

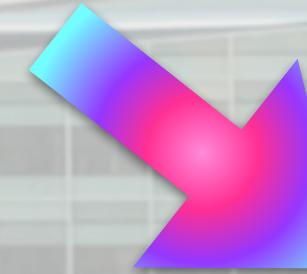
Aligning Student and Teacher Goals with Mastery Learning



Elias Castegren (elias.castegren@it.uu.se)

“Pedagogisk kvart”

9 oktober



Uppsala University Angström laboratoriet

Two Views of the Same Course



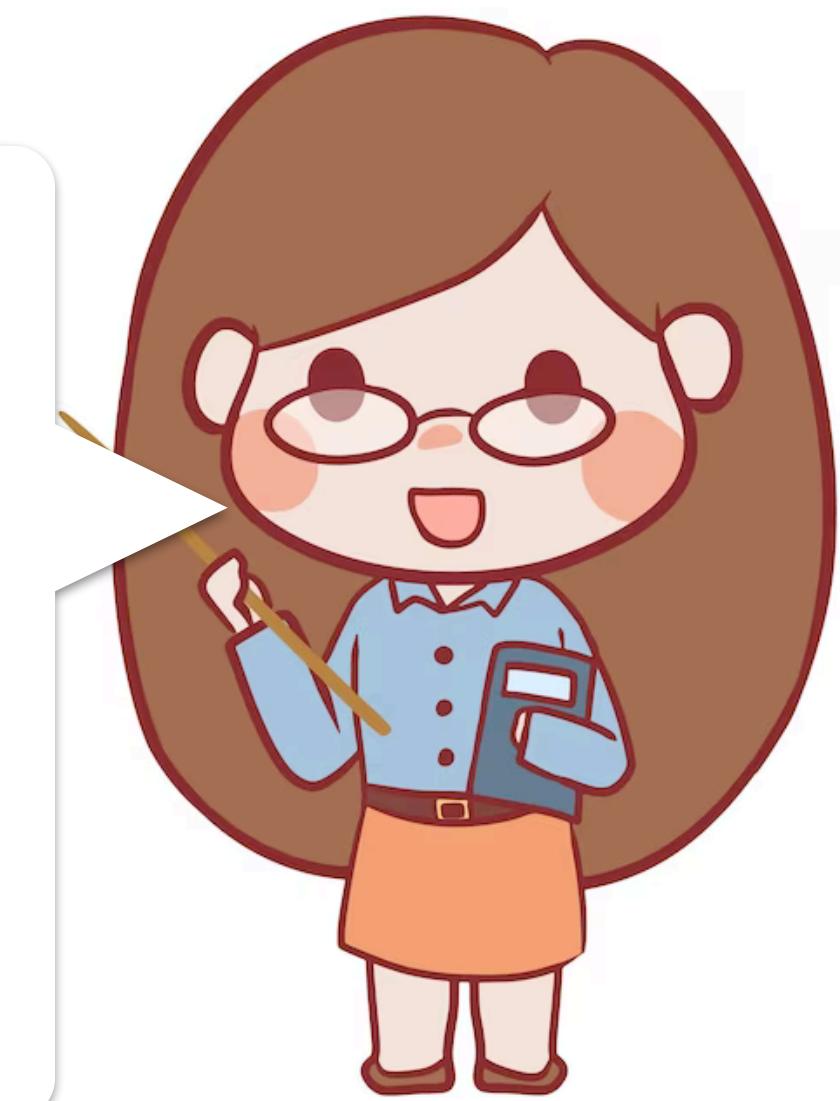
When I have done the assignments/exam I will have passed the course!

