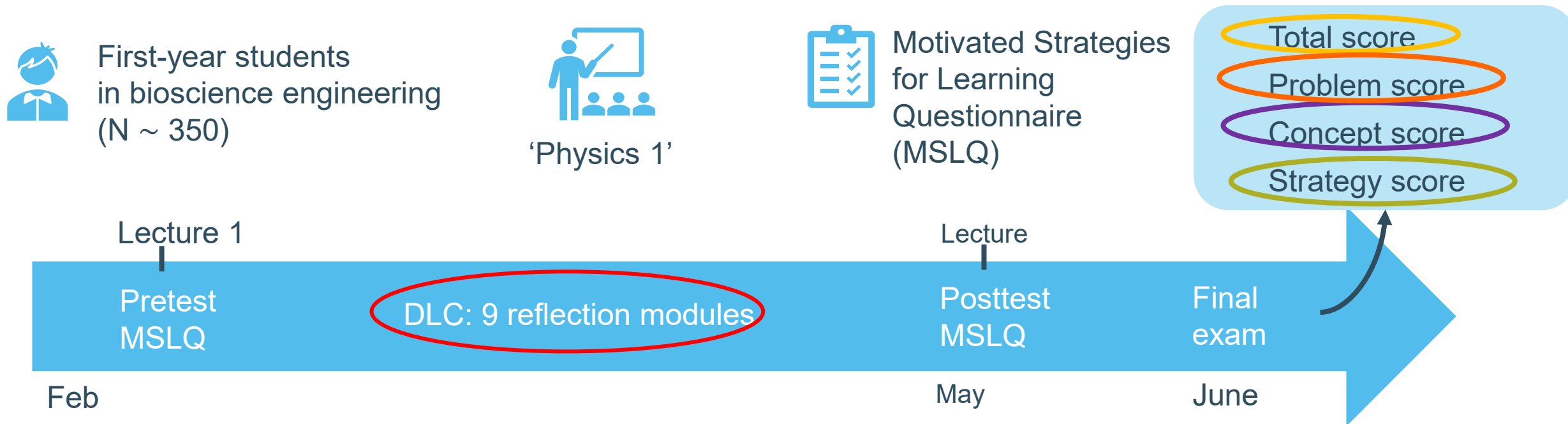
What is the direction and orientation of the acceleration  $\vec{a}_m$  of block  $m$ ?



- ☐ Something else.
- ☐ I don't know.



# Design of study

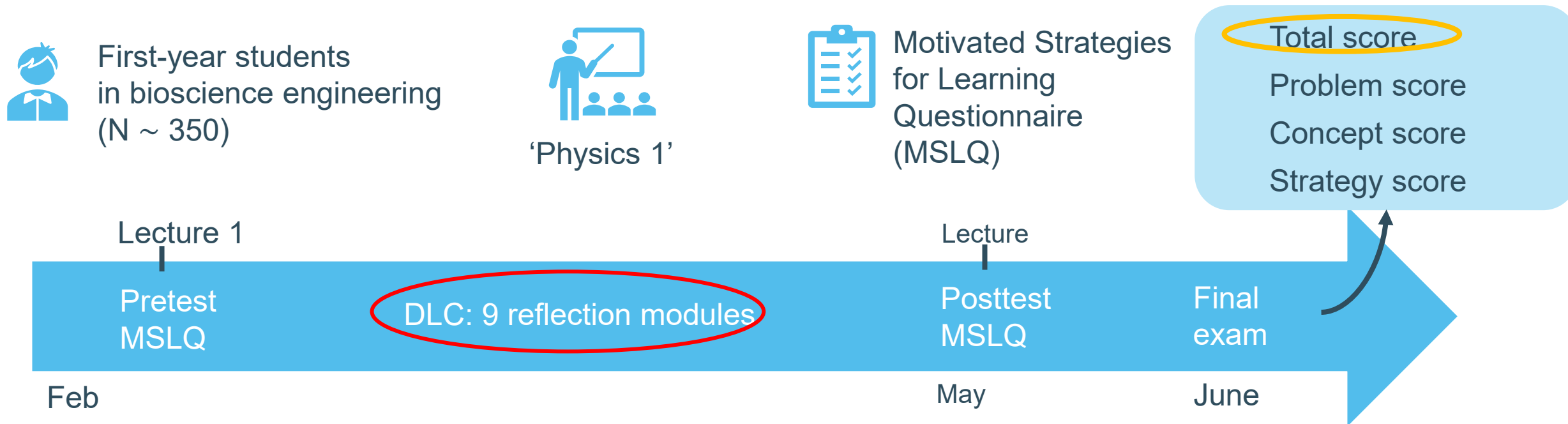


**RQ1.** How is students' **interaction with the DLC** related to their **academic achievement**?

**RQ2.** How is students' **interaction with (a particular physics topic in) the DLC** related to their **performance** on the corresponding exam problem and their **conceptual understanding** of this problem?

