A First Course on CPS - The Flipped-Classroom Experience

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The Big Picture

Long term: A CPS appreciation course for

- Graduate, undergraduate, and school programs
- Multiple departments and schools

Progress so far:

- Introduced at Halmstad University in 2012
  - Masters and senior undergraduate levels
- Program: Embedded and Intelligent Systems (EIS)
- 2 year MS program (1.5 years courses, 0.5 thesis)
- Diverse, international student body
- Graduates work in Sweden and abroad

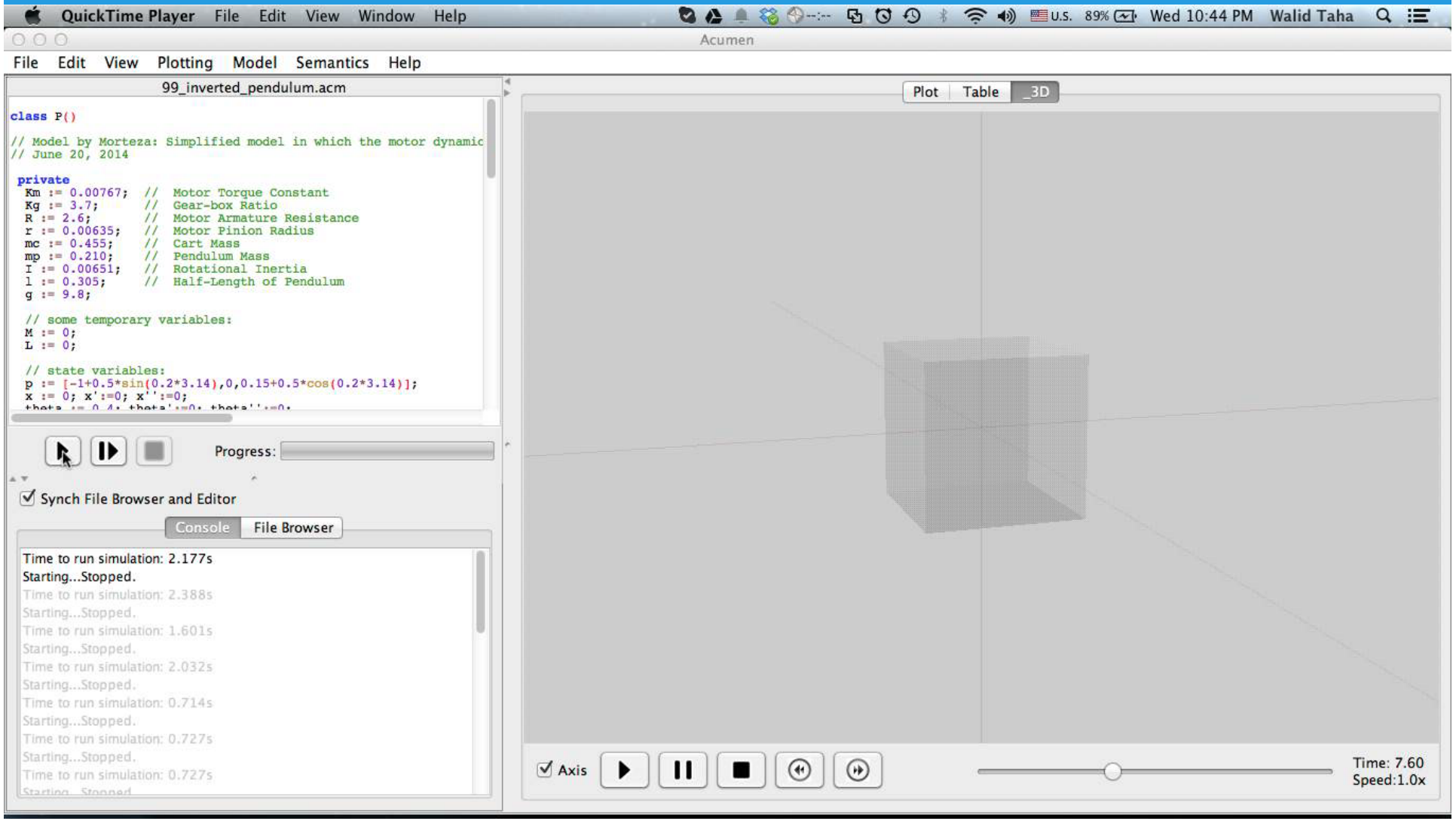
Approach

- Lecture Notes (Free, open CC)
- Quizzes
- Exercise problems
- Acumen (Free, open SW)
- Project (MB design, ping pong)
- Labs (focus on project & Acumen)
- Final exam

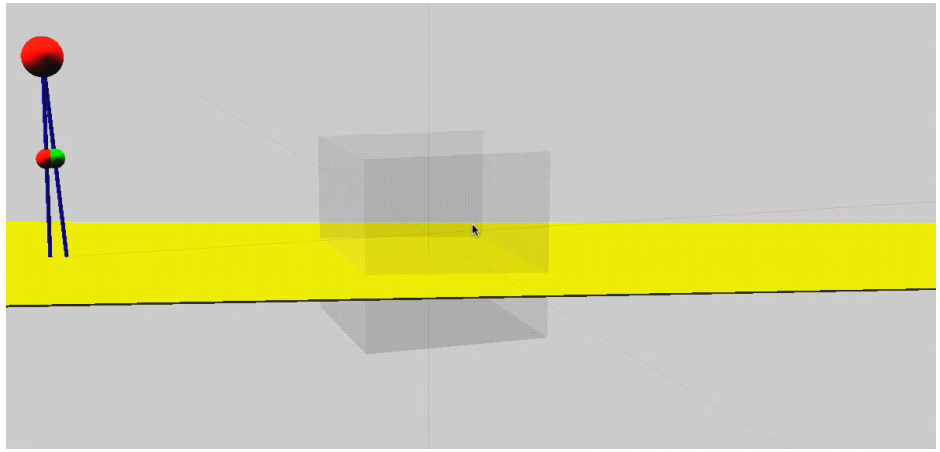
Lecture notes: Content & structure

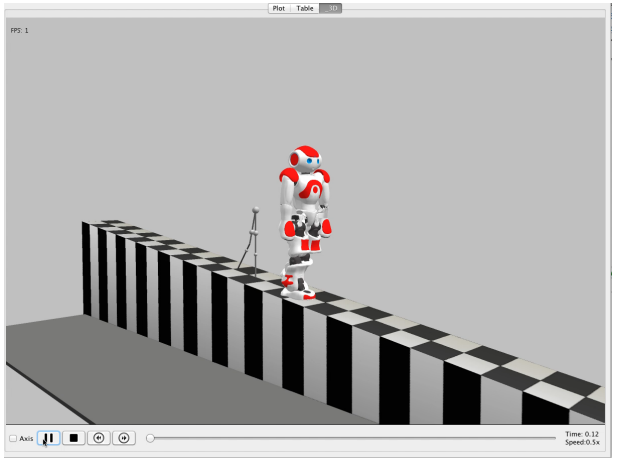
1. What is CPS?
2. Modeling Physical Systems
3. Hybrid Systems
4. Control
5. Modeling Computational Systems
6. Communications
7. Case study: A Single-Link Robot
8. Game theory