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

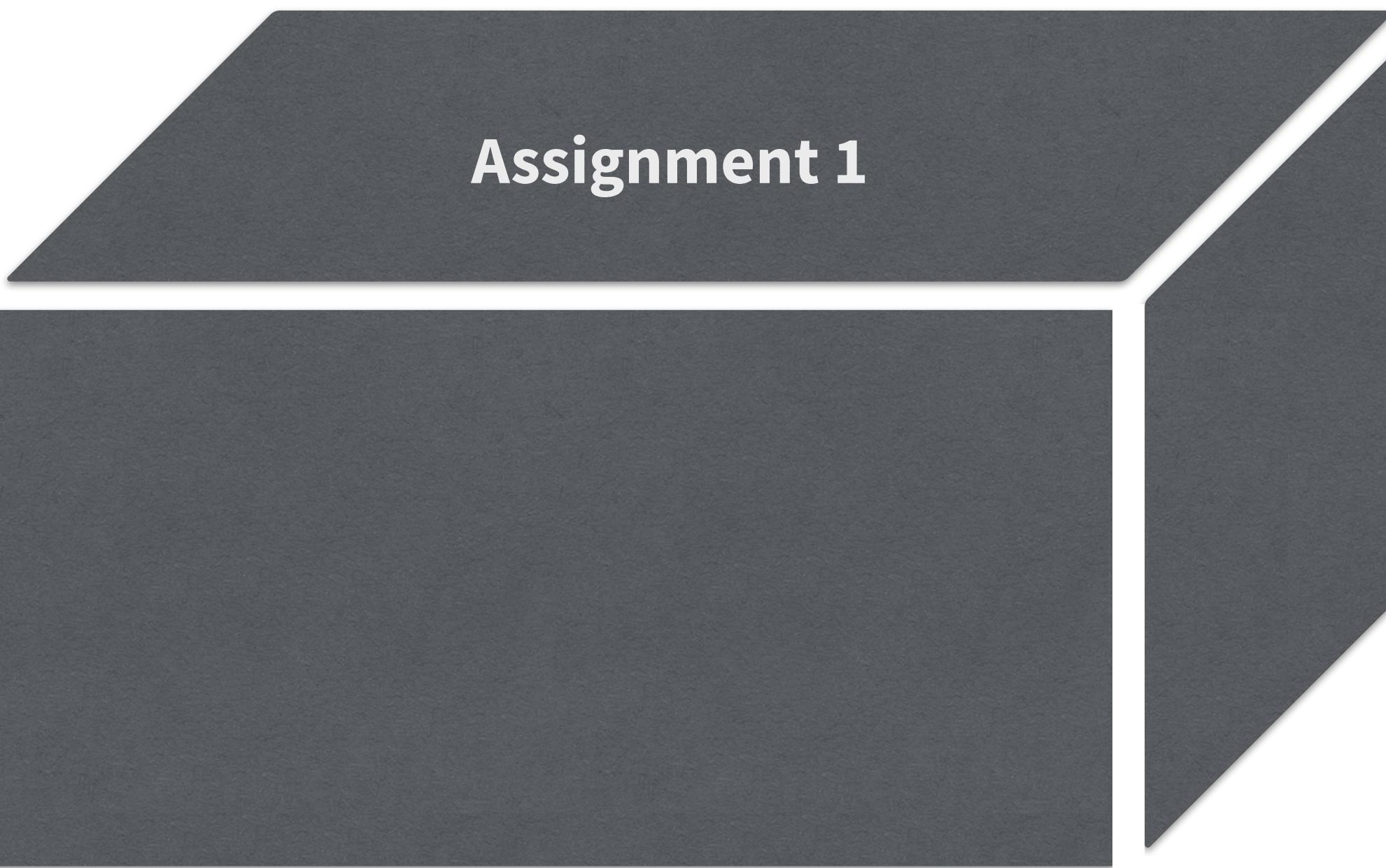
Homework due

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