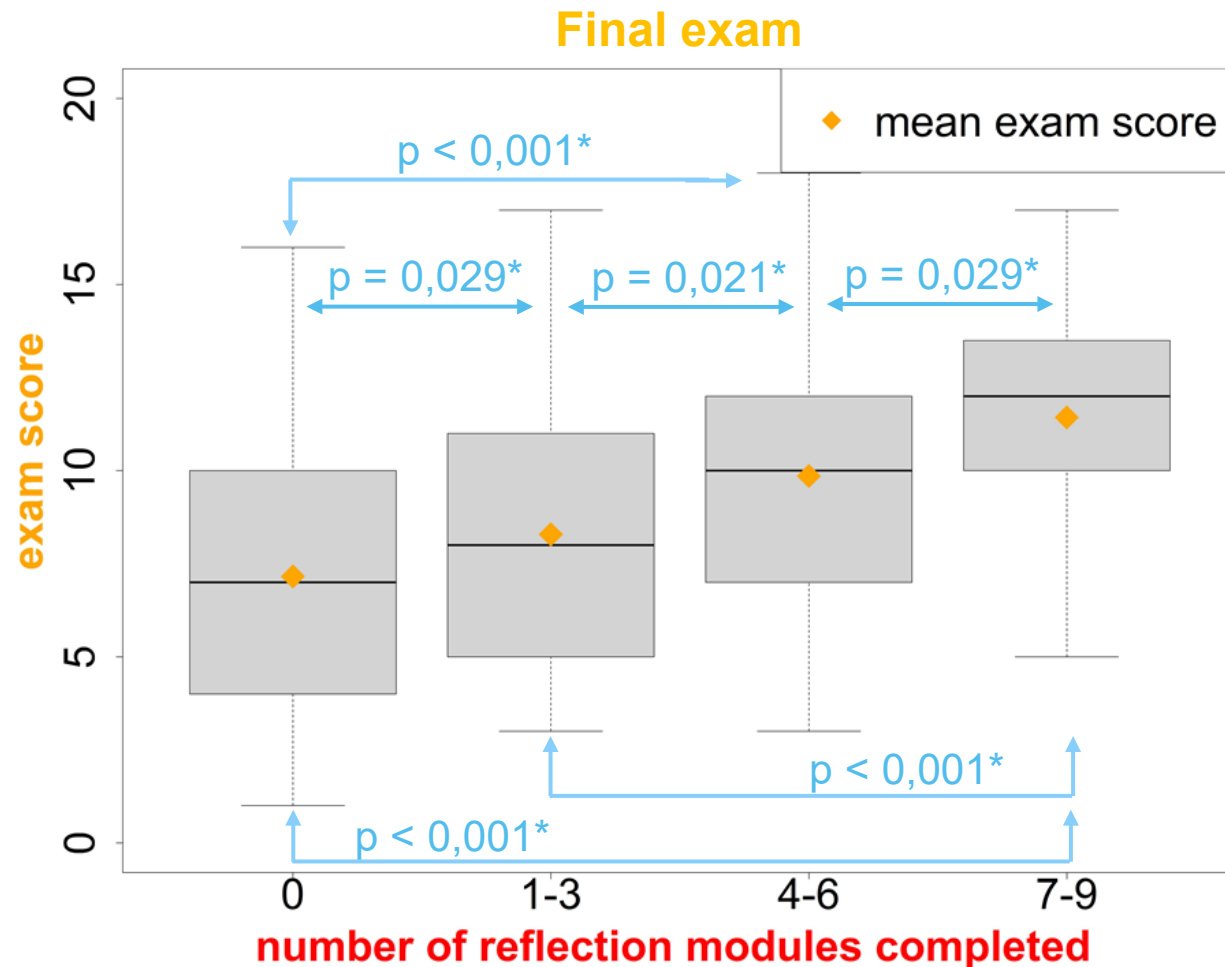
**RQ3.** How is students' **interaction with (a particular physics topic in) the DLC** related to their **strategic approach** to solve the corresponding exam problem?

# Design of study



**RQ1.** How is students' **interaction with the DLC** related to their **academic achievement**?

# Results - Interaction with DLC vs. academic achievement



→ Students that **interacted more with DLC** seem to obtain a **higher total exam score**

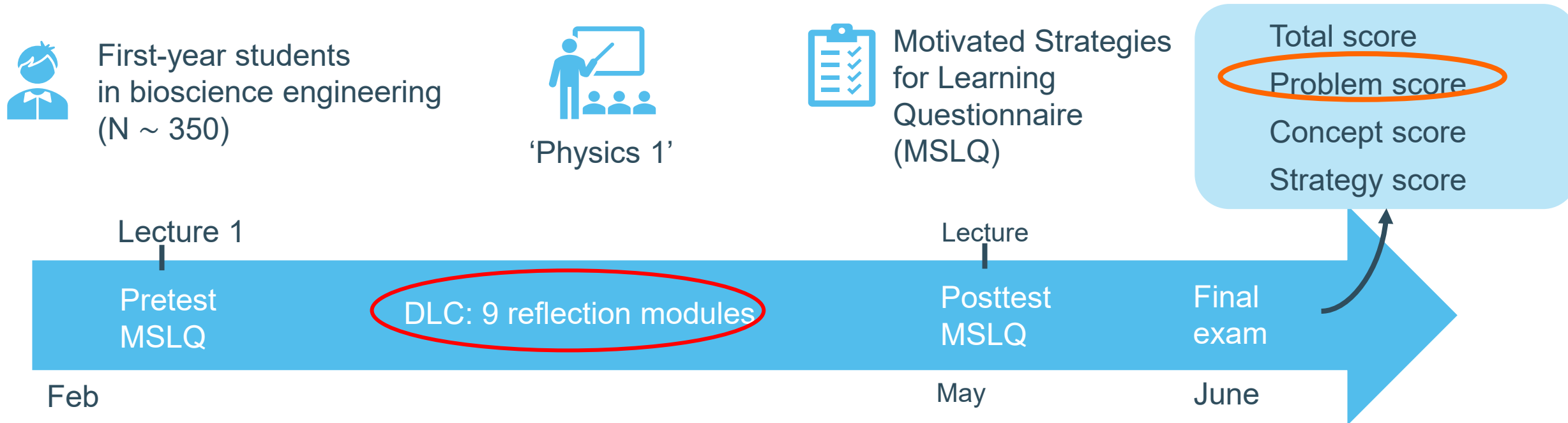
## Remark:

- Students that interacted more with DLC spend more time on studying/spend time more effectively?
- Improvement due to reflection on solving process or due to content of modules?

