"Flipping the Classroom" in an Introductory IT Course

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SWEDISH ICT SICS

Swedish Institute of Computer Science

MOTIVATION

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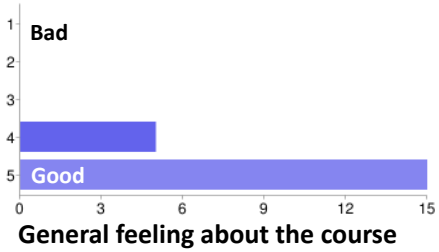
Good lectures, poor learning

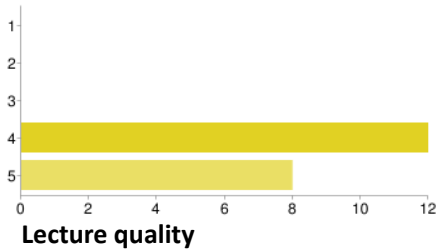
Introduction to Computer Architecture

- Fall 2011
- 5hp, 30 students, mixed background (2-4th year)

Students loved the course…

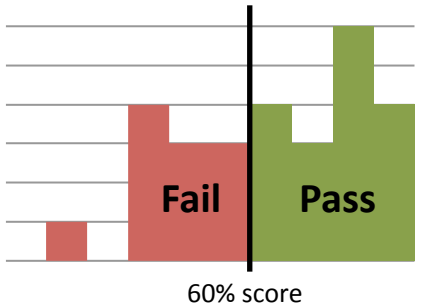


General feeling about the course



Lecture quality

…but didn't do so well on the exam.



60% score

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What's going on?

My hypothesis:

- The class was entertaining
- But not demanding

Even good lectures are very passive

How interactive are lectures?

- 90 minute class
  - 10 questions per class
  - 3 minutes per question
- 30 minutes of student interaction
  - **33% interactive**
- But, each question:
  - 1 minute student
  - 2 minutes teacher
- 10 minutes of student interaction
  - **11% interactive**
- But, 30 students per class:
- **20 seconds of student interaction**
  - 0.4% interactive
  - **99.6% passive**

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Can we do better with more active students?

Lous Deslauriers, et al. (2011)

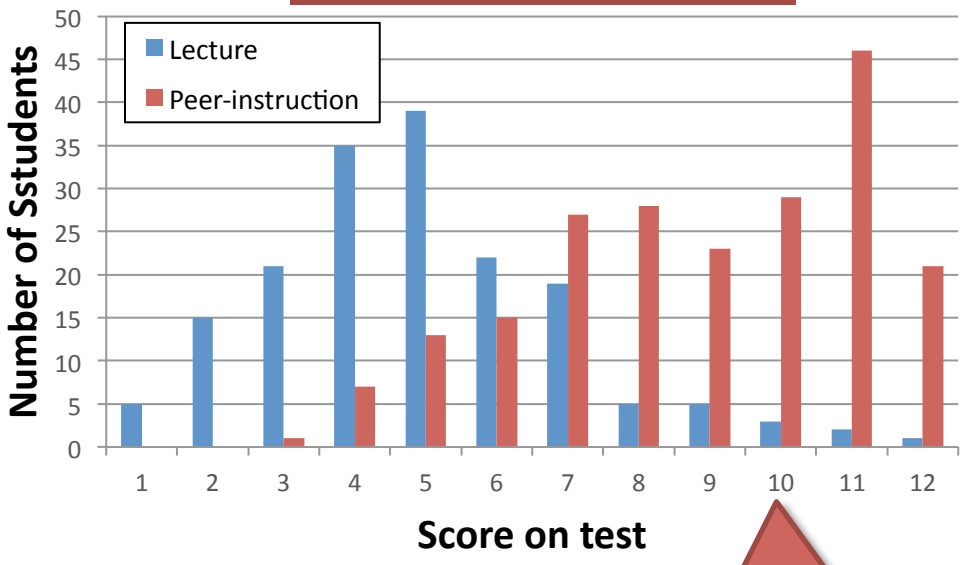
Experiment:

- **538 students** in a quantum mechanics class

For 1 week:

- ½ received 3 hours of **lectures** from an experienced teacher
- ½ received 3 hours of **peer-instruction**

This is AMAZING!



+20% attendance
+40% engagement

Peer-instruction was 2.5 std. dev. better!

Can we use MOOC technology to achieve this?

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Data reproduced from Louis Deslauriers, et al. "Improved Learning in a Large-Enrollment Physics Class." **Science** 332, 862 (2011).

Technology inspiration

23,000 students pass Stanford's artificial intelligence course at the same time.

Sebastian Thrun

Udacity/Stanford University, 2011

Sebastian finally got **online** education right:

- **Interactive** online lectures
- **Top-quality** instructors

I want to use this technology to do better in-class teaching.

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FLIPPING THE CLASSROOM

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Flipping the Classroom

	At Home	In-Class	
Traditional Lectures	**Solve Problems** Active Alone	**Listen to Lecture** Passive With Teacher	Wasting a great resource
Flipped Classroom	**Listen to Lecture** Passive Alone	**Solve Problems** Active With Teacher	Much better use of the teacher
Flipped Classroom + Technology	**Interactive Lecture** Active Alone	**Solve Problems** Active With Teacher With Peers	Ultimate goal: Fully active, Peer teaching

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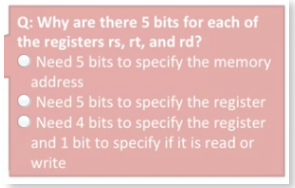
What is an "Interactive Lecture"?

Short lecture segments + self-assessment quizzes

Video

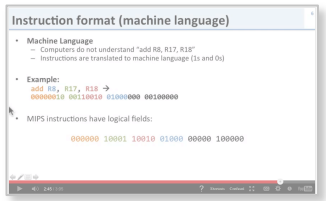
5-10 minutes

Quiz



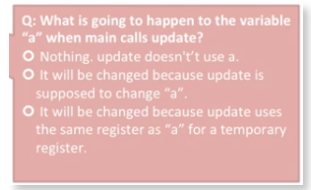
1-2 questions

Video



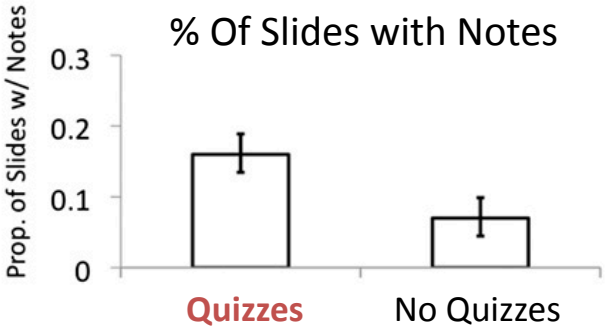
5-10 minutes

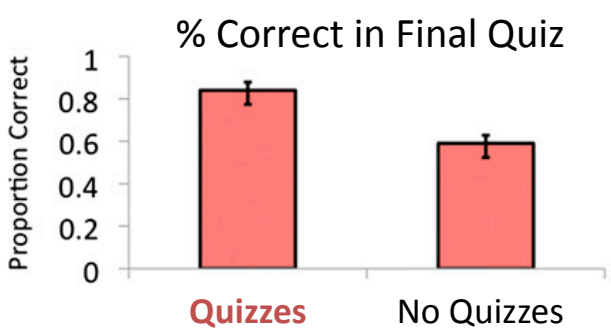
Quiz



1-2 questions

Do interactive lectures help learning?