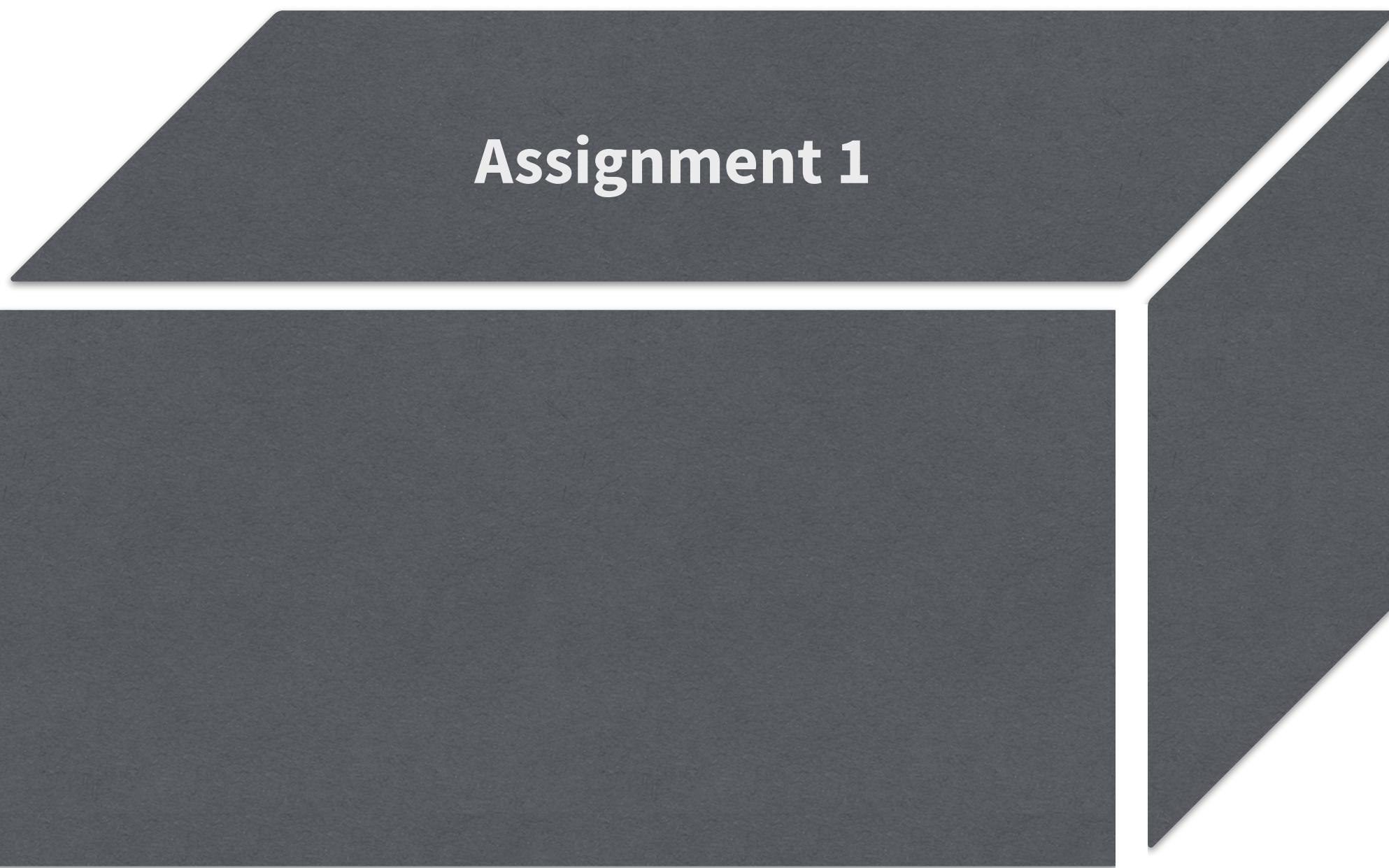
- * Learning outcome A
- * Learning outcome B
- * Learning outcome C
- * ...