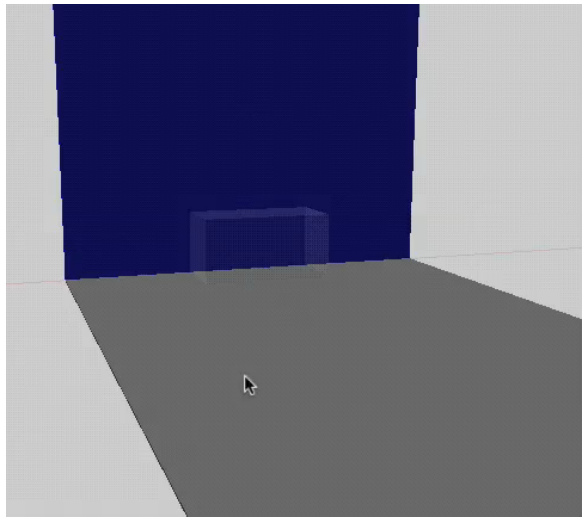
The Acumen IDE

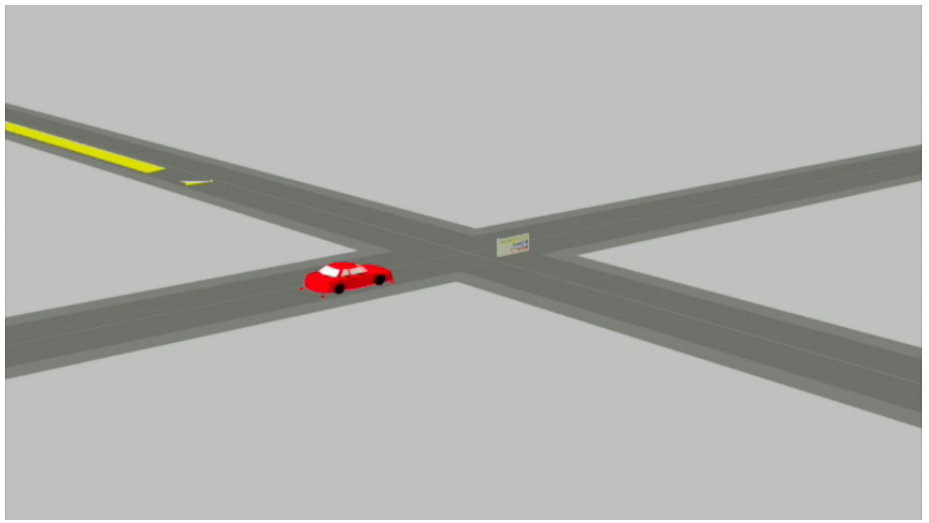


Easy 3D visualization





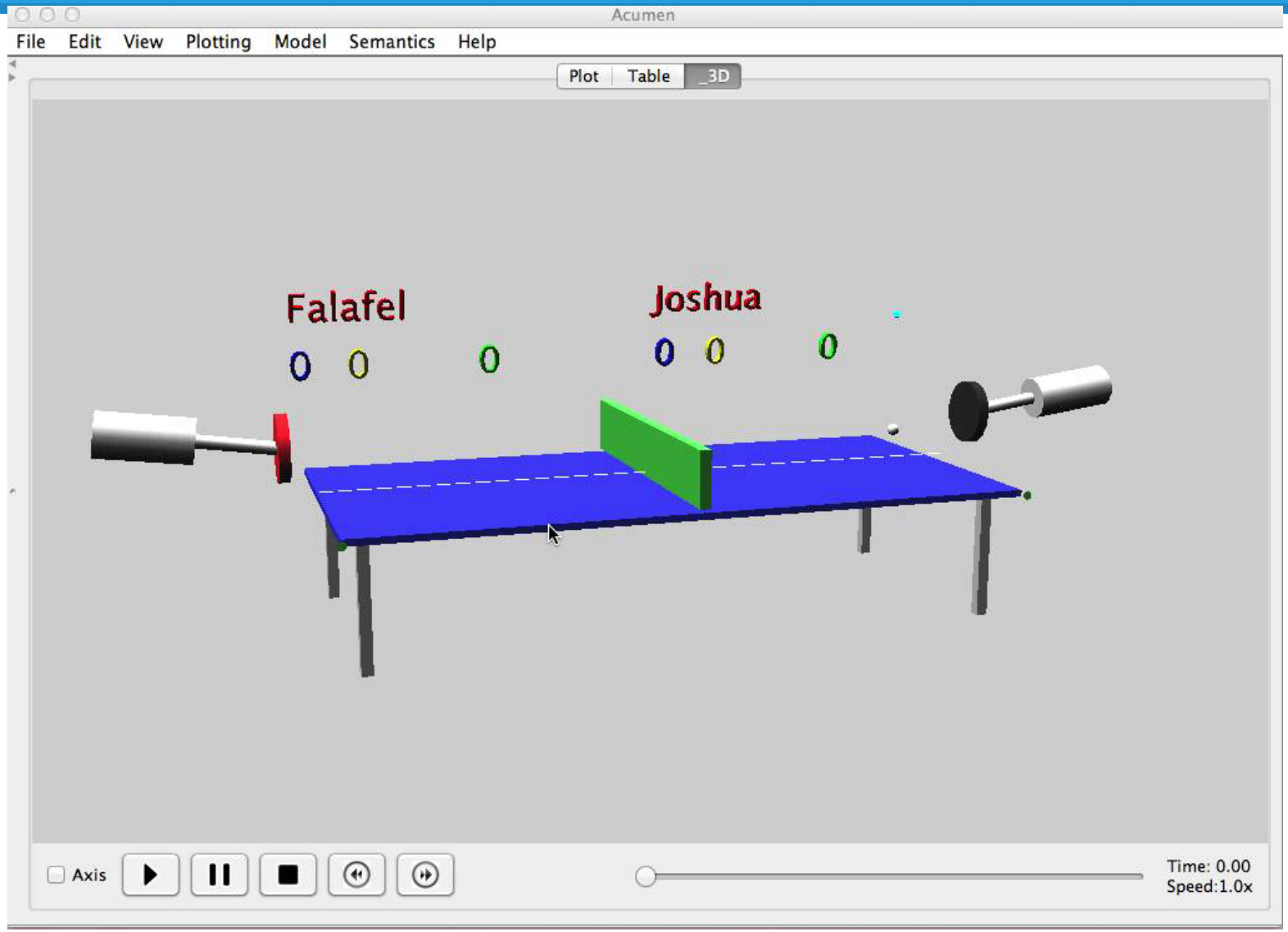




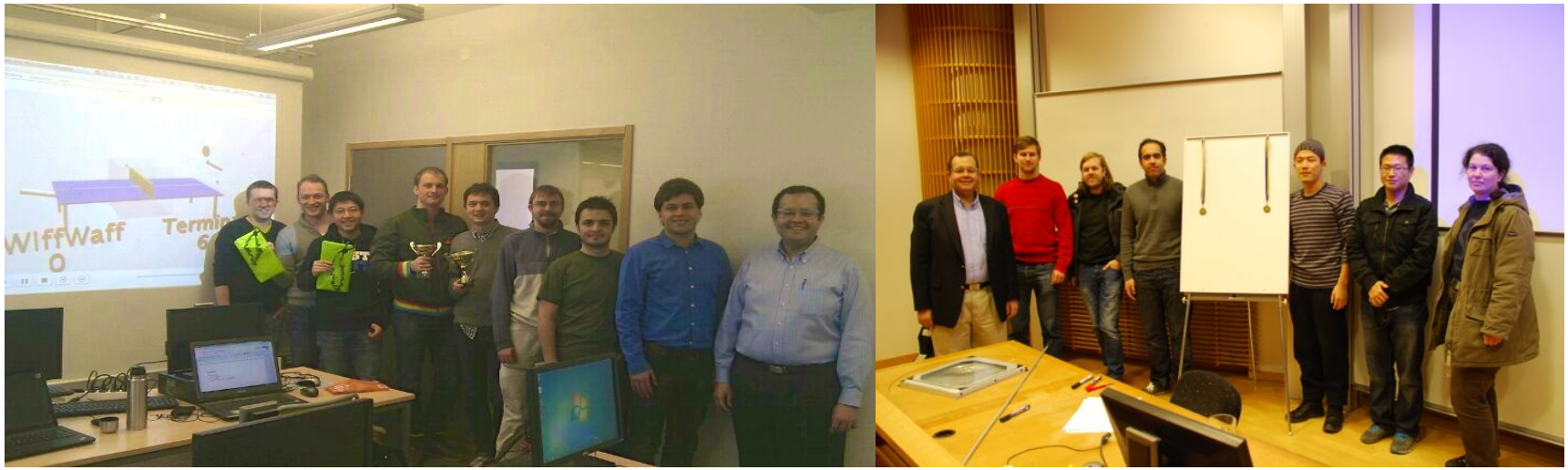
Project: Design a robot arm

- Students are given
  - Game and robot models w/ v3D visualization
  - Limited energy budget
  - Special scoring to encourage strategy
  - Teams of two students build one player model
- Designs forced to be increasingly realistic
  1. Bat is a 3D point controlled by speed
  2. Control bat through acceleration
  3. Deal with quantization and discretization
  4. Convert into torques & axial force

Project: Example from tournament



Project: Engages students



Awards presented at end 2013/P2 and 2014/P2

Feedback on 1st offering [CPS-Ed]

- “It was fun to run the design"
- “Support for 3D visualization was very useful”
- Requests for "more intermediate exercises"
  - improved in 2nd offering
- “The current project is difficult enough"
- “Too much reading on something easy"
  - improved in 2nd offering

Overall Student Satisfaction

- 5 on a scale from 1 (worst) to 6 (best)

Feedback on 2nd offering [WESE'13]

Things that work:

- Lecturing style: whiteboard, no slides, interactive, conversational