- **2x increase** in notes
- **20% better** learning
- **50% decrease** in mind wandering

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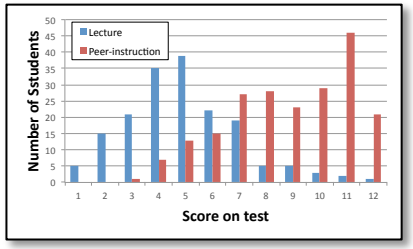
K. Szpunar, et. al. "Interpolated memory tests reduce mind wandering and improve learning of online lectures." PNAS, vol. 110, no. 16. 2013.

Flipping the Classroom

Goals:

- Use the **teacher time to help teach**, not read the book
- Maximize **interactive learning** time



Not a new idea:

- Eric Mazur peer instruction (Harvard, 1990s)
- J. Wesley Baker 2000: "sage on the stage" → "guide on the side"
- Khan Academy

"Hybrid" or "Blended" learning:

- Combine the **best of online and in-class**
- Use information from online lectures to direct in-class learning

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What Did I Do?

At home

- Online lectures before class
  (Short 5-10 minute video segments)
- 10-20 self-assessment quizzes

In-class

- Review self-assessment quizzes
- Answer questions from online lectures
- Peer practice problems in small groups

Demo from a live course

(Platform is a joint development project with the Swedish Institute for Computer Science.)

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MAKING LECTURES INTERACTIVE

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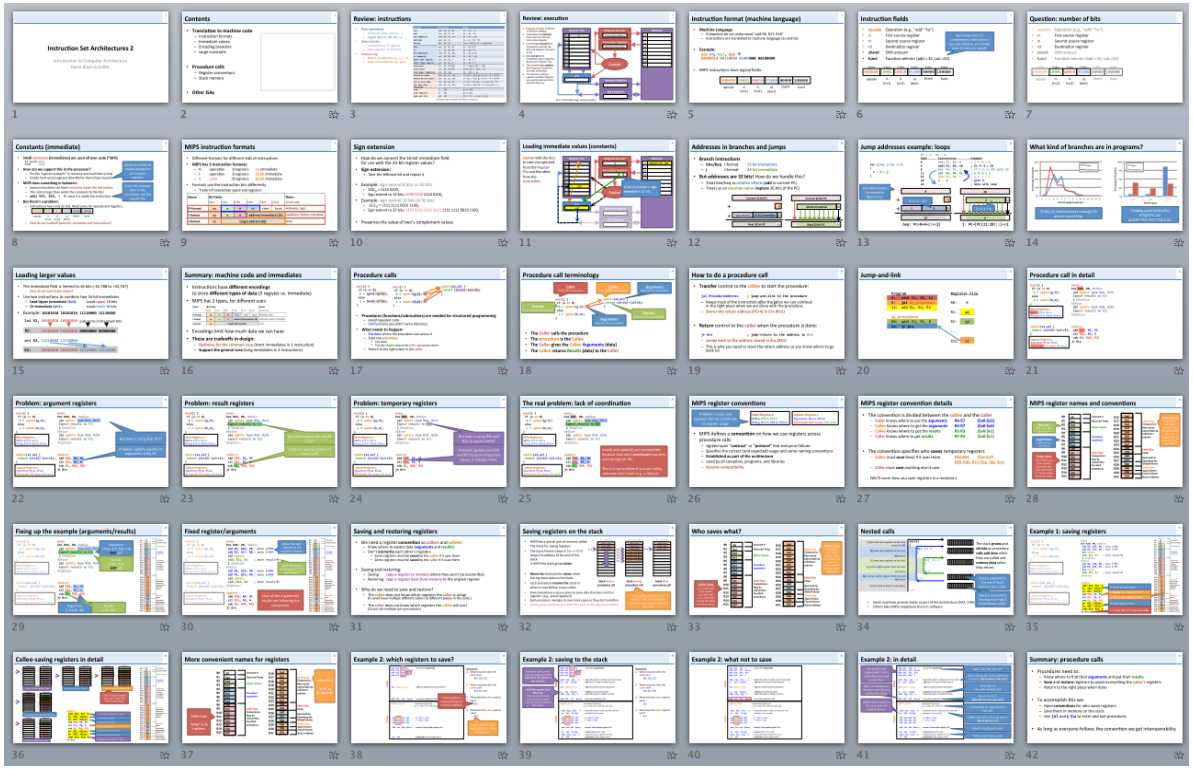
Making lectures interactive



1. Divide into 5-10 minute chunks

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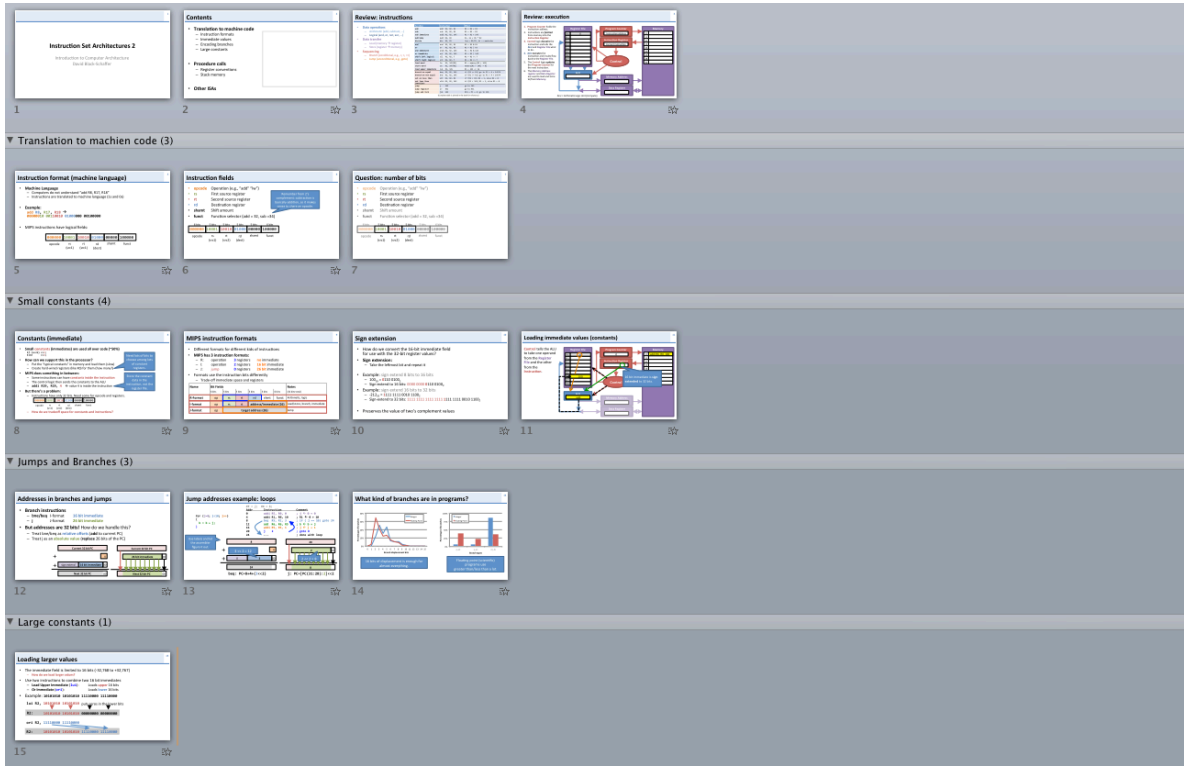
Making lectures interactive