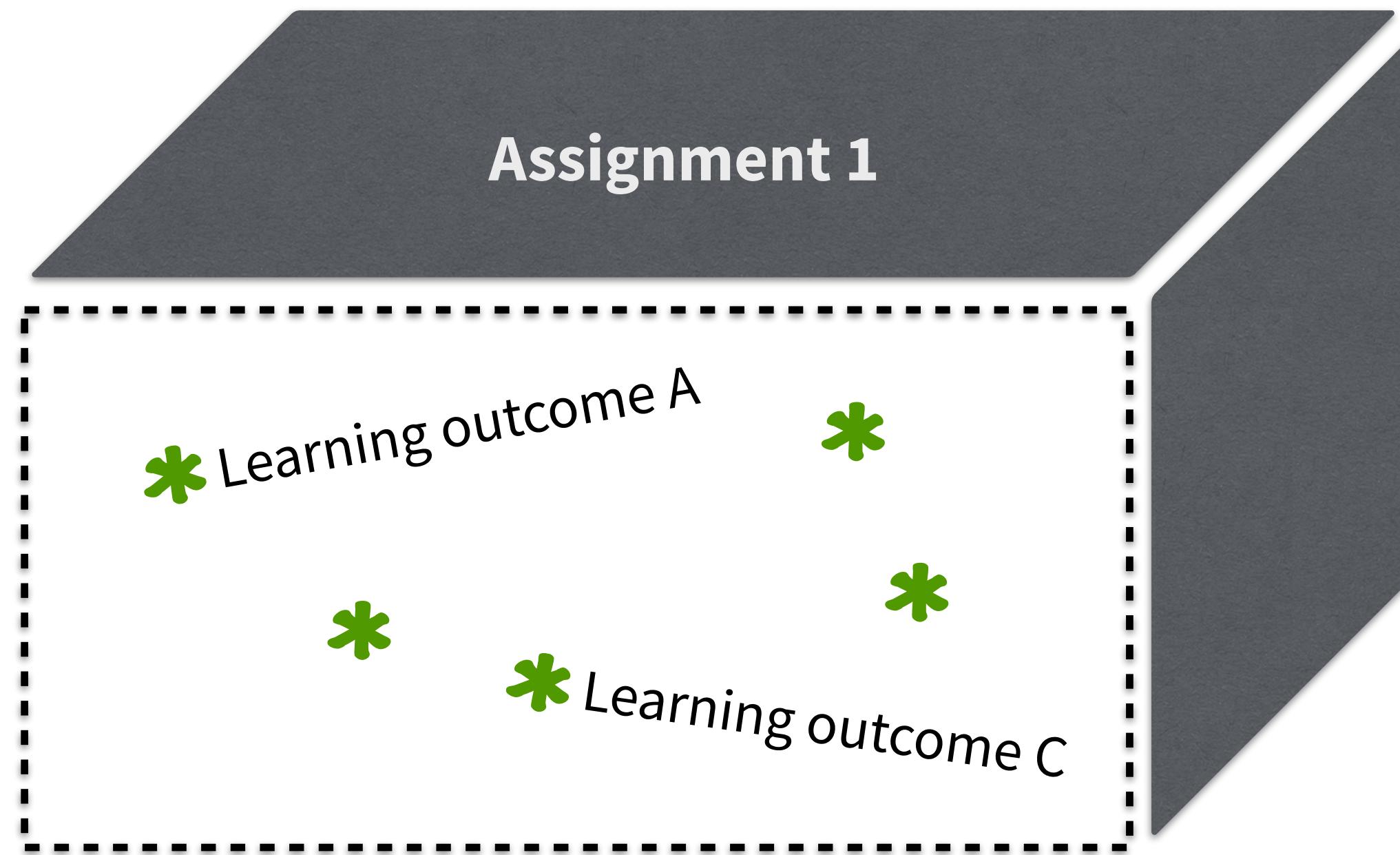
Assessment is Often a Black Box



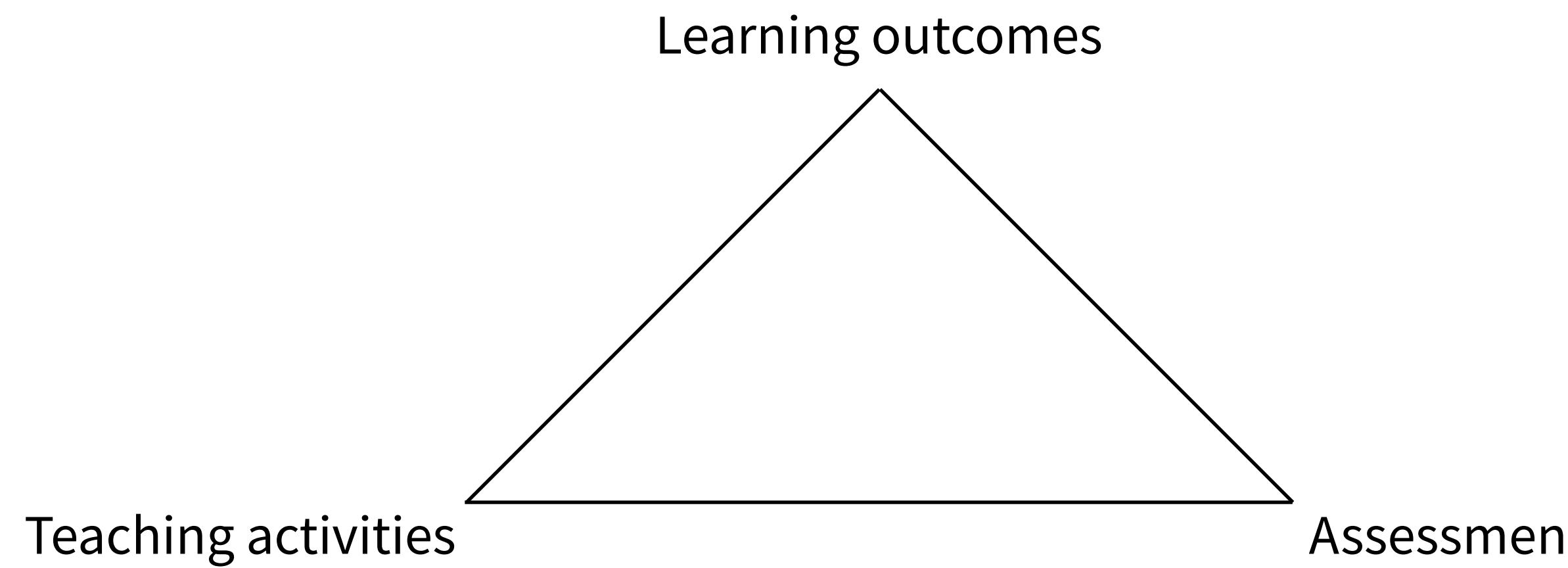
Assessment is Often a Black Box



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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**

