

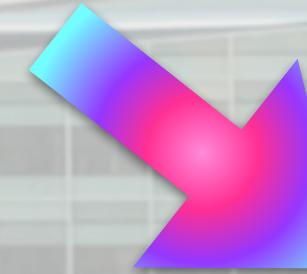
Aligning Student and Teacher Goals with Mastery Learning



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“Pedagogisk kvart”

9 oktober



Uppsala University Angström laboratoriet

Two Views of the Same Course



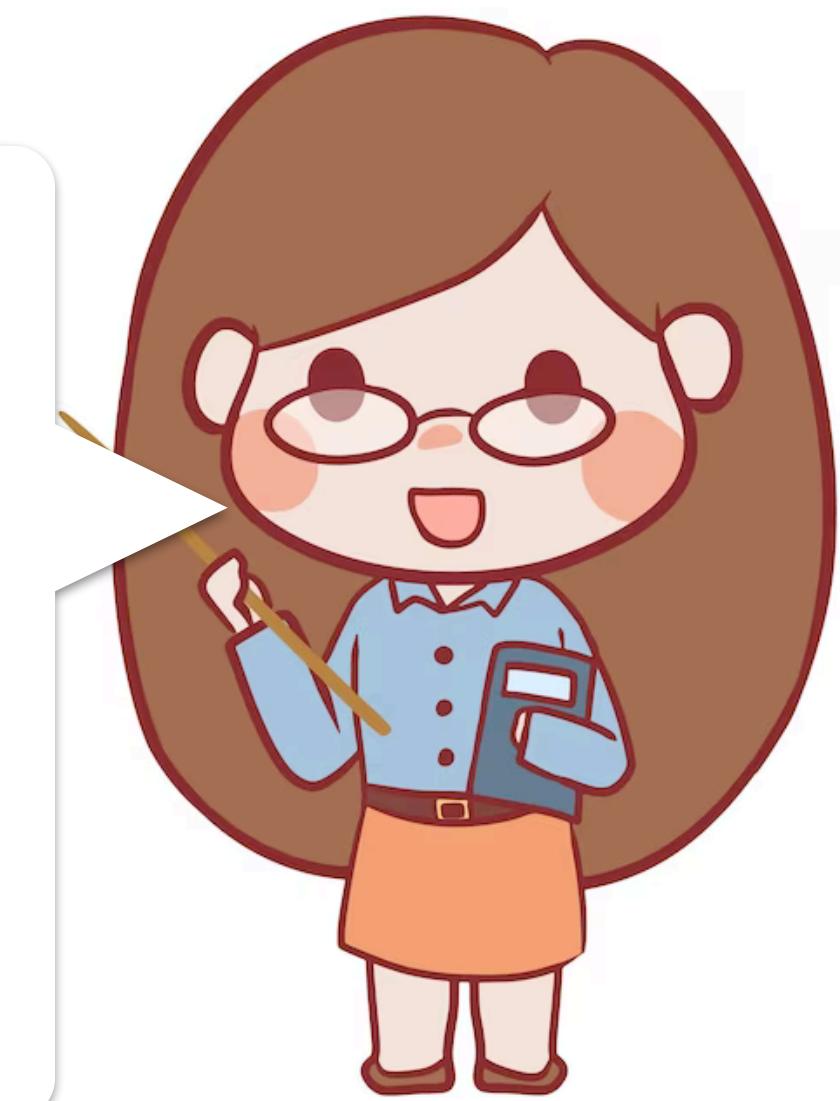
When I have done the assignments/exam I will have passed the course!