1. Divide into 5-10 minute chunks

2. Add section titles

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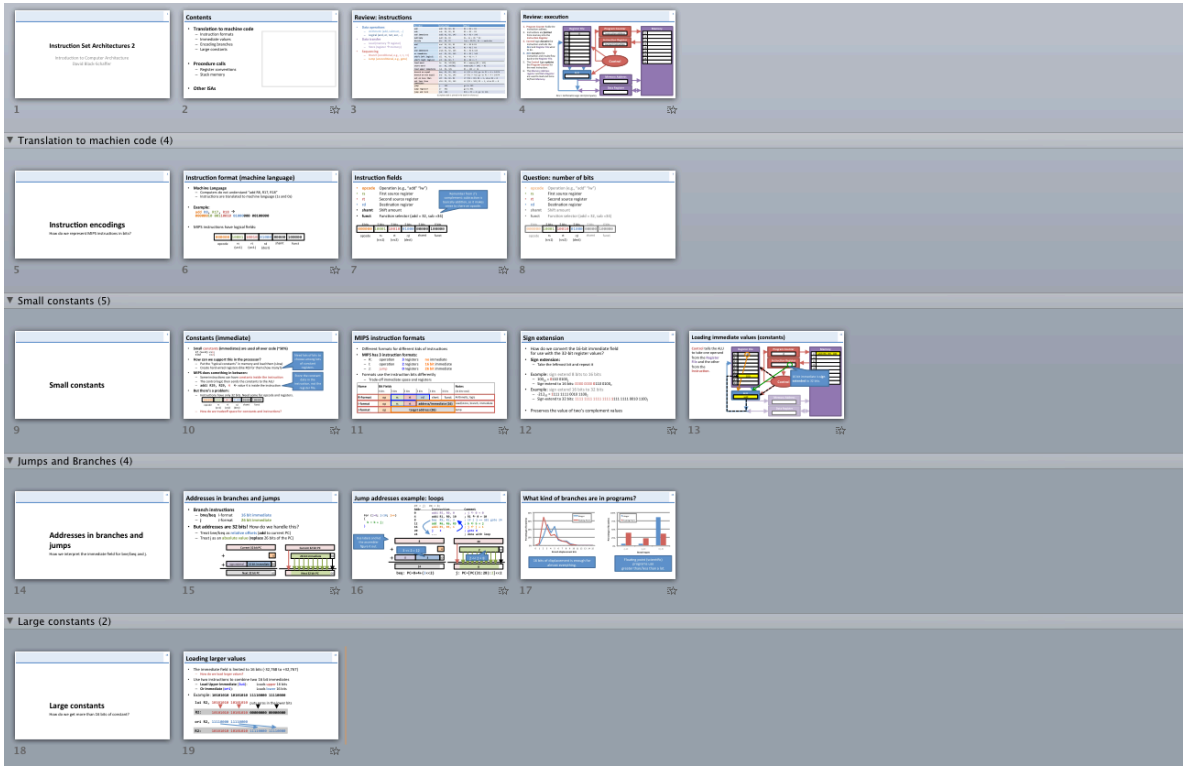
Making lectures interactive



1. Divide into 5-10 minute chunks

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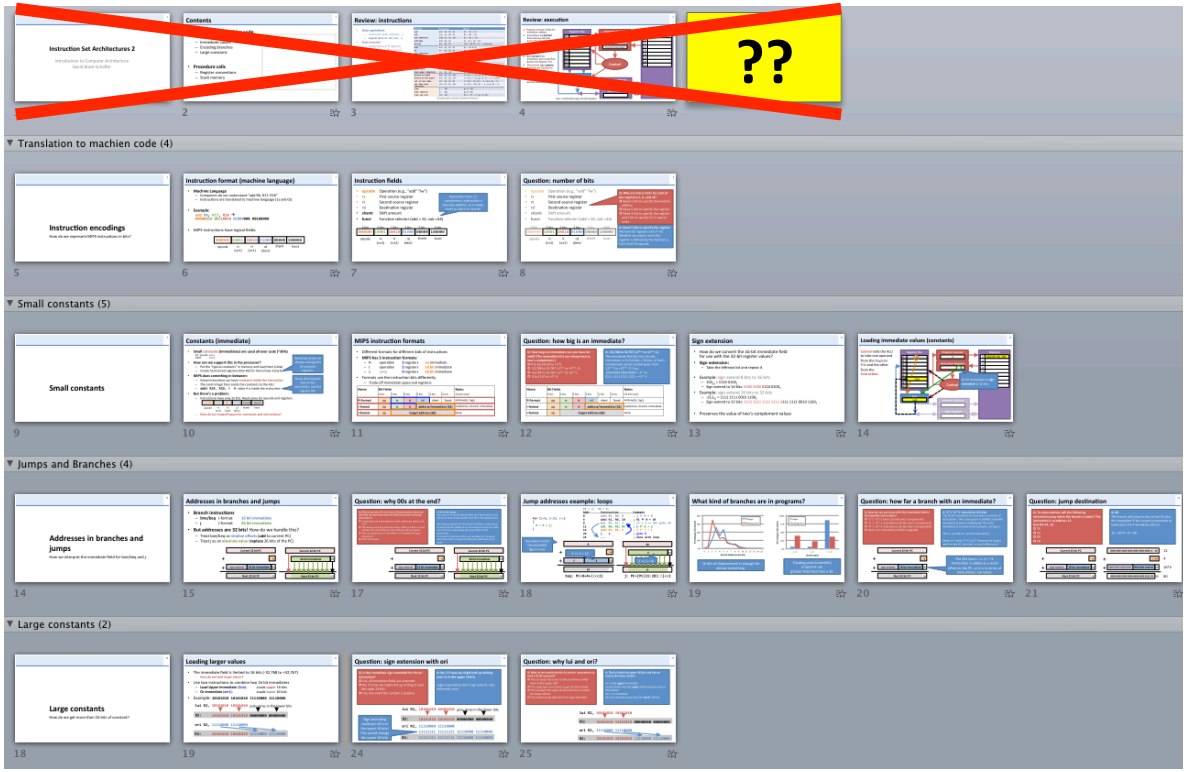
Making lectures interactive



1. Divide into 5-10 minute chunks

2. Add section titles

3. Add questions

This is the hard part.

- Choosing questions
- Writing questions

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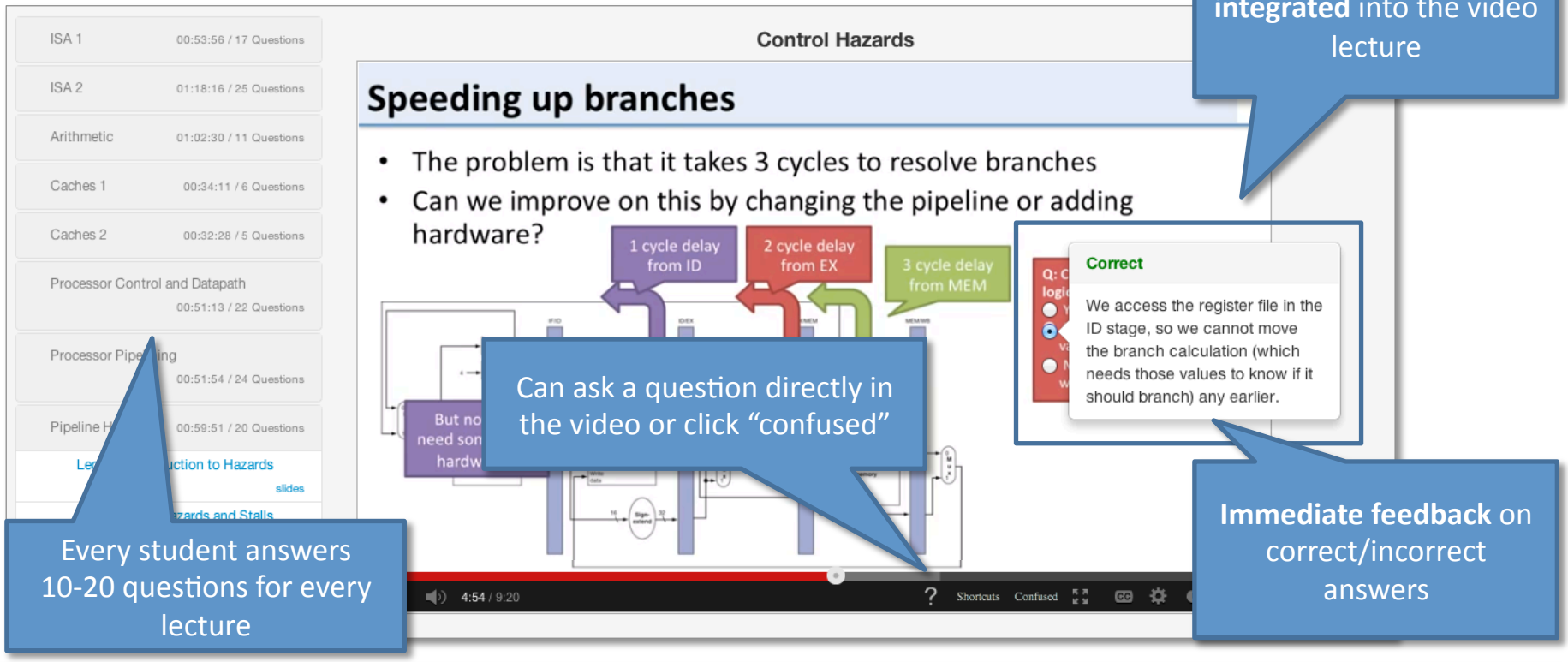
At Home: Interactive lectures