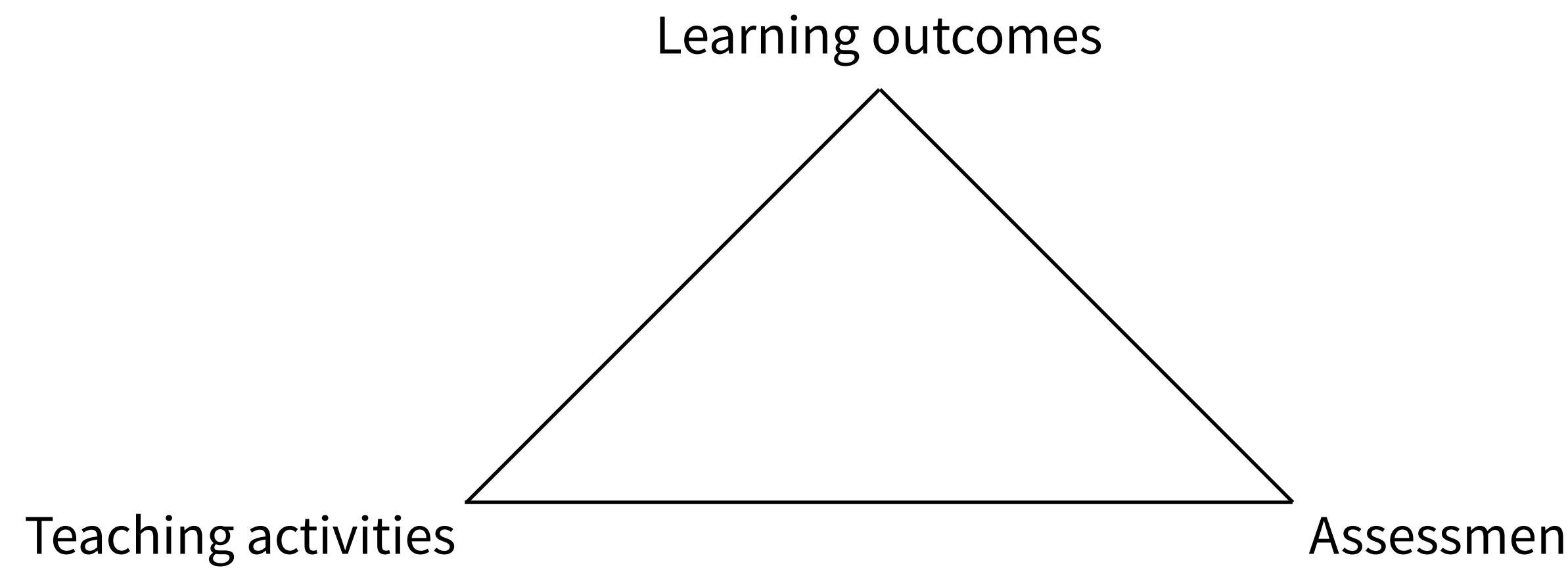
Each presentation is **pass/fail**

Failed demonstrations are neither punished nor recorded

“Any” number of tries (bounded by resources)