- Open access course material
- Collaborative real-time note taking

Things that can be improved:

- Gap between lectures and assignments: need more progressive levels of difficulty
- Some open-ended problems are too big and difficult
- Chapter on communication "is too abstract"

Overall satisfaction still high (4-5 / 6)

Feedback on 3rd offering [WESE'14]

Things that work:

- Assignments, Lecture notes
- Tournament
- 3D Animation
- Modeling physical systems

Things that can be improved:

- Workload is *HUGE*
- Gap between lectures and assignments remains
- Faster feedback on h. work, clearer grade structure
- Acumen: Speed. Semantics. Debugging. Not a PL?!

Overall satis. may be down (Survey changed)

Summary so far (5 minute video)

Available online from bit.ly/CPS-video

Preparations for 4th offering

- “Flip” the course with existing videos
- More practice problems (and do in class)
- Reduce project stages
- Drop Communications chapter
- Several updates to Acumen
  - Better syntax. Easier installation (jPCT)
  - Error messages w. line numbers
  - Faster implementation
- Proper staffing to support larger size

Why flip the classroom?

- Mazur, Deslauriers, Black-Schafer notice:
  - Most students are **passive** in traditional lectures
  - Even if a few students as questions, the **percentage engagement** is miniscule
  - If classes had **activities** that students need to prepare for ahead of time, things can be different.

How did we flip the classroom?

- **Before class**, students:
  - Watch the lectures online
  - Read the lectures notes
  - Do online quiz (thanks Prf. Marwedel!)
- **In class**
  - Review quiz results
  - Ask questions (before doing problems)
  - Do group problems (and discuss)
  - Do individual problems (and discuss)

How did we incentivize it?

- Explain it carefully at start
- Have online quiz before class
- Lecture videos available only up to class
- Grades for class work can help final grade
  - The maximum of the following two:
    - Final exam
    - 0.6 * Final exam + 0.4 * course work
  - Minimal grade for final exam = 60%
- Medals for project

Feedback on 4th offering – in class

Things that work:

- The flipped classroom
- Reduced work
- Easier installation
- New syntax
- Student satisfaction

Things that can be improved:

- Video recordings (post-editing needed)
- Sign-up for group projects still tricky

Feedback on 4th offering – written

"I really liked the 'flipped classroom' idea!"