# Conclusion

**RQ1.** Positive relationship between **interaction with DLC** and **academic achievement**

# Design of study

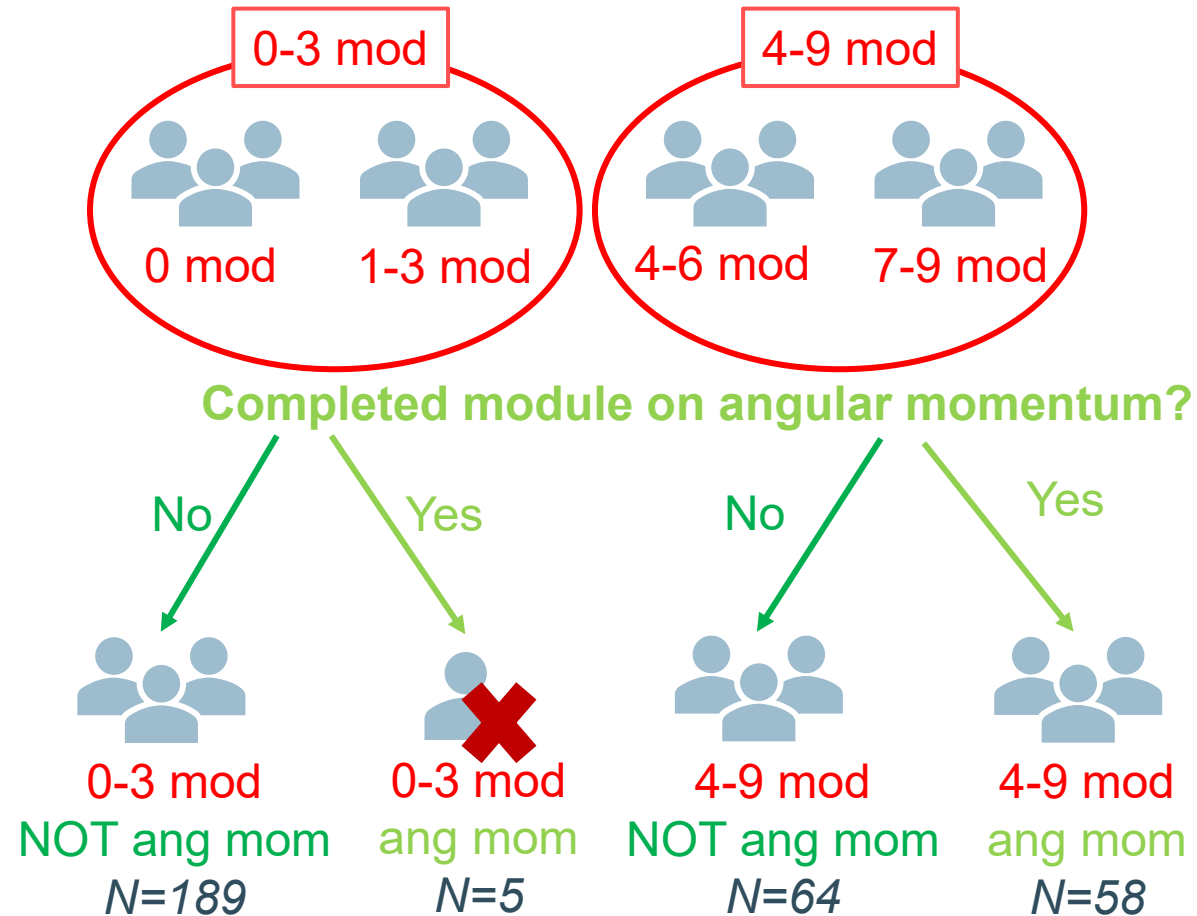


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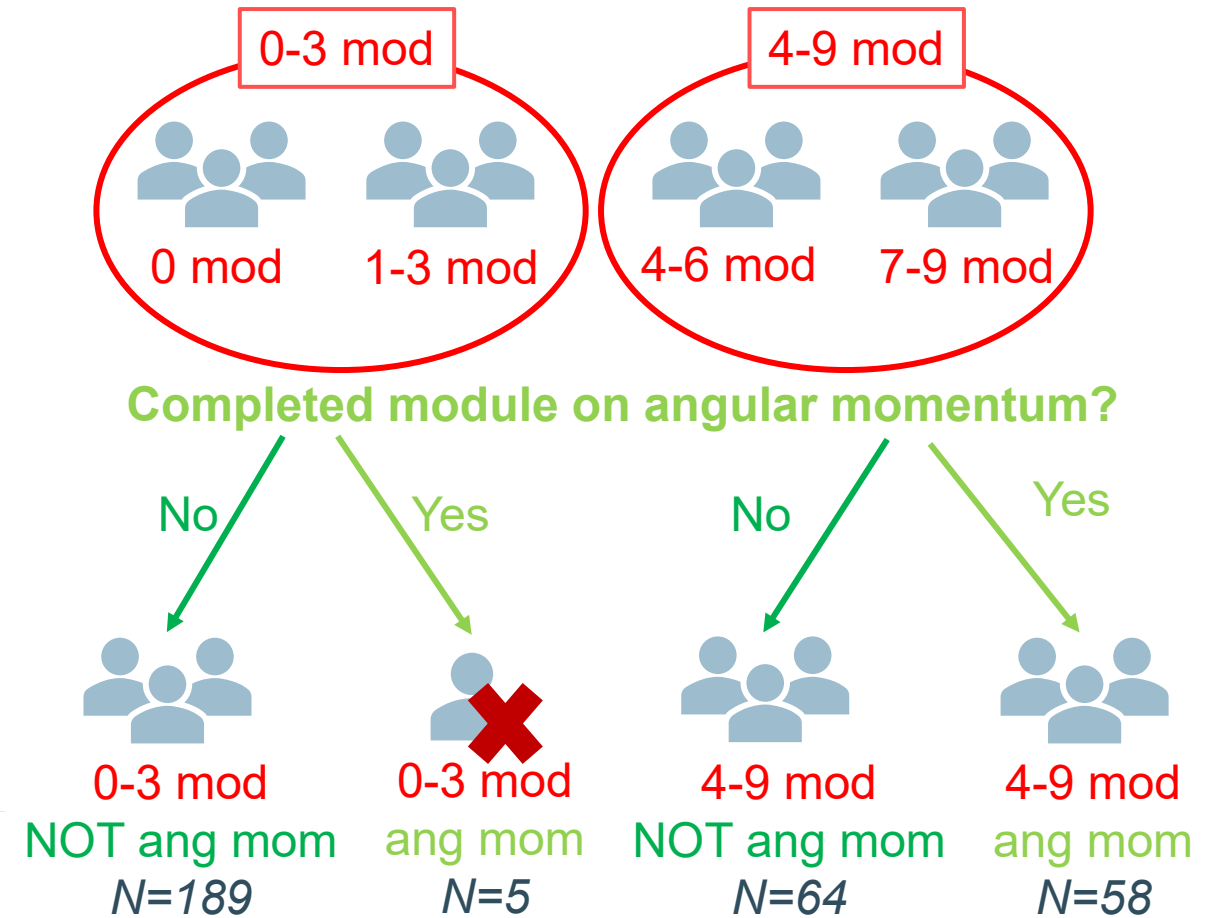
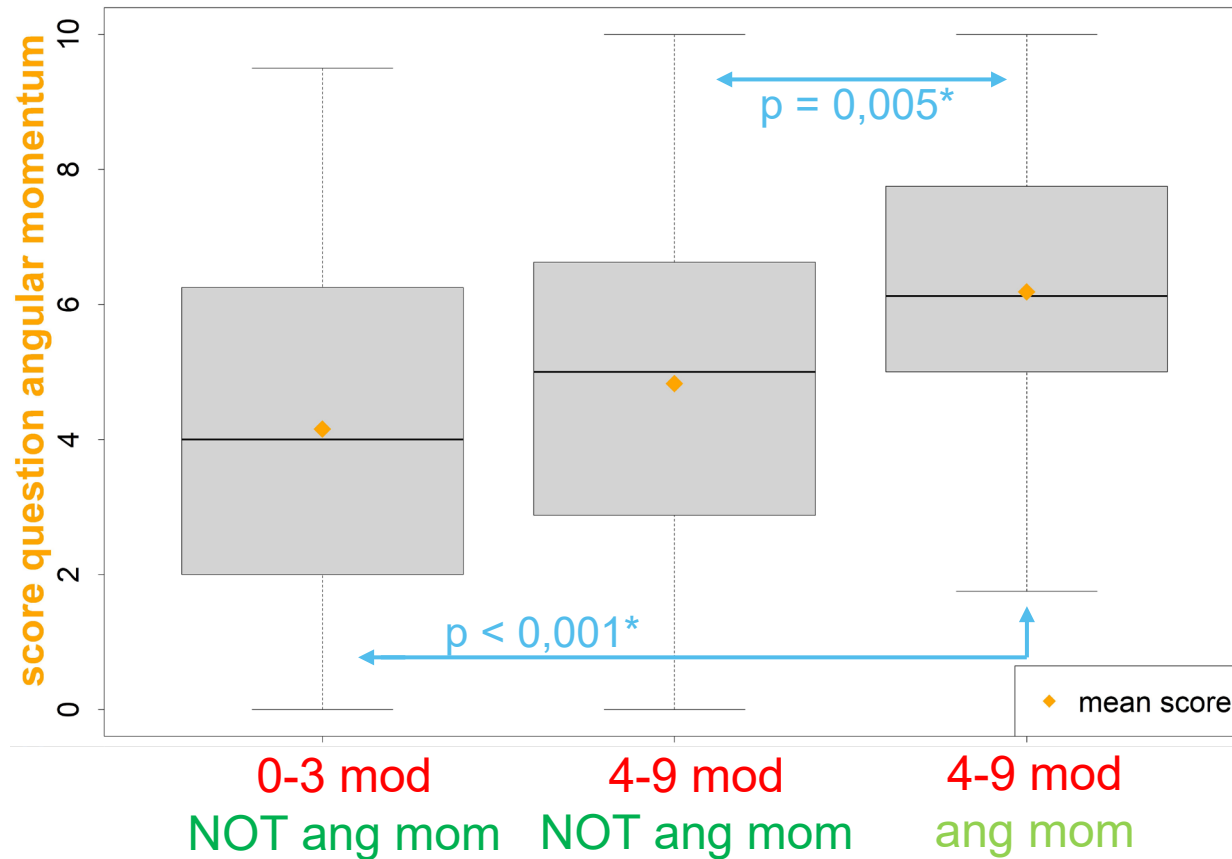
**RQ3.** How is students' **interaction with (a particular physics topic in) the DLC** related to their **strategic approach** to solve the corresponding exam problem?