Self-assessment **quizzes integrated** into the video lecture

Can ask a question directly in the video or click "confused"

Every student answers 10-20 questions for every lecture

Immediate feedback on correct/incorrect answers

Maximize interactivity & collect data

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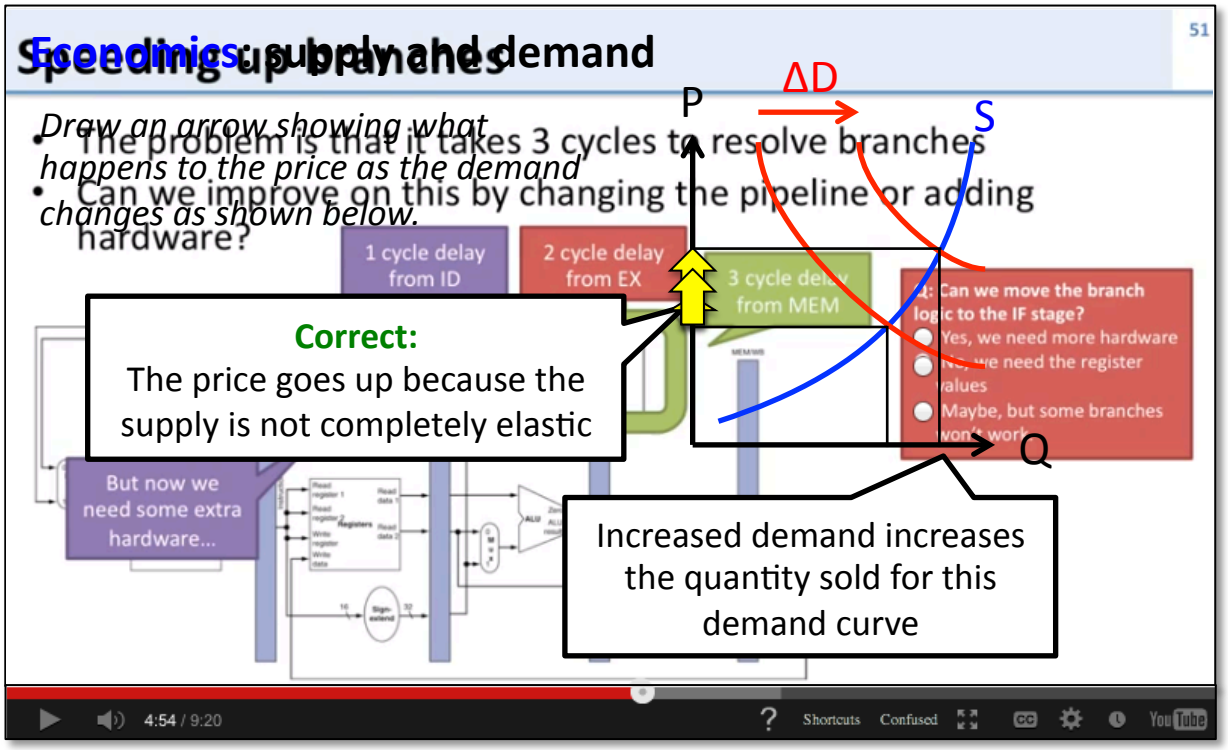
Interactive lectures



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Interactive lectures

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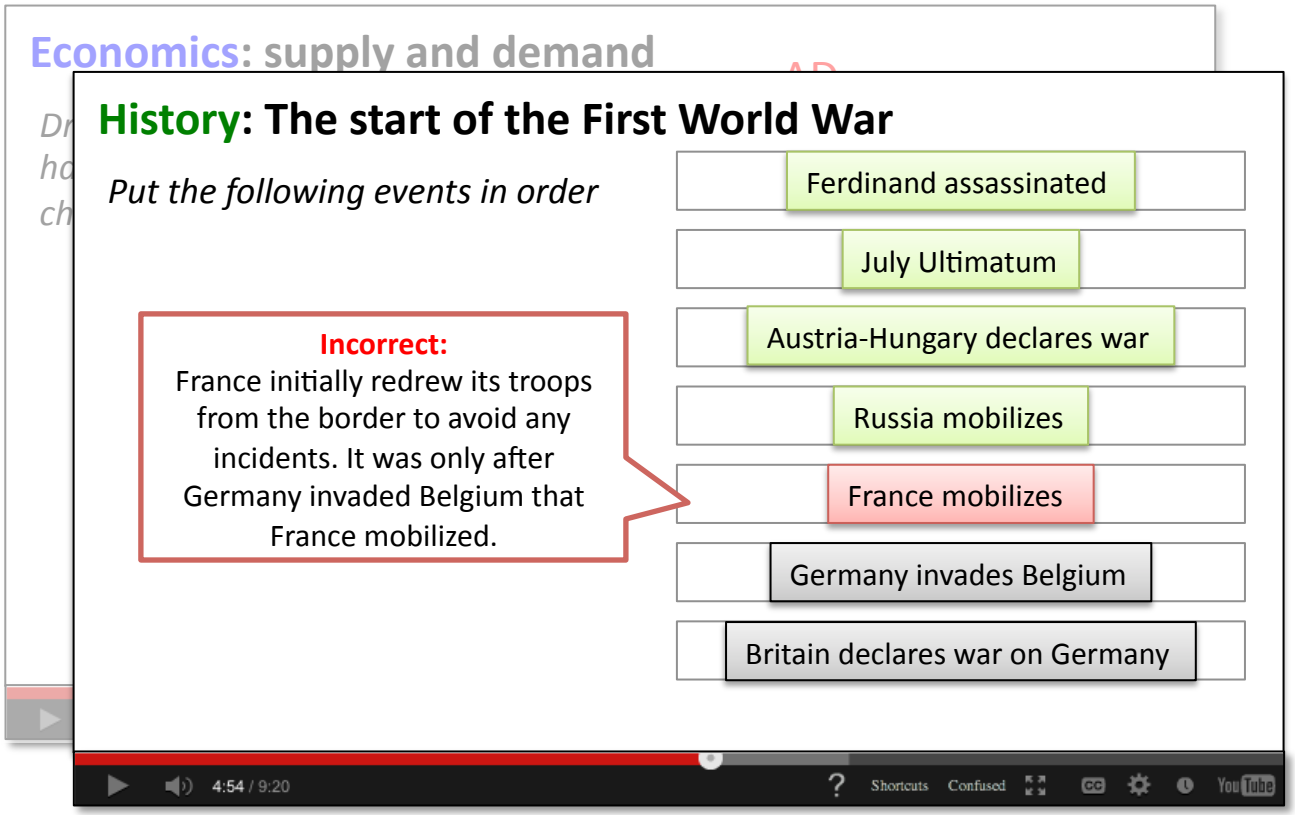
Interactive lectures