Constructive Alignment

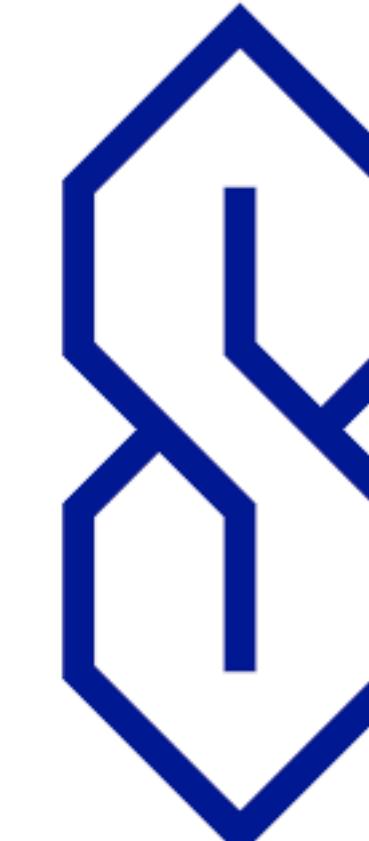


EXTREME

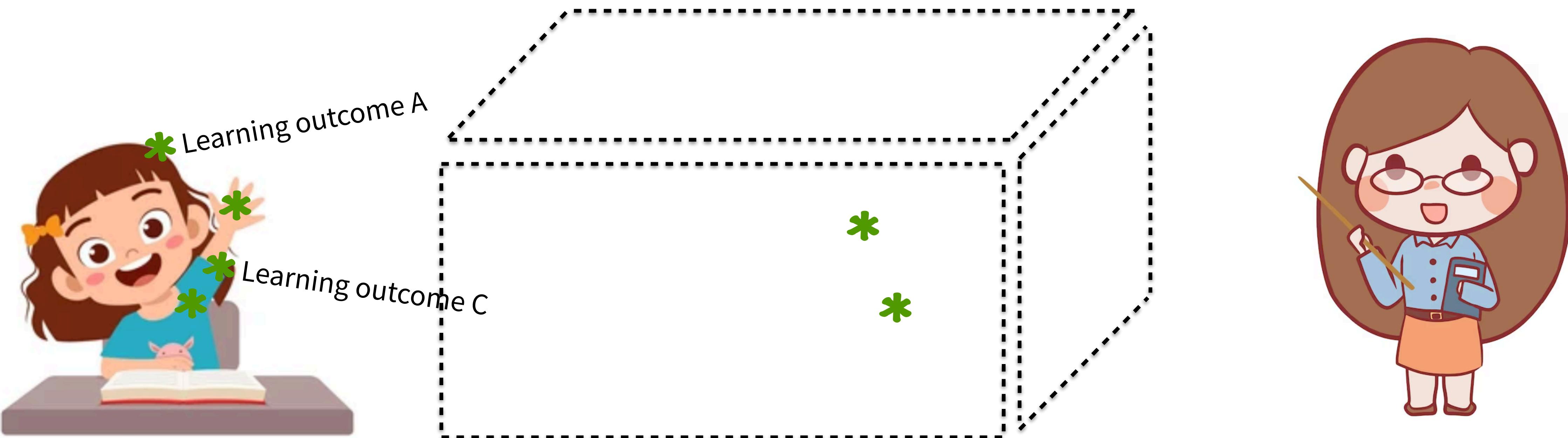
Constructive Alignment

Learning outcomes

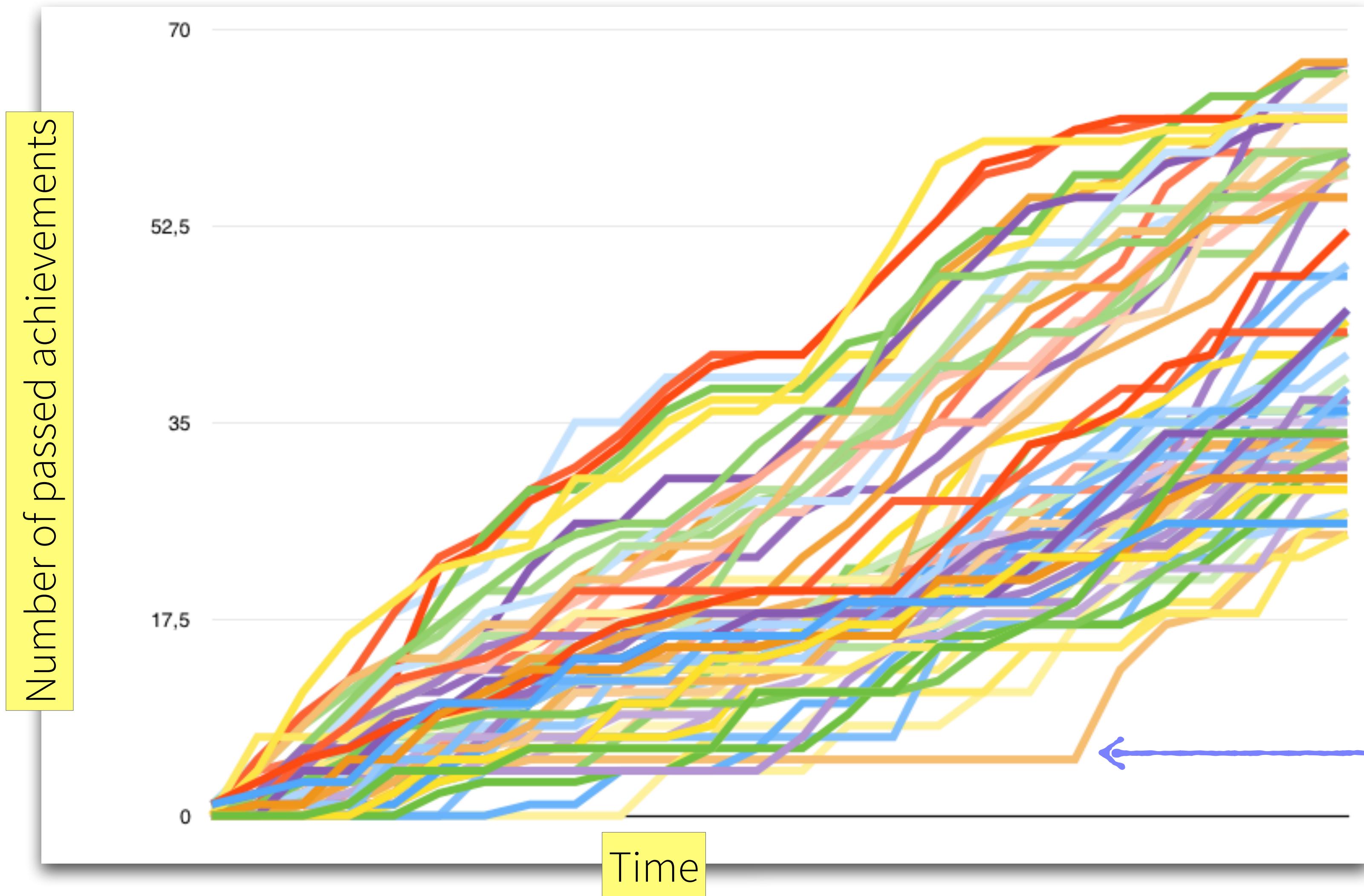
Teaching activities • Assessment