# Results - Interaction with (particular physics topic in) DLC



# Results - Interaction with DLC vs. performance

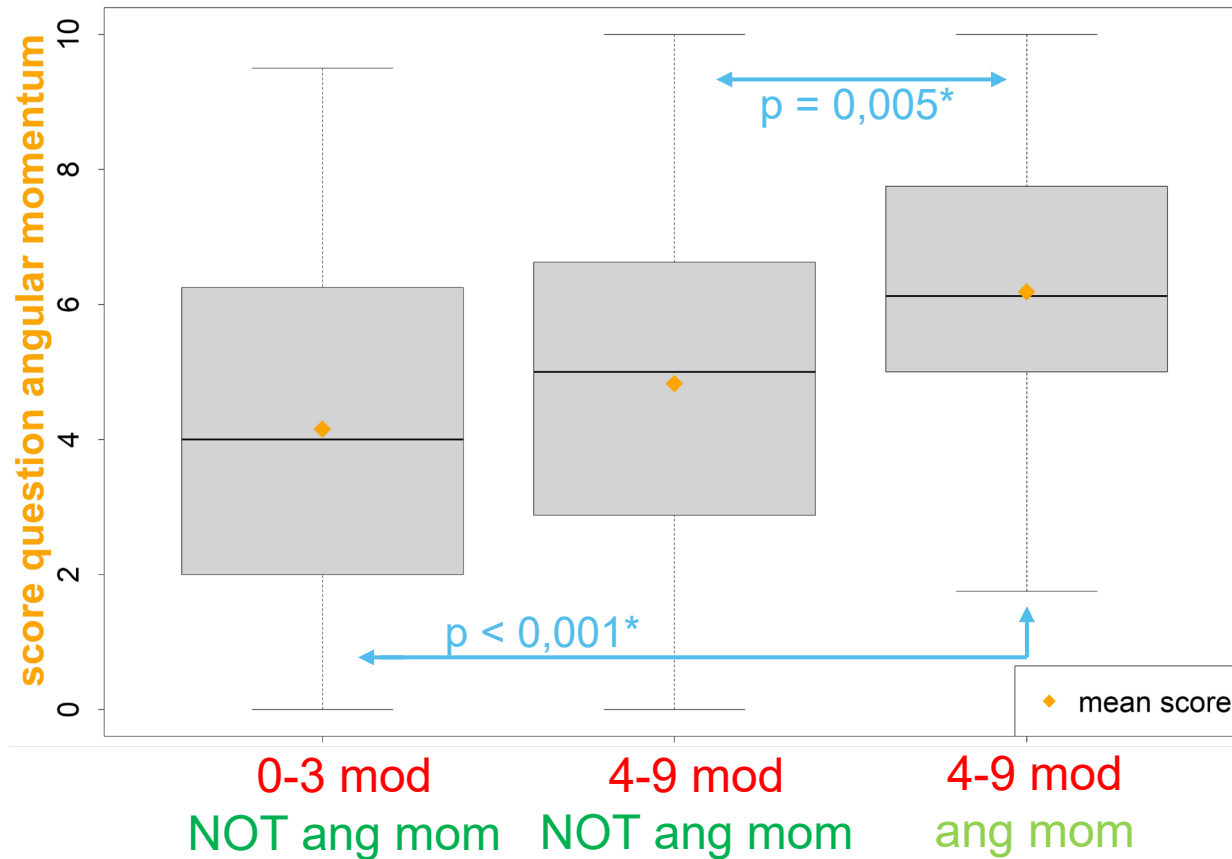
Exam problem on angular momentum





# Results - Interaction with DLC vs. performance

## Exam problem on angular momentum

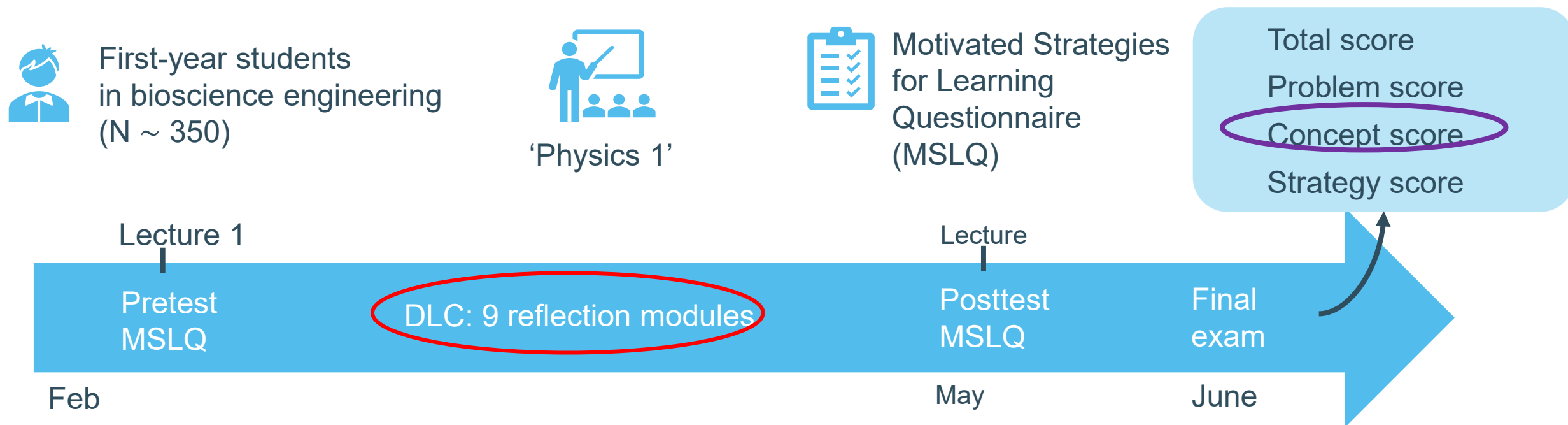


→ Content modules seems to play a role