$$\sum_{n=1}^N x^n = x^1 + x^2 + \dots + x^N$$

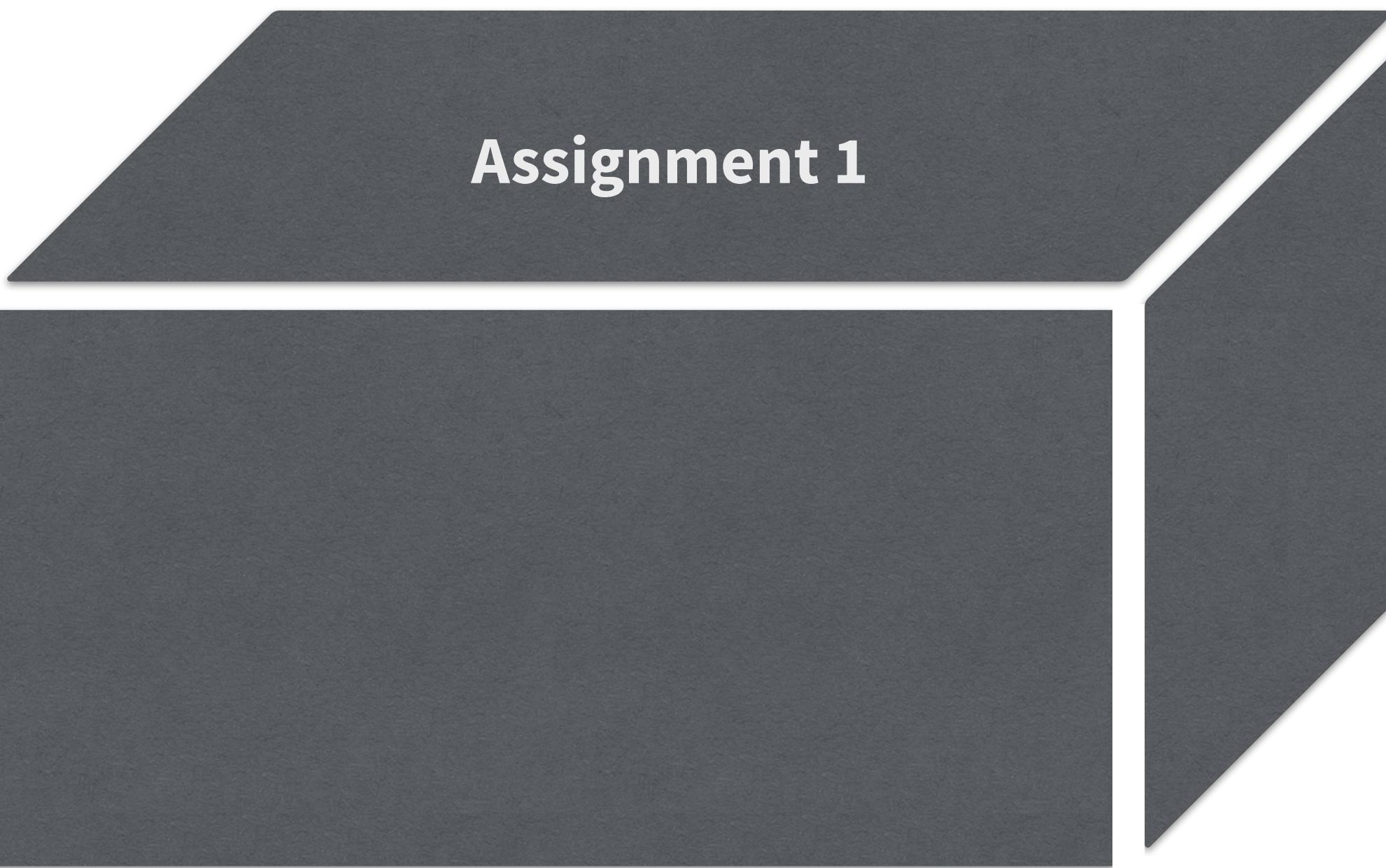
Homework due

When the student has passed my course, they will understand:

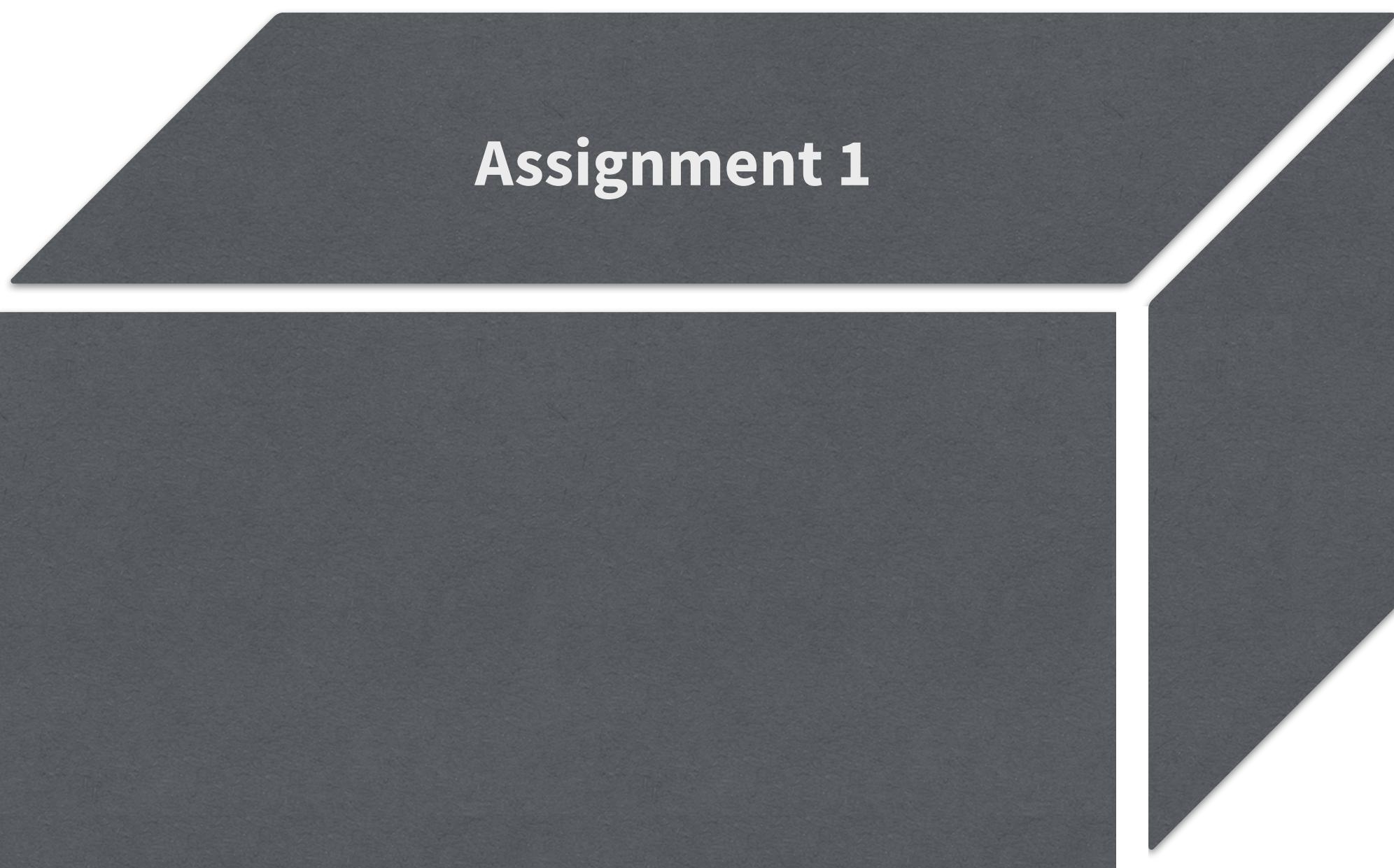
- * Learning outcome A
- * Learning outcome B
- * Learning outcome C
- * ...