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Interactive lectures

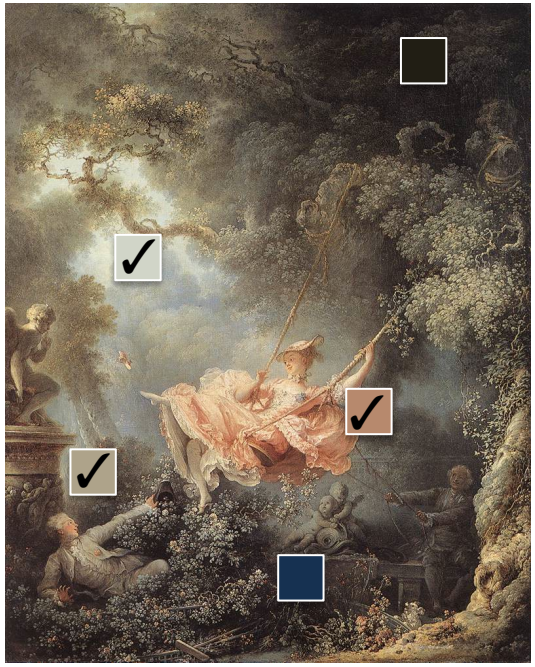
Economics: supply and demand

History: The start of the First World War

Art: The Rococo color pallet

Select the colors used in this work that differentiate it from the earlier Baroque pallet.

Correct:
The Rococo pallet uses more "playful" pastels and lighter colors in place of the Baroques intense, darker colors and tones.



L'Escarpolette (The Swing). Jean-Honoré Fragonard, 1766

4:54 / 9:20 Shortcuts Confused

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Interactive lectures

Economics: supply and demand

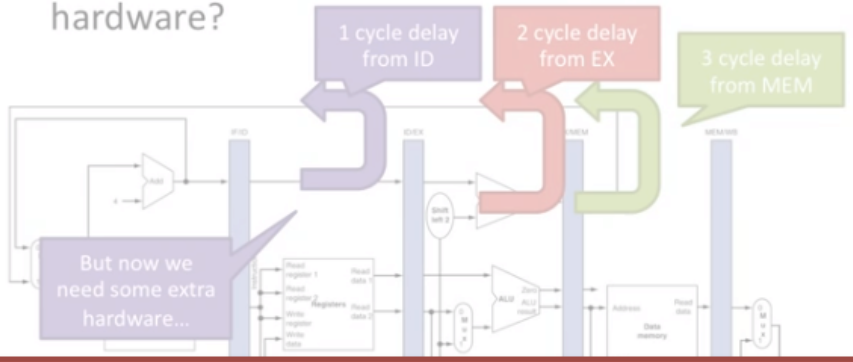
History: The start of the First World War

Art: The Rococo color pallet

Computer Science: Speeding up branches

51

- The problem is that it takes 3 cycles to resolve branches
- Can we improve on this by changing the pipeline or adding hardware?



Q: Can we move the branch logic to the IF stage?
- Yes, we need more hardware
- No, we need the register values
- Maybe, but some branches won't work.

Many fields, many types of questions

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IMPROVING IN-CLASS TEACHING

Using the information from the online lectures.

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Teacher's View: What did students learn?

Do not need to review this material

Review if we have time

Definitely review!

And probably improve the lecture material.

Know where to spend in-class time *before* coming to class

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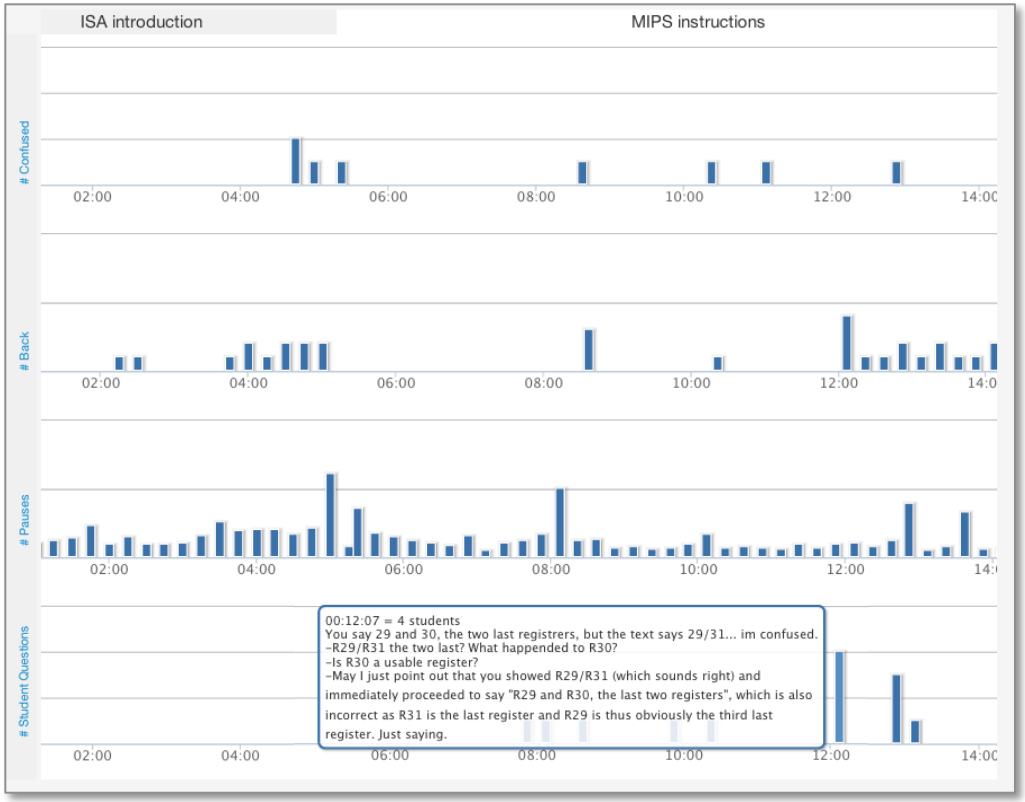
Teacher's View: Where did students have trouble?