"Flipped class environment is good and the study problems helped to understand the concepts clearly"

"It was really an interesting course. Teacher's feedback, positiveness towards students was really appreciated."

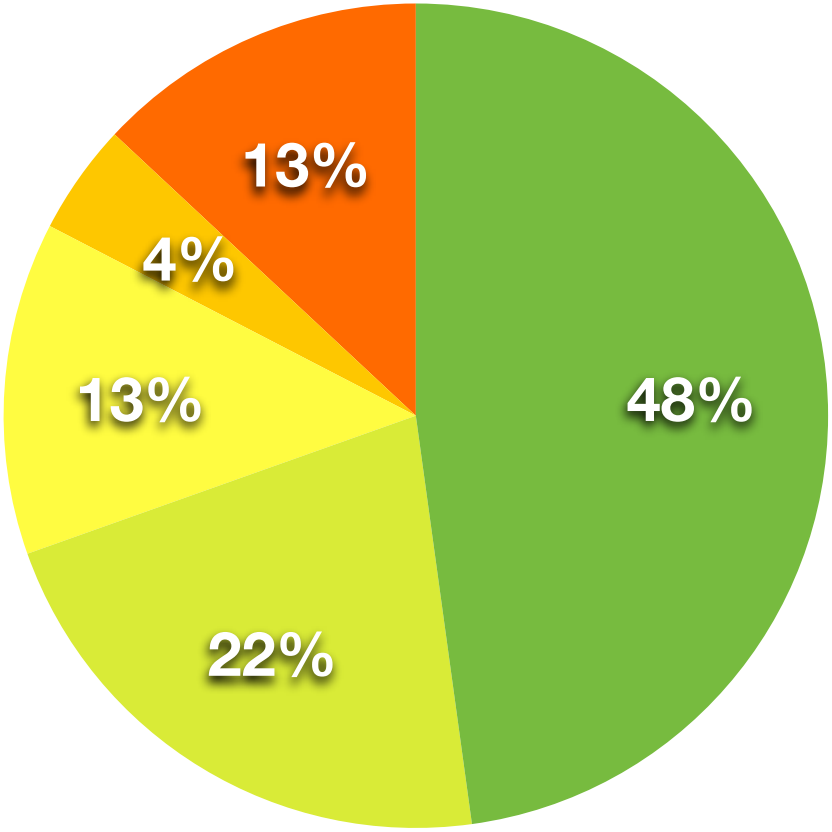
"I very much appreciated the lectures and the professor's feedback."

"I didn't like the method of this class, the 'flipped classroom'. I think that it could work if the teacher don't lose much time waiting the student answer his questions. If he's solving one exercise, he should solve and not expect the student tell him the answer, so, if the students don't know or want to reply him we couldn't see the correct answer because the time of the class always finish before it. So, the teacher didn't know how to measure the time for the class, and with this method the class was just for exercises, so we lose the main objective for this flipped class. So, for me was better study at home then go to the class… I didn't have motivation to go there and just see half solved exercises. "