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

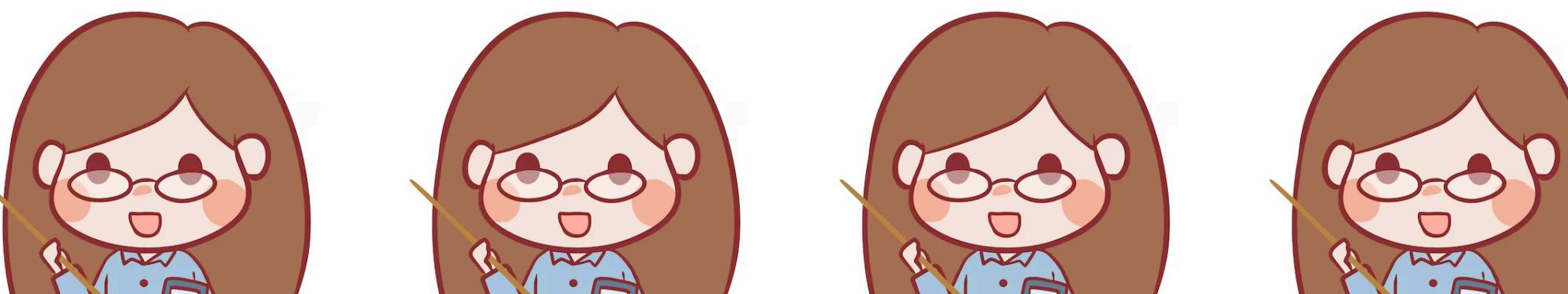
- Students appreciate the freedom and feel like they learn a lot



- 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!