Confused

Rewind

Pauses

Questions

Lecture Time →

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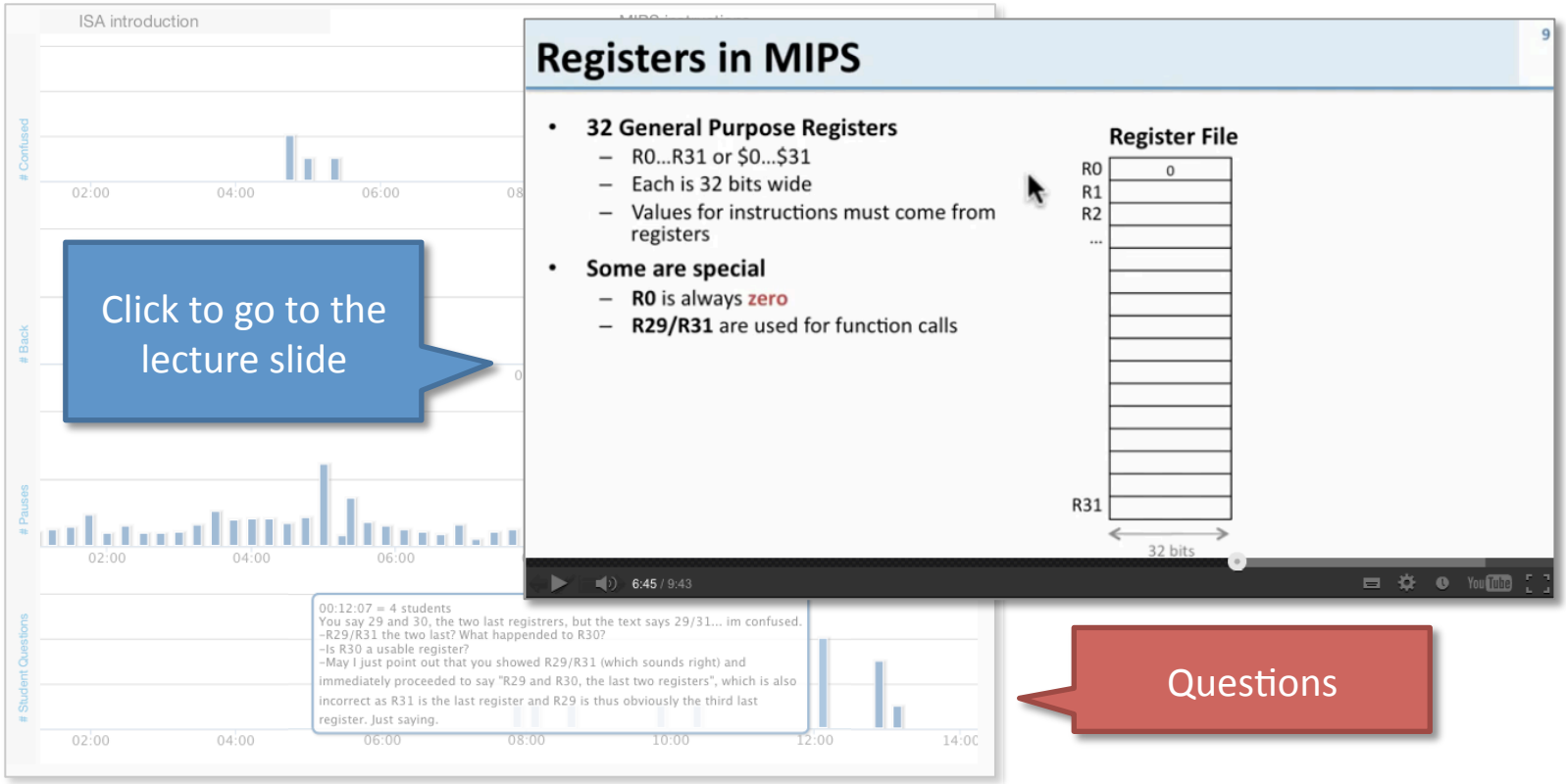
Teacher's View: Where did students have trouble?



Click to go to the lecture slide

Questions

Understand *where* students are confused and have questions

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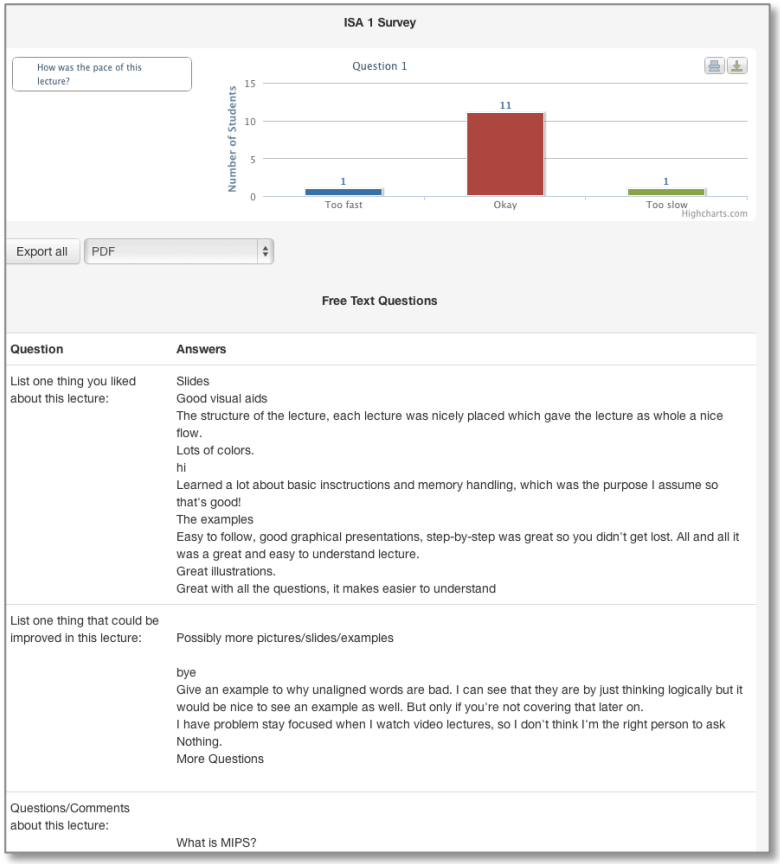
Teacher's View: Responding to student feedback



ISA 1 Survey

How was the pace of this lecture?

Question 1

Export all PDF

Free Text Questions

Question	Answers
List one thing you liked about this lecture:	Slides Good visual aids The structure of the lecture, each lecture was nicely placed which gave the lecture as whole a nice flow. Lots of colors. hi Learned a lot about basic insctructions and memory handling, which was the purpose I assume so that's good! The examples Easy to follow, good graphical presentations, step-by-step was great so you didn't get lost. All and all it was a great and easy to understand lecture. Great illustrations. Great with all the questions, it makes easier to understand
List one thing that could be improved in this lecture:	Possibly more pictures/slides/examples bye Give an example to why unaligned words are bad. I can see that they are by just thinking logically but it would be nice to see an example as well. But only if you're not covering that later on. I have problem stay focused when I watch video lectures, so I don't think I'm the right person to ask Nothing. More Questions
Questions/Comments about this lecture:	What is MIPS?