**Remark:** modules helping to improve

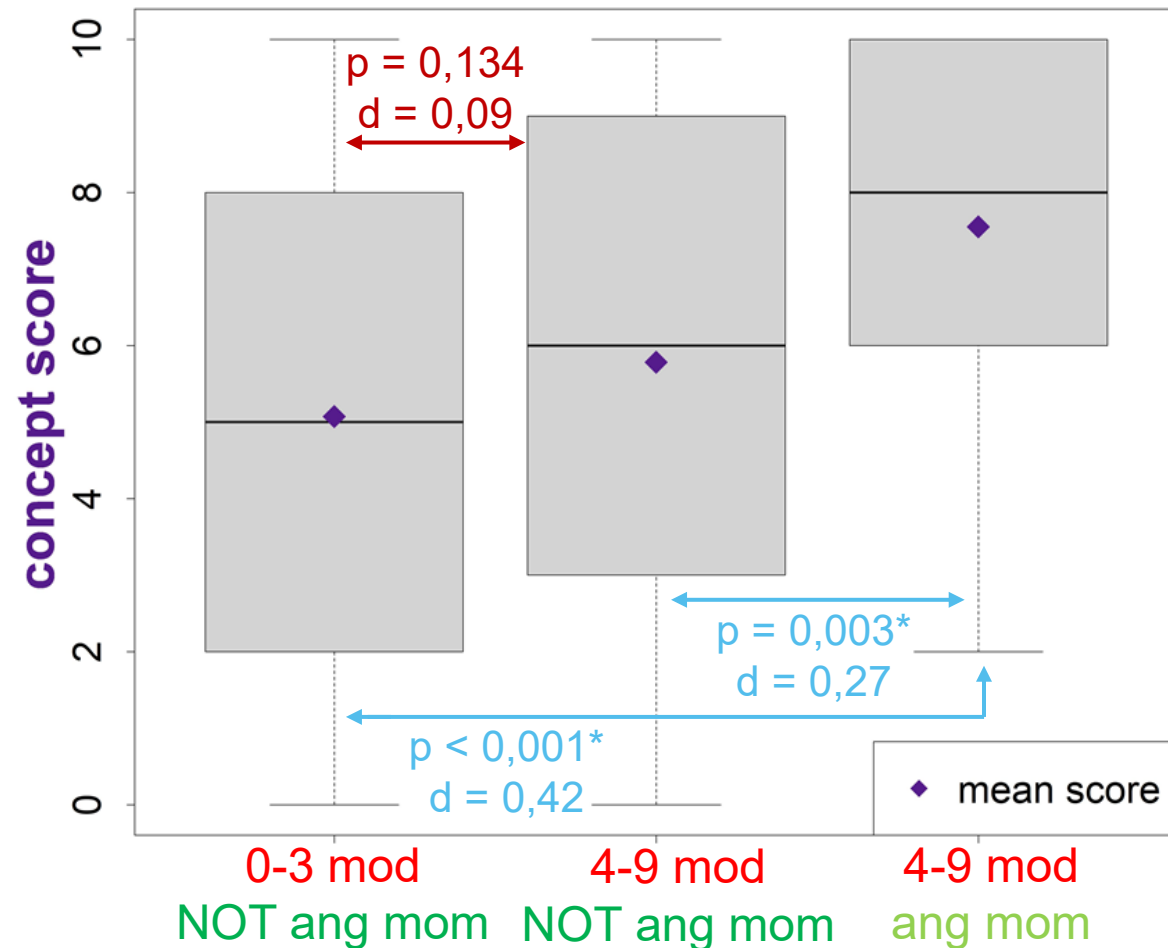
- conceptual understanding?
- problem solving skills?
- metacognitive abilities?

# Design of study



# Results – Interaction with DLC vs. conceptual understanding

exam problem on angular momentum



# Conclusion

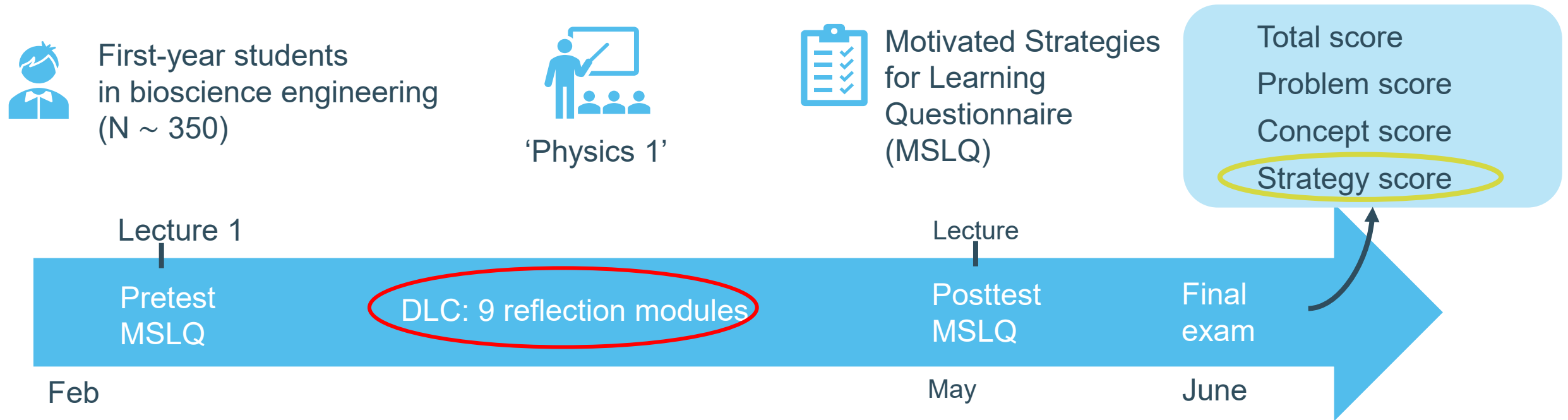
**RQ2.** Positive relationship between **interaction with DLC** and **academic achievement**