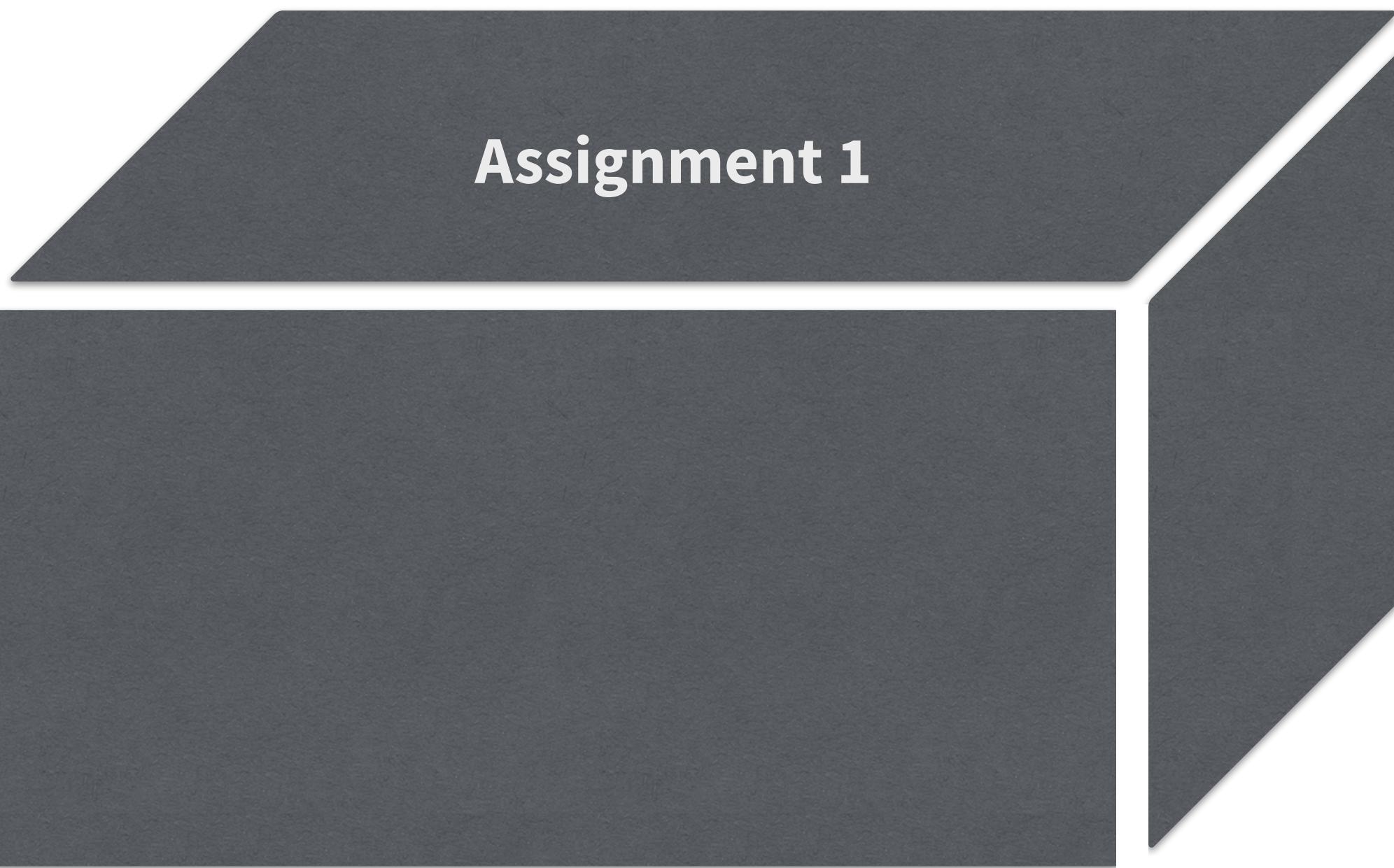
Assessment is Often a Black Box



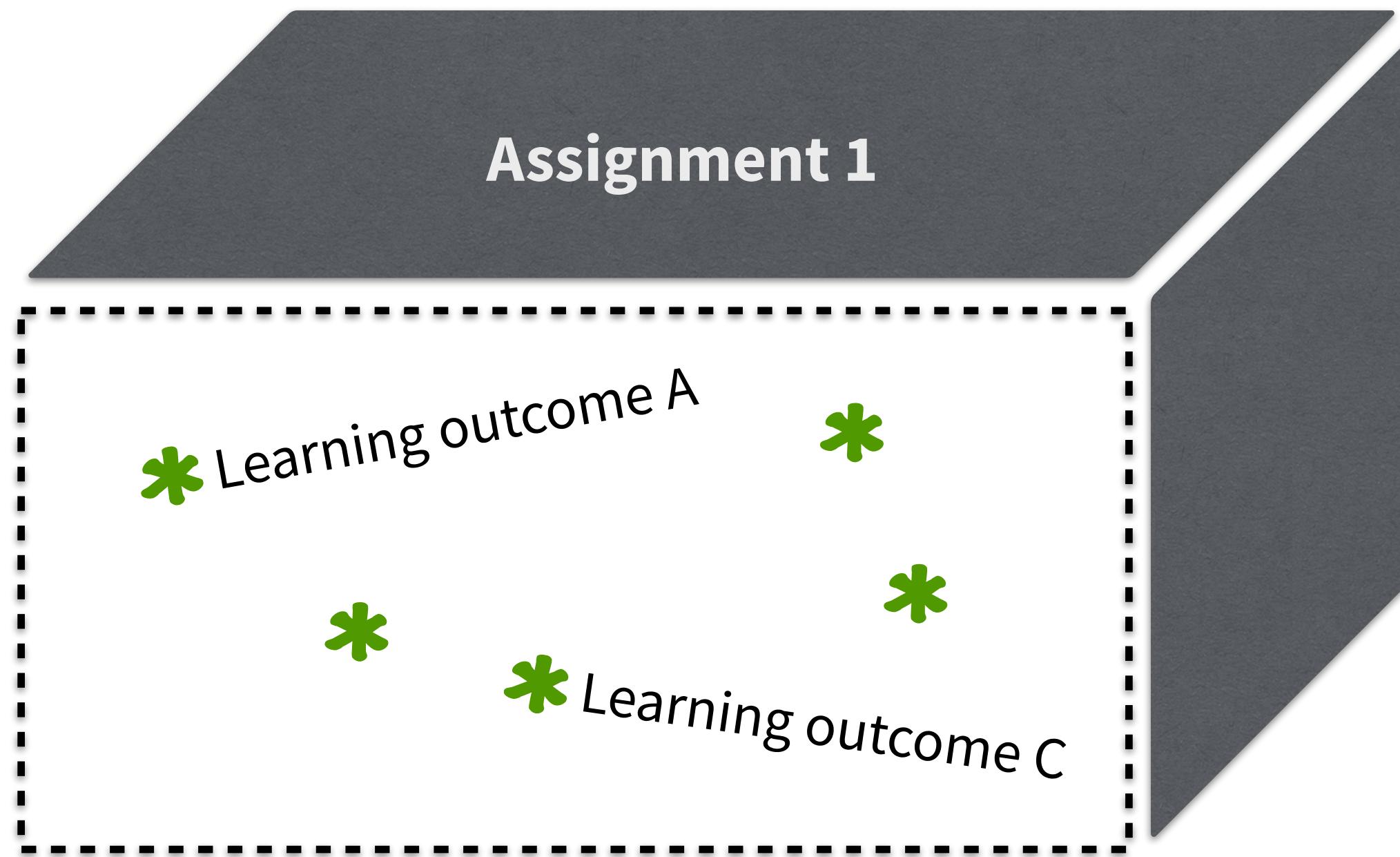
Assessment is Often a Black Box



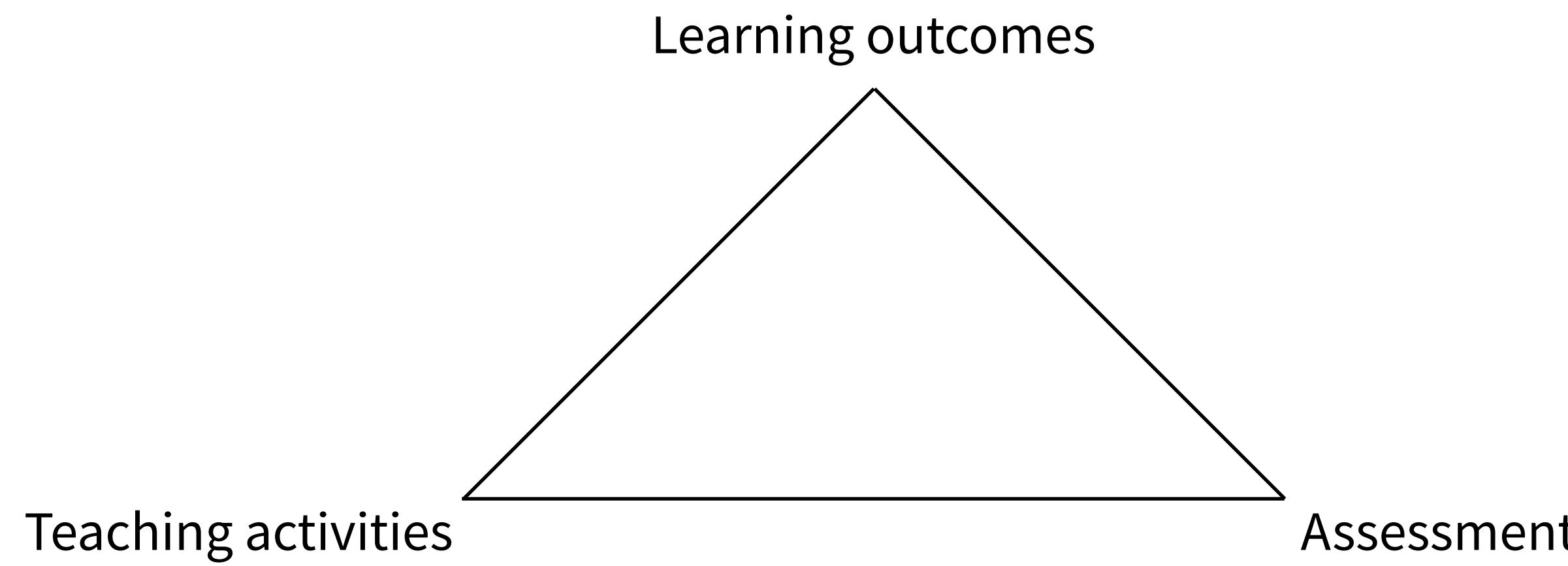
Assessment is Often a Black Box



Assessment is Often a Black Box



Constructive Alignment





~~60~~ 10 Years Ago...

- In 2013 we redesigned the course Imperative and Object-Oriented Programming Methodology with the following goals:
 - Have students take responsibility for their own learning
 - Move focus from “this program does the right thing” to the concepts we want to teach