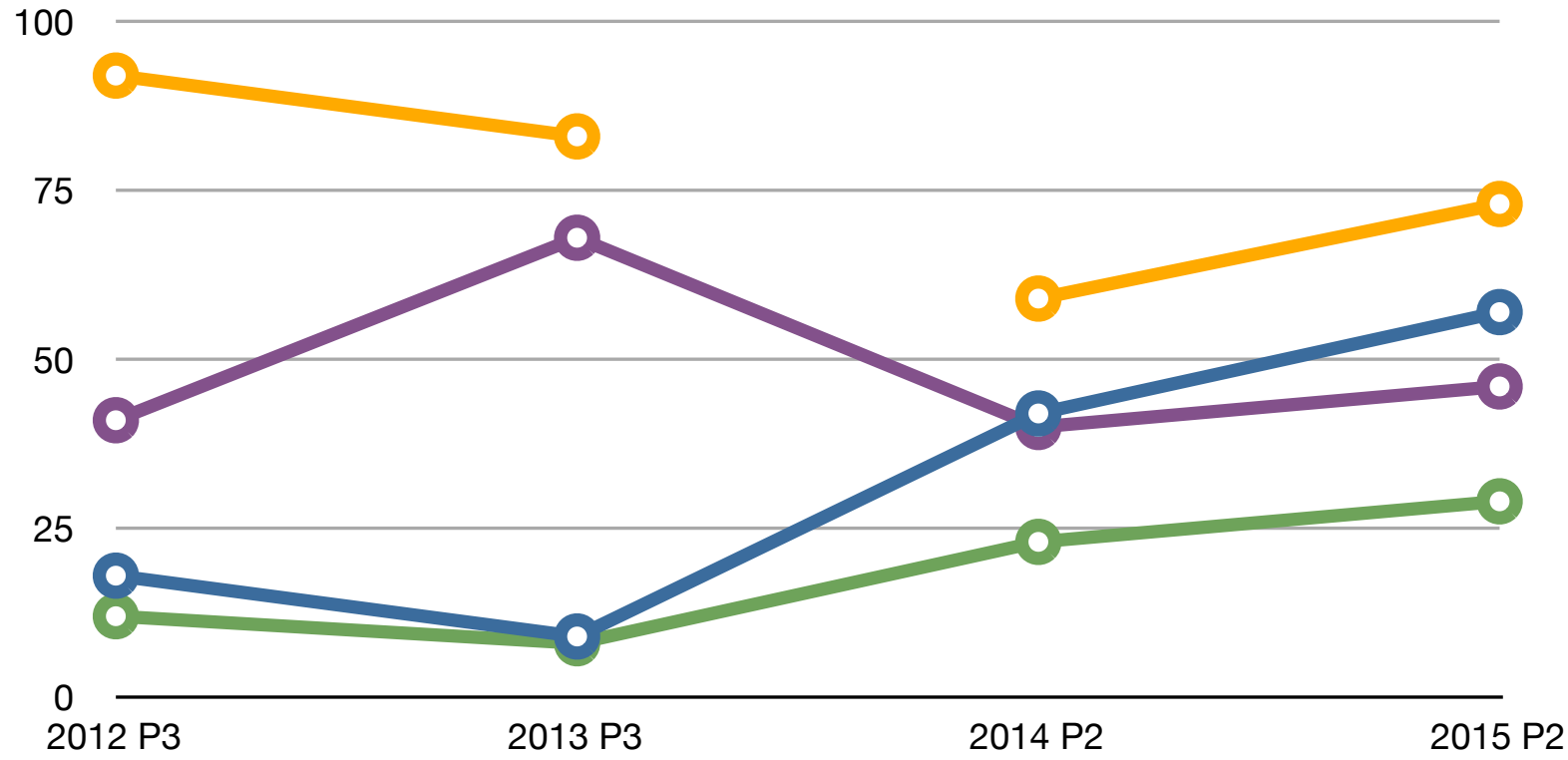
"If the course covers less criteria and gets deeper in existing ones [it] would be even better."

Feedback on 4th offering – written

How well did the flipped classroom work?



Eval, Grade, Signup, and Passing



Preparations for 5th offering

- Improve flipped classroom activities
  - Always start with group activity
  - Always follow with individual activity
- Continue to improve lecture notes and make more accessible
- If time allows, we may introduce:
  - Additional online quizzes to help self-check (and track) reading
  - Automatic grading server

Conclusions

- Our flipped classroom experience
  - Every *aggregate* metric improved
  - Many - but not all - where happy
  - Unhappy ones may have not been active
  - Significant effort for teacher to execute
  - Only reason to do it is to help students
- Quantification & customized evaluation help!
- All materials at bit.ly/CPS-course