**RQ3.** Positive relationship between **interaction with (particular topic in) DLC** and **performance** on corresponding exam problem and **conceptual understanding** of this problem

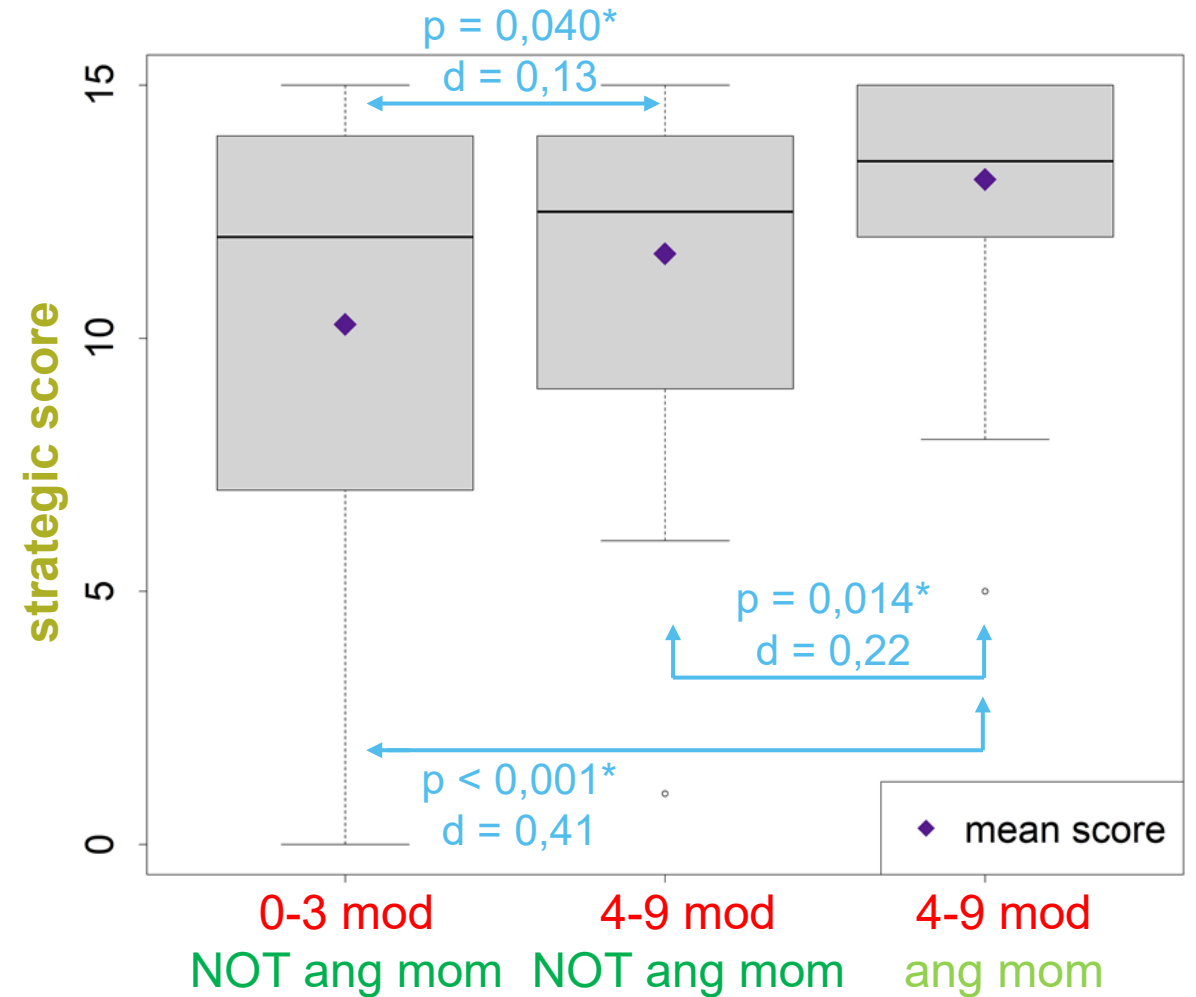
→ Content of module seems to play a role in