 - Promote a more holistic view of the course material

Mastery Learning [Bloom 1968]

(maybe actually Competency Learning...?)

Our Implementation of Mastery Learning (applied since 2013)

- Start from the formal course goals and break it down into smaller “achievements” to be demonstrated by the students

Each achievement is tied to a grade (3/4/5)

Students get a grade when *all* achievements for that level and down have to be successfully demonstrated

After passing the course, the student should be able to:

* Explain how a program executes and stores information

Achievement F13 (grade 3):
Understand the difference between iteration and recursion

Achievement J26 (grade 3):
Understand the difference between heap and stack memory

Achievement J28: (grade 4)
Explain the difference between manual and automatic memory management

- Students can book demonstrations regularly during the course and demonstrate the achievements **in any order**

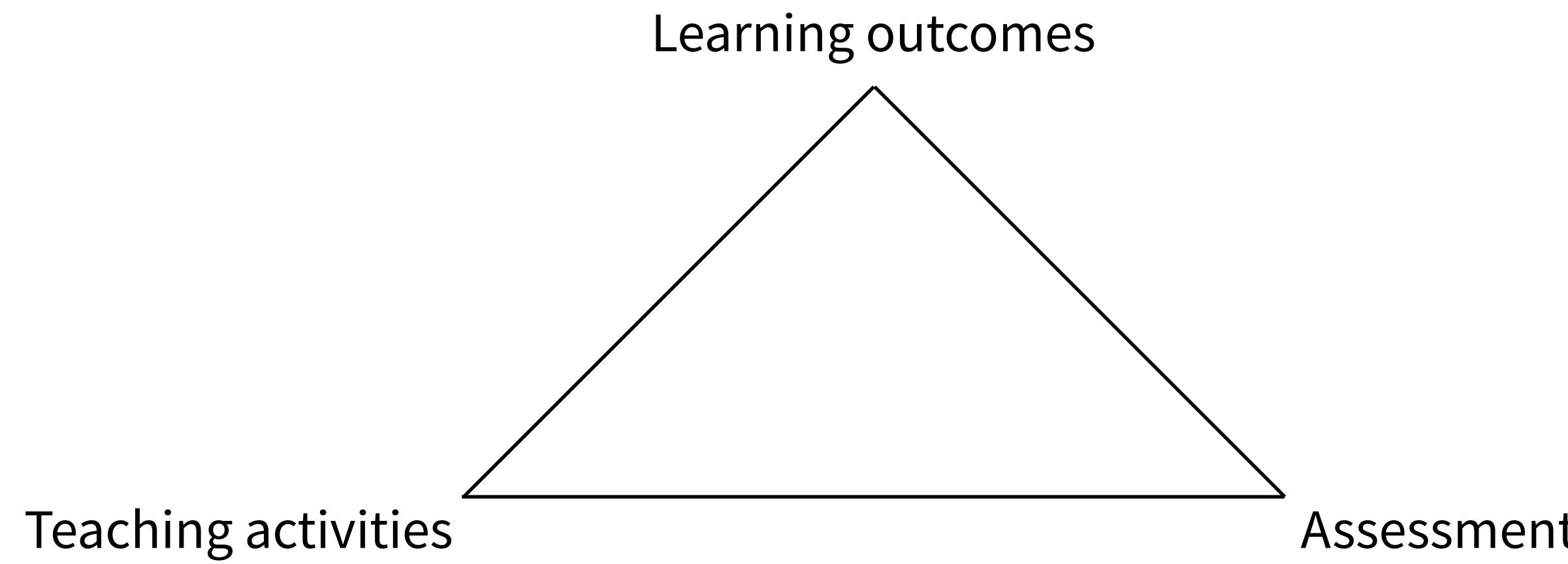
Each presentation is **pass/fail**

Failed demonstrations are neither punished nor recorded

“Any” number of tries (bounded by resources)