Multiple choice

Free text

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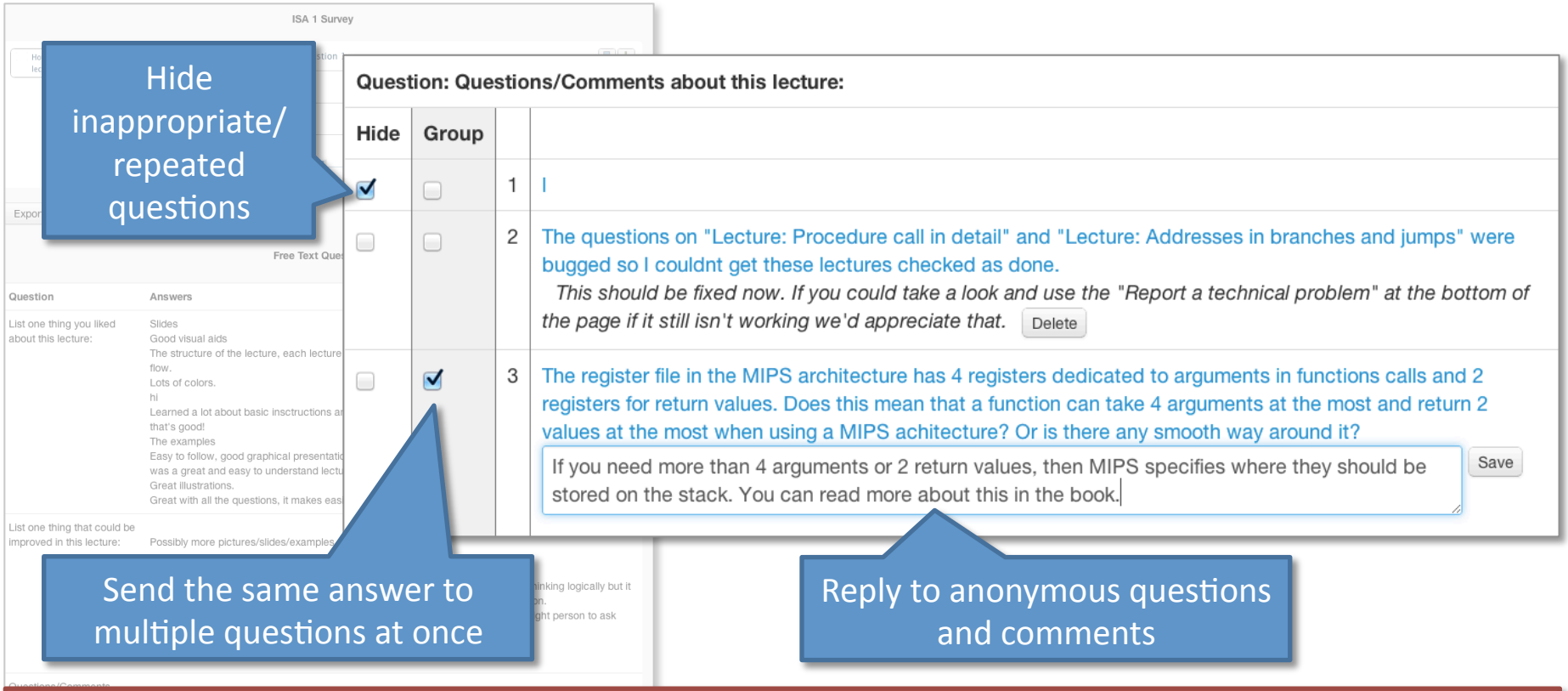
Teacher's View: Responding to student feedback



Show the students you care about their feedback and questions

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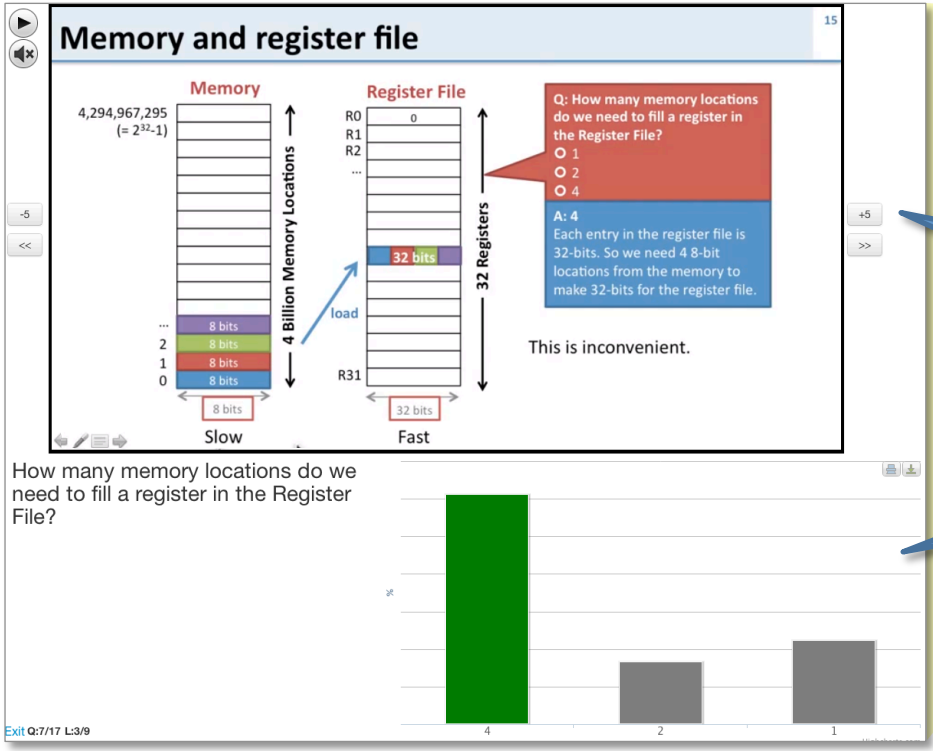
In-Class: Using the data to help teaching

In-Class View: Quiz Results



Step through the question and solution

Student **quiz** results

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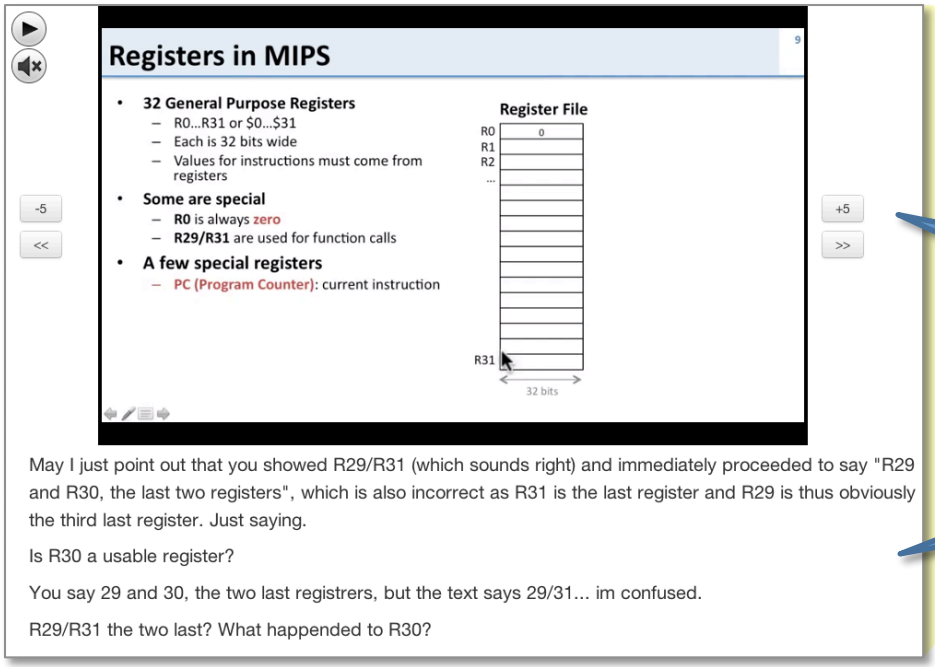
In-Class: Using the data to help teaching

In-Class View: Questions



Questions grouped by 30 second intervals

4 student had **questions at the same place**

Use online information *easily* in class

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Implementation: In-class

- **Review** self-assessment quizzes
  - Teacher knows which questions students had trouble with
  - Use in-class time effectively
- **Review** student questions and feedback
  - Can prepare ahead of time
  - Build trust with the students that you listen

This is for free:
Know where the students need help and better feedback

- **Practice** problems
  - Small group practice problems
  - Interact with other students and teachers

This is the goal:
Spend the in-class time working with the material, not lecturing!

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In-Class: Peer learning with practice problems

2) How far does a loop branch?

5

Identify the instruction for the jump, and fill in the constant needed to jump to that point.

Hint: This code increments i inside the loop until it reaches 10. At that point the loop should exit.

-3 instructions: -12 bytes, plus 4 bytes = -8 bytes

```
offset
 bytes
   -16   addi $t0, $zero, $zero     # i = 0
   -12   addi $t1, $zero, 10        # j = 10
    -8   addi $t0, $t0, 1           # i++
    -4   slt $t2, $t0, $t1
    -0   bne $t2, $zero, -3         #  jump to ?
```

-3 instructions: don't forget we always do PC+4!