- improving academic achievement
- developing conceptual understanding

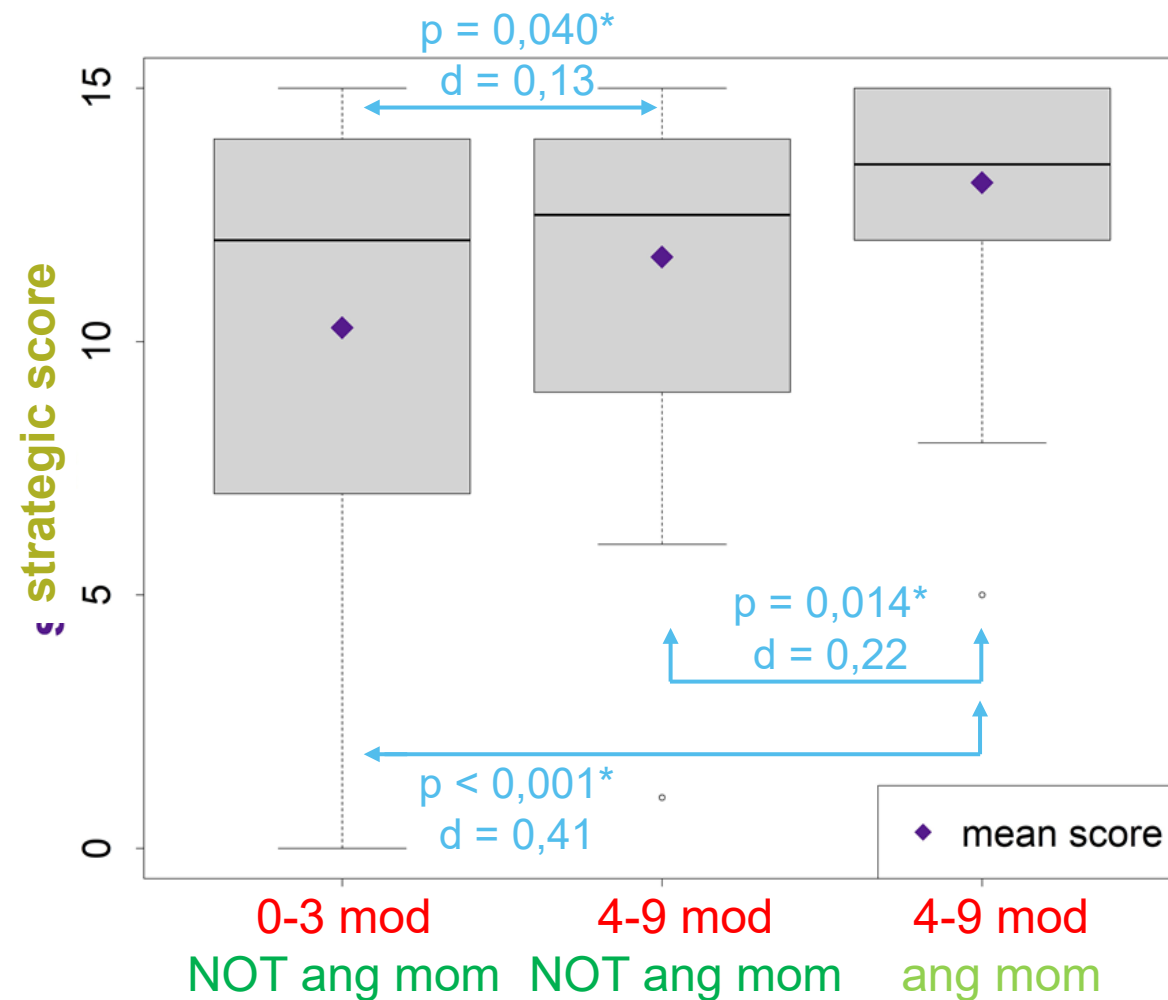
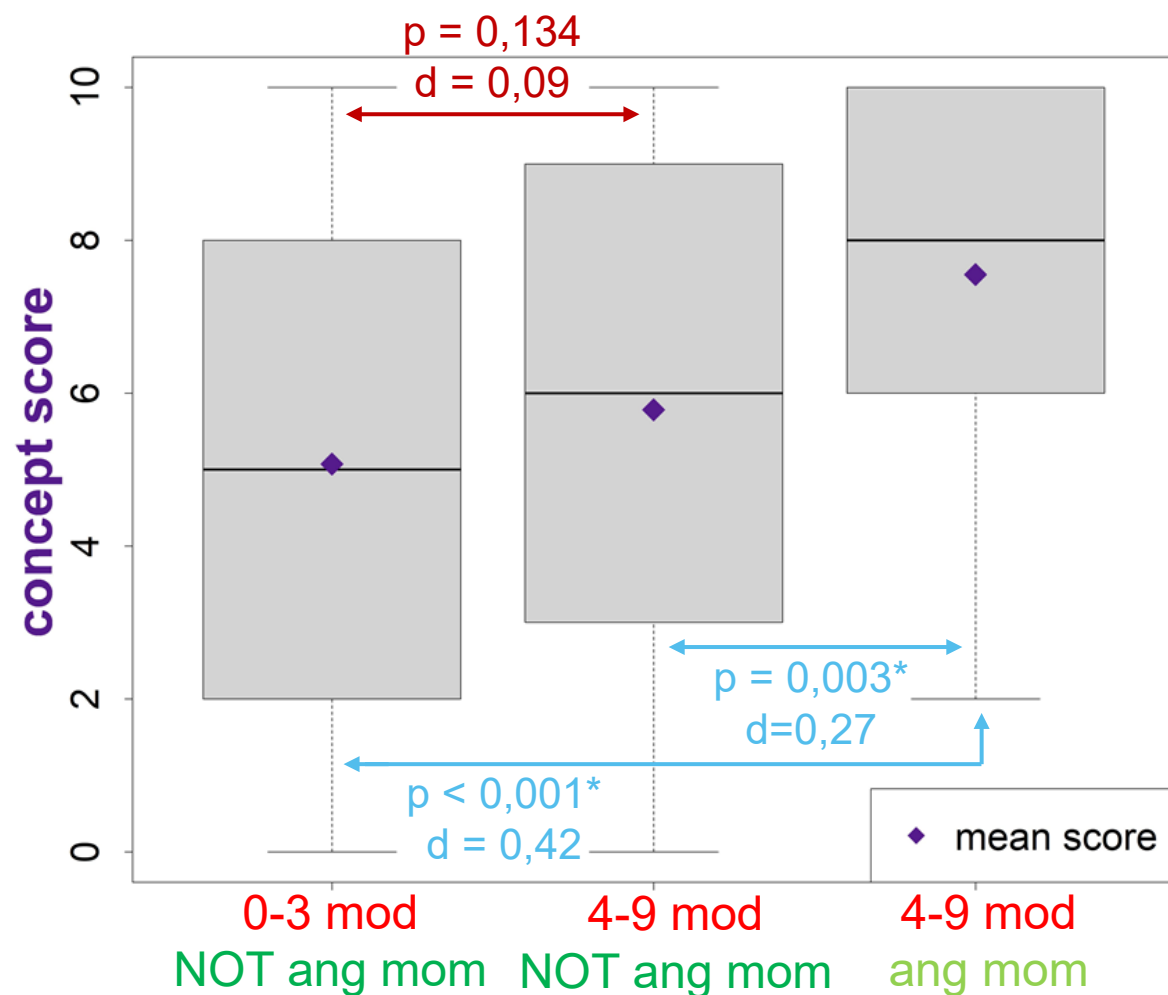
# Design of study



## Results – Interaction DLC vs. strategic approach



## Results – Interaction DLC vs. conceptual understanding + strategic approach





# Conclusion

**RQ2.** Positive relationship between **interaction with DLC** and **academic achievement**

**RQ3.** Positive relationship between **interaction with (particular topic in) DLC** and **performance** on corresponding exam problem and **conceptual understanding** of this problem

→ Content of module seems to play a role in

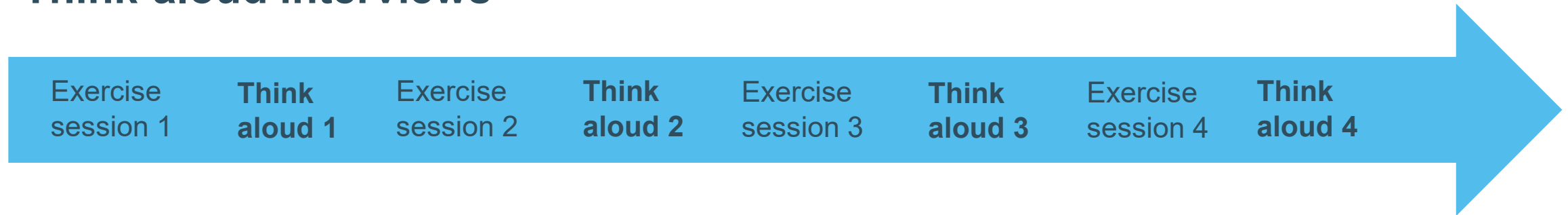
- improving academic achievement
- developing conceptual understanding