Constructive Alignment



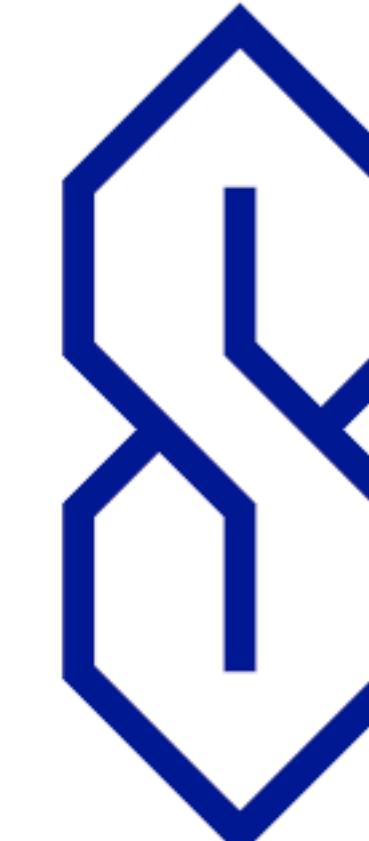
EXTREME

Constructive Alignment

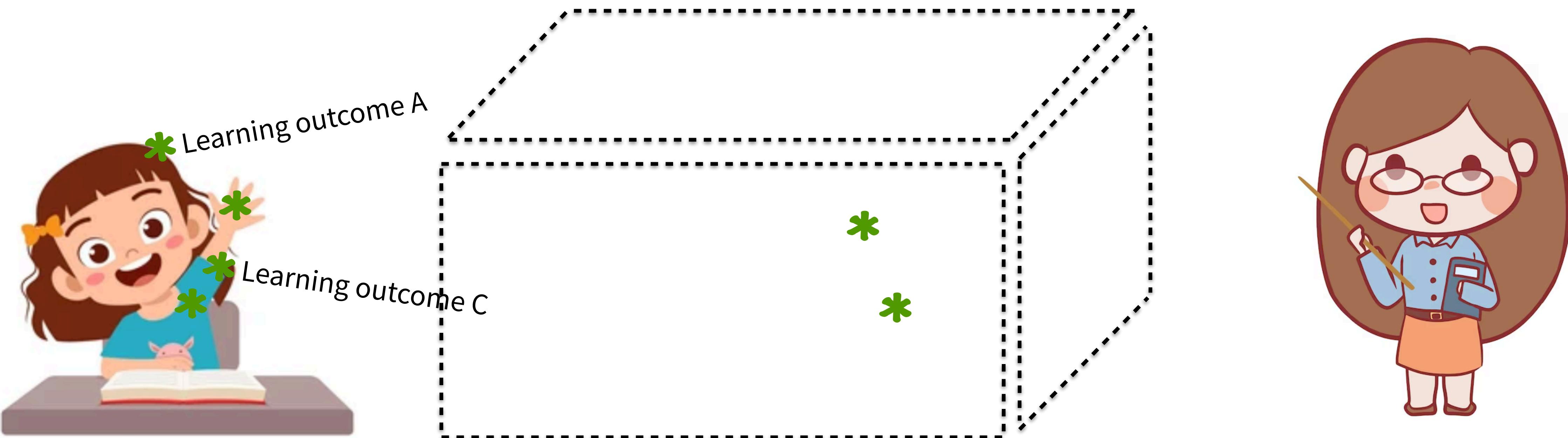
Learning outcomes



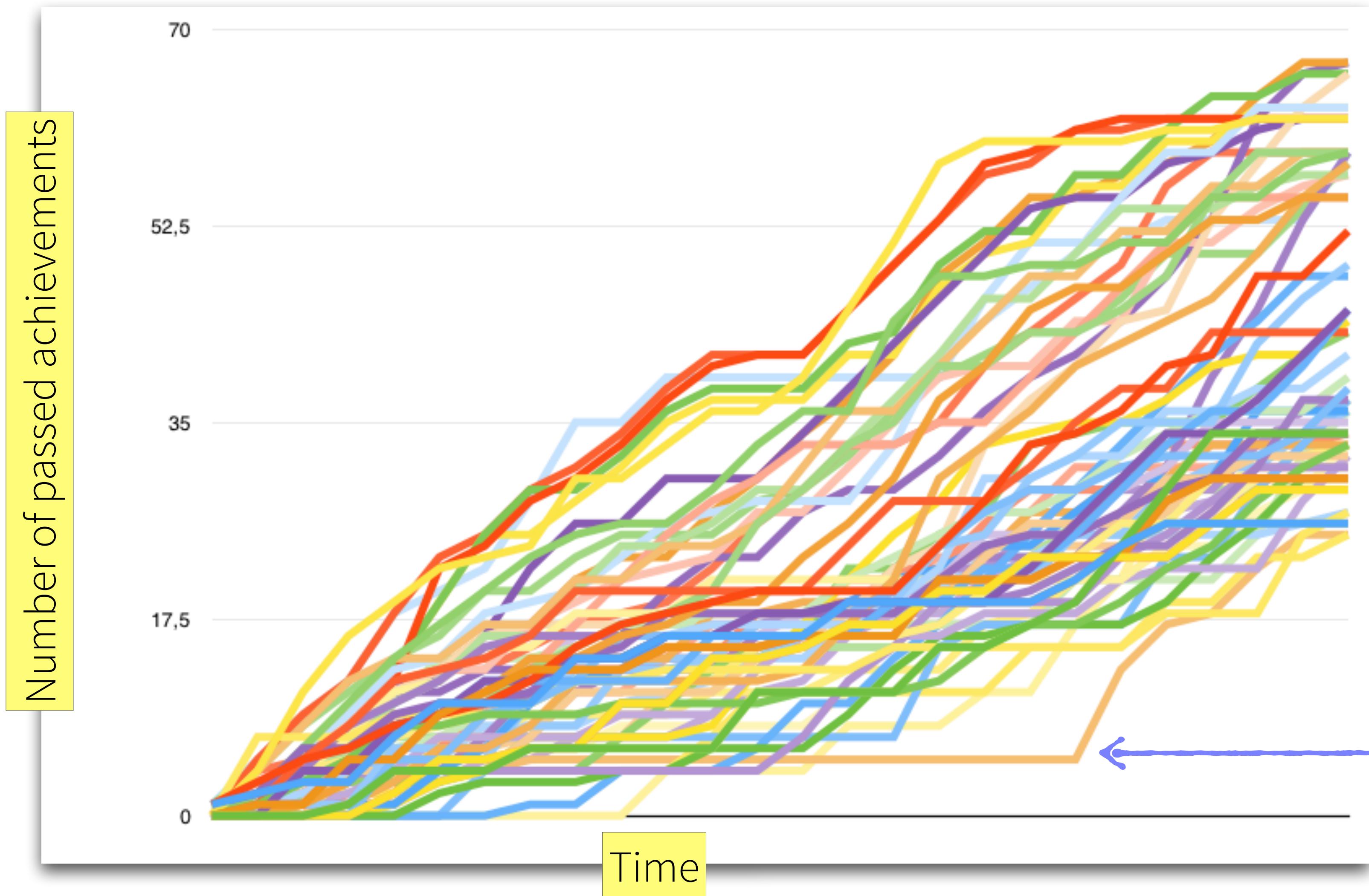
Teaching activities Assessment



Assessment is Explicitly of the Learning Outcomes



Progress is Quantifiable for Students and Teachers



Progress tracking lets us find
and help this student in time

Perspectives

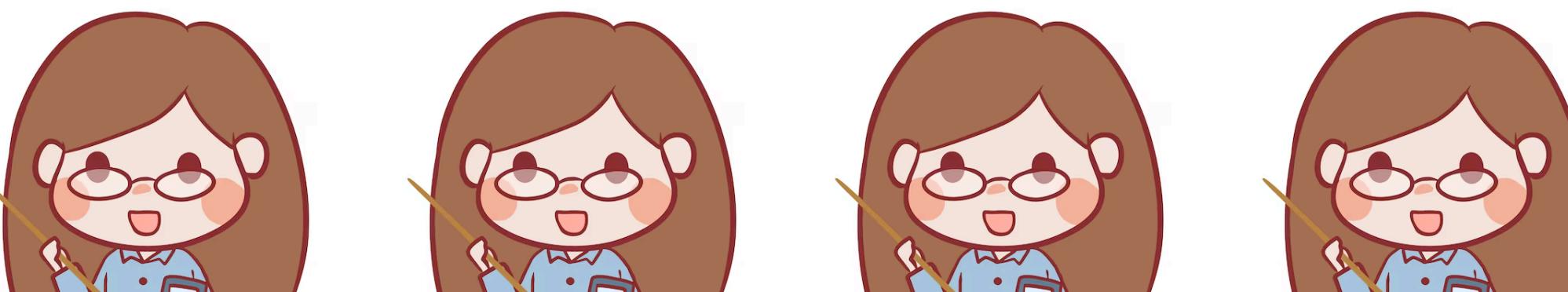
- Students appreciate the freedom and feel like they learn a lot



- Teachers can focus on concepts rather than, e.g., solving model assignments



- Teaching assistants enjoy the varied work (“anything can happen”)



Courses using Achievement-Based Mastery Learning

- The department has applied this system in courses of different sizes
 - Imperative and Object-Oriented Programming Methodology (20hp, 120–140 students)
10hp achievements + 5hp coding exams + 5hp project
 - Advanced Software Design (5hp, 80–100) **5hp achievements**
 - Semantics of Programming Languages (5hp, 30–40 students) **5hp achievements**
- The same approach has been applied at the University of Lugano and the University of British Columbia



Things that we have Learned

- Assignments are still necessary!
 - There needs to be a meaningful context for the demonstration of achievements
- Constrained resources (in terms of demonstration opportunities) is a source of synergy
 - Demonstrating achievements together creates connections between concepts
- For courses with large numbers of achievements and students, software support is vital
 - During the last instance of IOOPM (130) students, over 5000 individual achievements were demonstrated!