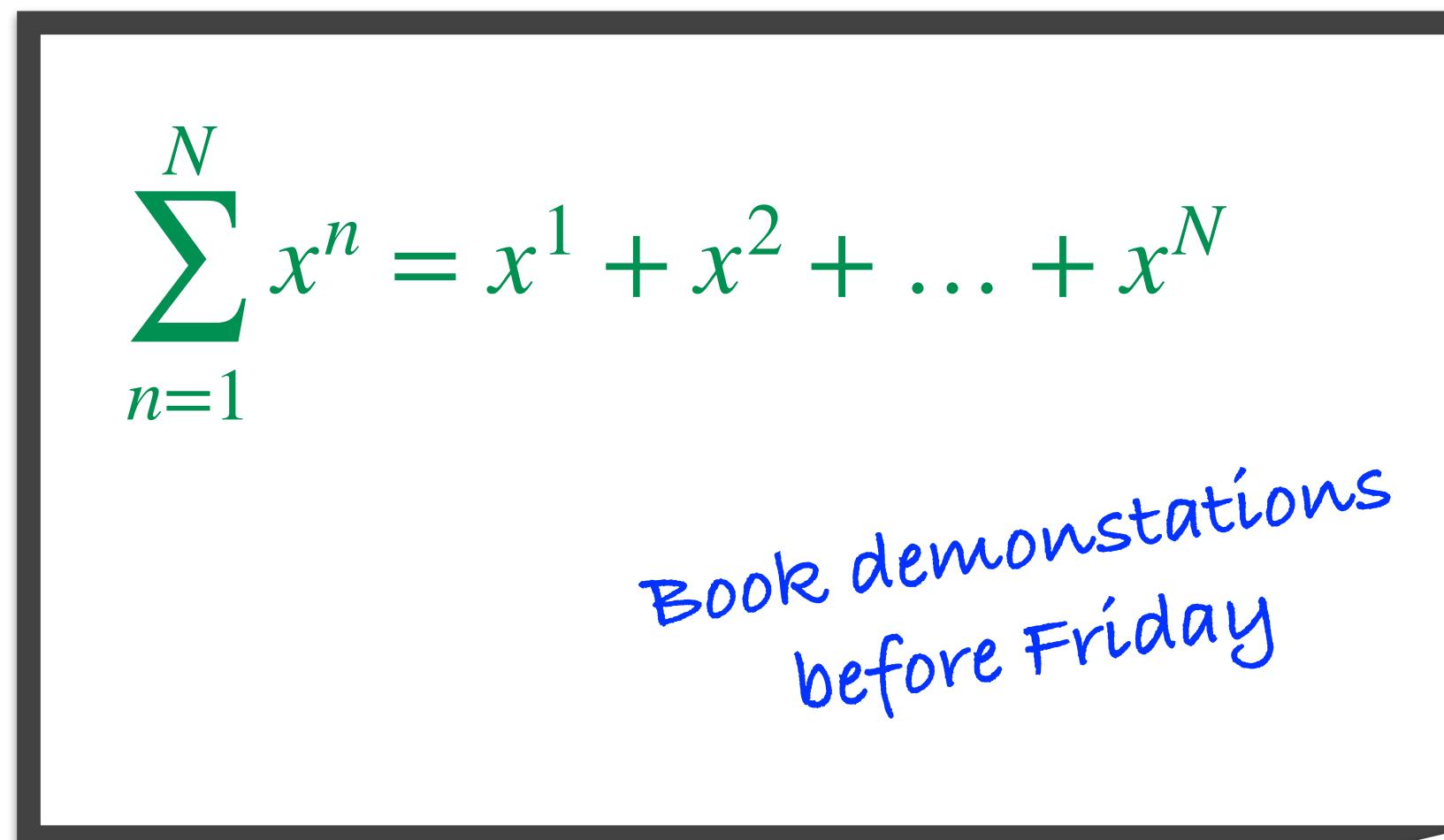
See <https://bubify.github.io>

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:

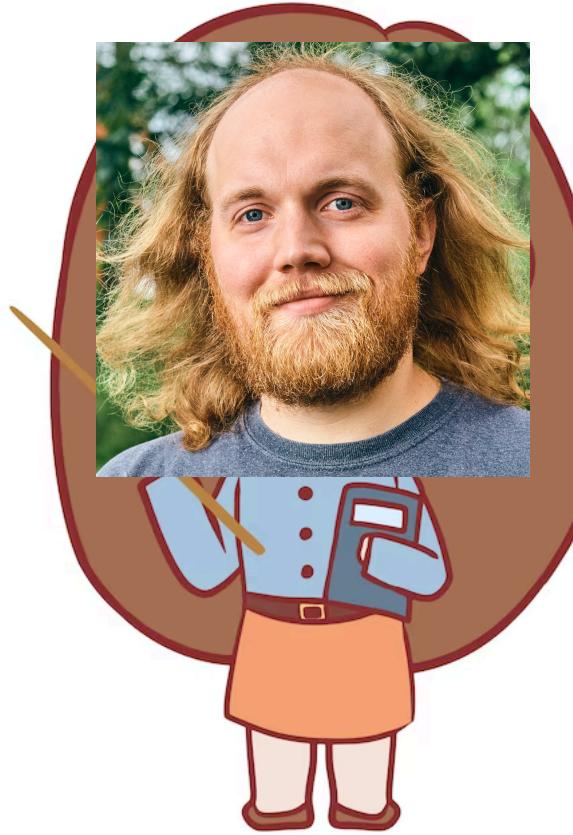
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Would you Like to Know More?

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

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- 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



These slides