**RQ4.** Positive relationship between **interaction with (particular topic in) DLC** and **strategic approach** to solve corresponding exam problem

→ Content of module seems to be less important in development strategic approach

# Current work: qualitative study

## Think-aloud interviews



### Procedure of think-aloud interview

1. Student solves new problem
  - Does the student plan/monitor/control/evaluate the solving process and the solution?
  - How does the use of metacognitive activities evolve in time?
2. Student completes corresponding reflection module
  - Does the student adapt his/her solution based on feedback received?
  - Which (meta)cognitive activities are triggered? By which reflection questions/feedback?

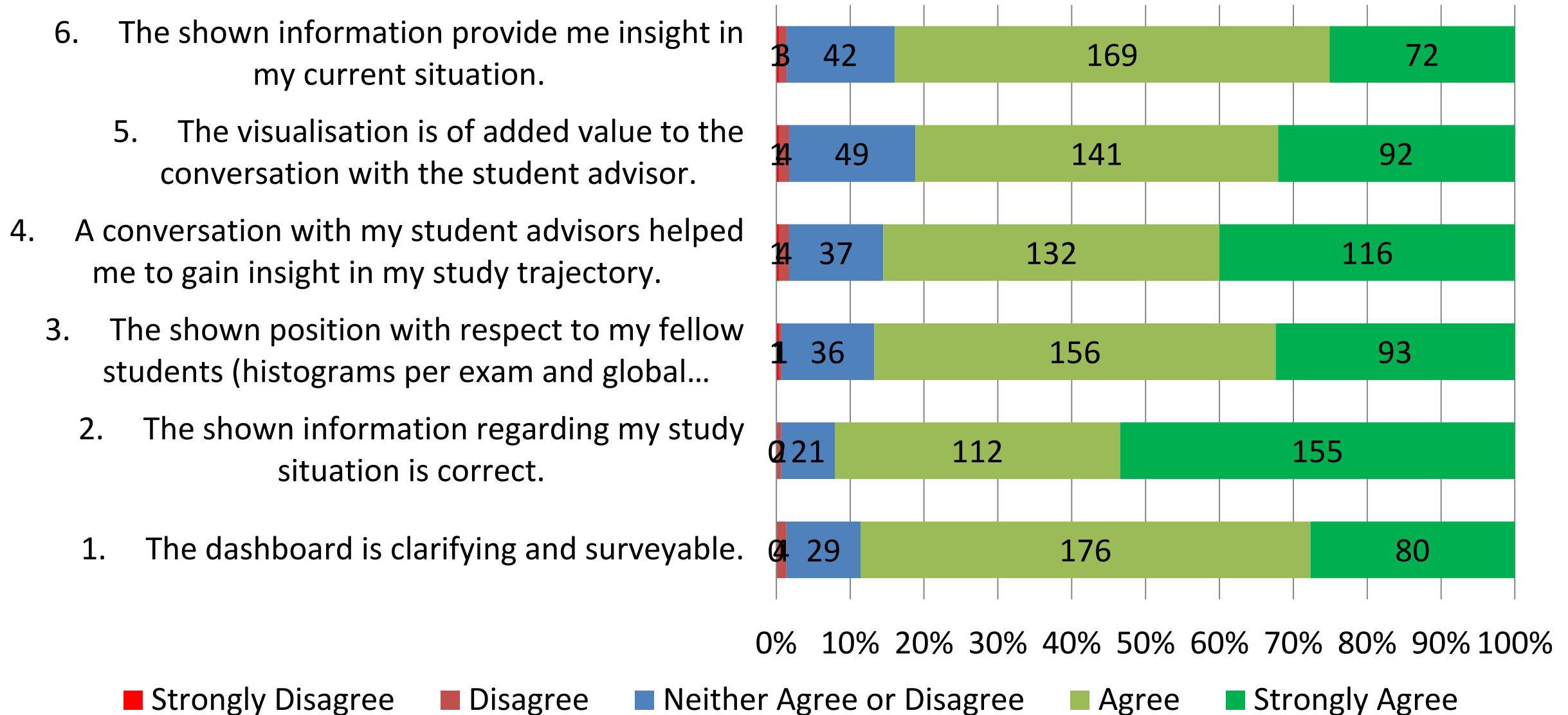
# So what have I shared with you today?

- Pragmatic view on Learning Analytics?
- Experience with interactive courseware
- Latest research on using reflection modules to stimulate metacognition.



Thank you!

## Student questionnaire (N=291)





### 3. Mathematical model

Were you able to translate Newton's second law into a set of equations?

The equations below are valid when you choose the  $x$ -axis to be horizontal and the  $y$ -axis to be vertical.

$$\vec{F}_{G_m} + \vec{F}_{N_m} = m\vec{a}$$

$$\Leftrightarrow \begin{cases} -F_{G_m} + F_{mM,y} = 0 \\ F_{mM,x} = ma \end{cases}$$

$$\Leftrightarrow \begin{cases} -mg + F_{mM} \cos \vartheta = 0 \\ F_{mM} \sin \vartheta = ma \end{cases}$$

- ☐ Yes.
- ☐ No, I did not use Newton's second law, hence I didn't translate this law into a set of equations.
- ☐ No, I forgot to take one or more (components of) forces into account.
- ☐ No, I did not take the direction and/or orientation of forces into account or made a mistake on this.
- ☐ No, I was not able to express one or more (components of) forces mathematically.
- ☐ No, I made another mistake.
- ☐ I don't know.



## 4. Computations

Were you able to solve the set of equations obtained by applying Newton's second law correctly?

### Solution:

$$a = g \tan \theta$$

$$F = (m + M)g \tan \theta$$

- ☐ Yes.
- ☐ No, I was not able to set up this set of equations, hence I was not able to solve it.
- ☐ No, I inserted the wrong values for the known quantities.
- ☐ No, I made a mistake on the rules for computations.
- ☐ No, I made another mistake.
- ☐ I don't know.





## 5. Interpretation

Which of the following methods did you apply to check your answer?

- ☐ I did not check my answer.
- ☐ Checking units.
- ☐ Checking whether the sign (positive or negative) of the result is reasonable.
- ☐ Considering limiting cases and checking whether my answer agrees with my expectations.
- ☐ I used another method to check my answer.
- ☐ I don't know.