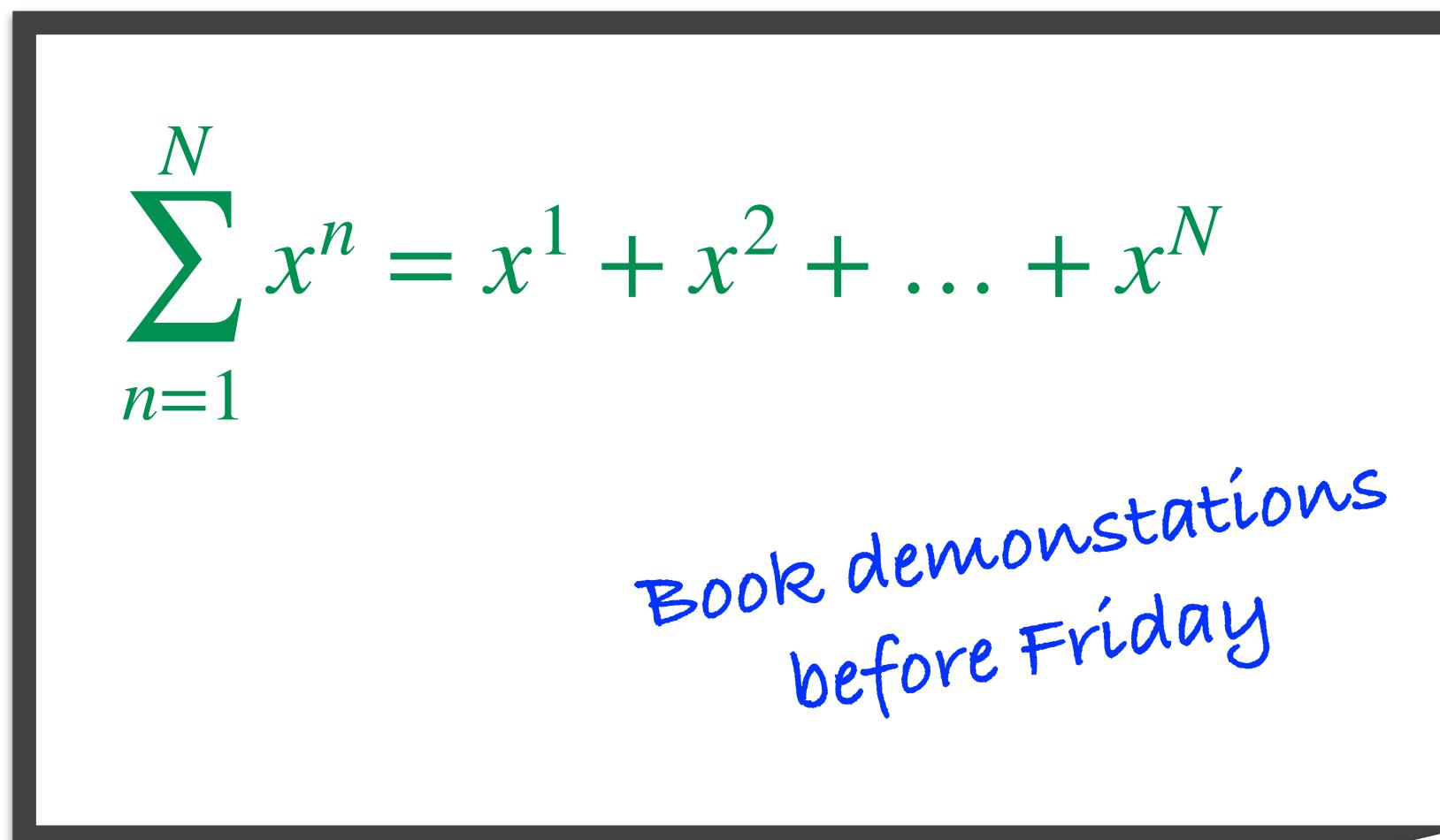
See <https://bubify.github.io>

Parameters

- The two biggest parameters are **the number of achievements** and **the number of demonstration opportunities**

	Achievements	no. Opportunities	Course staff
IOOPM 20hp, 130 students	$30+16+8 = 54$	27 lab sessions	2 teachers + ~20 TAs
Design 5hp, 90 students	$11+9+1 = 21$	8 group sessions	1 teacher + 3 TAs
Semantics 5hp, 40 students	$8+5+4 = 17$	8 bookable sessions	1 teacher + 1 TA

An Aligned View of Learning



In order to pass the course, students need to demonstrate:

- * Learning outcome A
- * Learning outcome B
- * Learning outcome C
- * ...



Would you Like to Know More?

- Feel free to reach out if you want to talk!

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TODO: QR-code for these slides

- Related papers:

Mastery Learning-Like Teaching with Achievements

(Tobias Wrigstad, Elias Castegren), SPLASH-E '17

The Impact of Opt-in Gamification on Students' Grades in a Software Design Course

(Kiko Fernandez-Reyes, Dave Clarke, Janina Hornbach), MODELS'18

Teaching Software Construction at Scale with Mastery Learning: a Case Study

(Elisa Baniassad, Alice Campbell, Tiara Allidina, Asrai Ord), ICSE-SEET'19