10 minutes to work, then walk through the solution

Provide printed out copies of the questions

Active learning with peers

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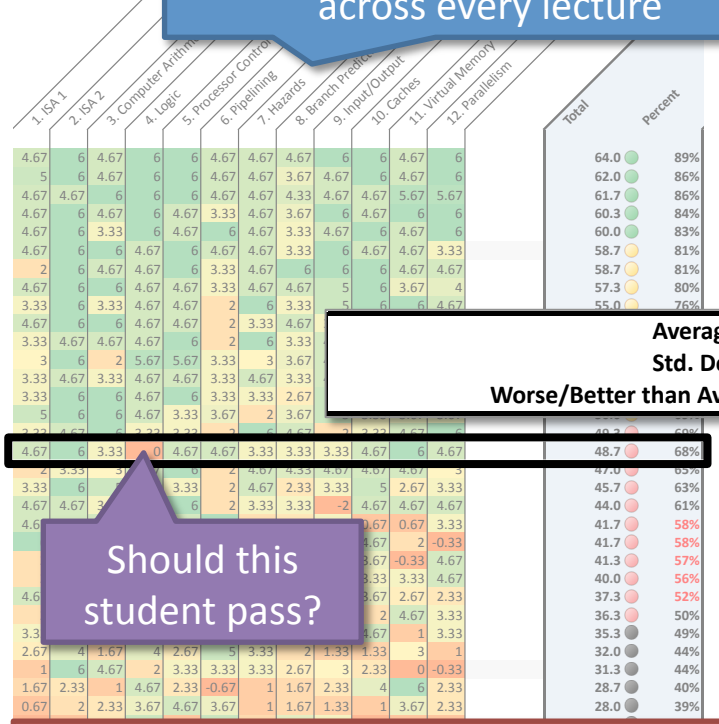
Exams: Connecting outcomes and teaching

(Not yet integrated)

72 short questions: test knowledge across every lecture



	1. ISA 1	2. ISA 2	3. Computer Arithmetic	4. Logic	5. Processor Control and Datapath	6. Pipelining	7. Hazards	8. Branch Prediction and Exceptions	9. Input/Output	10. Caches	11. Virtual Memory	12. Parallelism
Average	3.0	4.7	3.8	4.3	4.2	2.9	3.5	3.0	3.4	3.8	3.6	3.6
Std. Dev	1.8	1.6	1.7	1.4	1.7	1.8	1.6	1.3	1.9	1.9	1.8	1.9
Worse/Better than Average	-0.6	1.1	0.1	0.7	0.5	-0.8	-0.2	-0.6	-0.2	0.1	0.0	-0.1

Should this student pass?

Understand which lectures are working

Quantitatively tie exam performance to lecture content

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Results

- **Increased student interaction**
  - 20 seconds per lecture → **60 minutes per lecture**
  - *Every* student answers 10-20 questions *for every lecture*

- **Students loved it**
  - Online lectures and questions
  - In-class problem solving
  - Tremendous feedback to/from students

- Most fun **I've** had teaching in years

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5 LESSONS LEARNED

(although I don't have all the answers)

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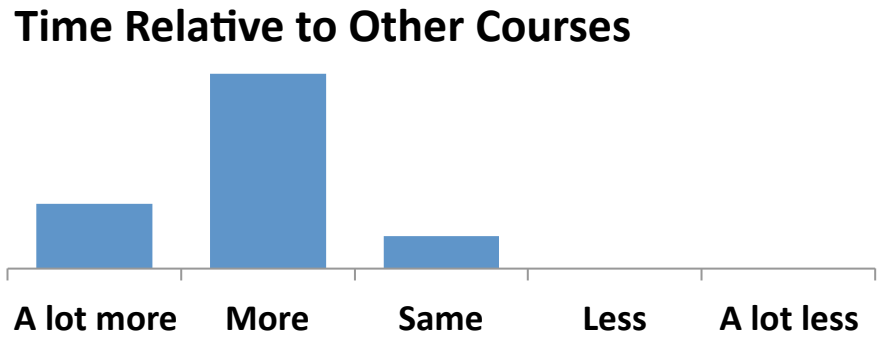
1. Students love this approach

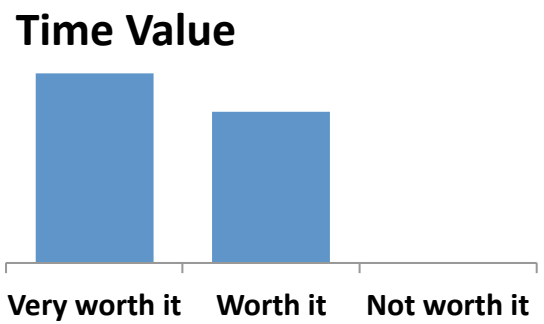
Takes more time, but worth it

- Resist required lectures and practice problems (at first)

Appreciate:

- **Interactive** lectures
- Rewind/**review** lectures
- Asking **questions** online
- In-class **practice** problems





Full course report available at: http://www.it.uu.se/edu/course/homepage/dark/ht12/course-report-draft-local.pdf

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Student Quotes

What was good?

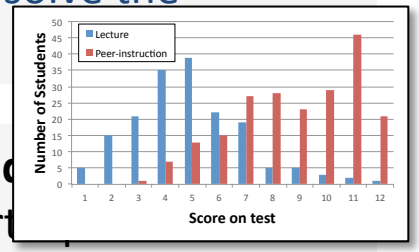
The whole concept of **video lectures is excellent**. It lets you play, repeat or pause. You **lose** the possibility of **dialog during the lectures**, but we get this at the **practice sessions** so this is not a problem.

What could have been better?

Always a **minimum of 2 questions on the quizzes**, and sometimes **more** of those questions in the middle of the lecture. Always a **footnote as well when getting the wrong thing on the quizzes**, it helps the learning.

I really **like the online lectures and I love the quizzes**.
I'm also **happy that the problem solving sessions are reasonably difficult** and that we have enough time so solve the problems. :D

In this course it was **manc** through **lectures** and part exercises which essentially **doubled the time** spent on the course.
I would benefit more from traditional exercise sessions = handouts + **teacher solves the given problems**.



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2. Awesome experience for the teacher

Interacting with the students

- Much more fun than lecturing
- Much more rewarding than lecturing

Know problem areas/questions before class time

- Prepare review material
- Prepare material to answer questions

Most fun I've had teaching in years

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3. Recording isn't the time-consuming part

Most common concern is extra time to record

- Record in 5-10 minute chunks
- Software/hardware cheap/free

If you have good lectures, then the recording is easy.

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4. Producing questions is hard

1 minute questions (online quizzes)
(10-20 per 90 minute online lecture)

- Identify key concepts from lecture
- Produce good multiple choice questions

10 minute questions (in-class)
(5-10 per 90 minutes of class time)

- Develop multi-part questions
- Address different student levels

100 minute questions (at home)
(1-2 per week of class time)

- Labs/essays (same as before)

What kind of questions?

How many questions?

How hard should they be?

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5. Adapting to feedback is hard

More feedback *per lecture* than for the whole class previously

- Great, but now I feel I have to re-do all my slides…
- How to triage comments?
- How to aggregate comments over time?

New types of feedback

- Confused/paused in the lectures
- Self-assessment quiz results

40% of the students point out errors

- Never happened before
- Depressing the first time

12 problems pointed out in one lecture

1. Q11.1.1 It was impossible to choose the right answer, because when I clicked submit button, canvas scrambled all the alternatives, but my answer didn't change with them.
2. Q11.4.1 I saw two "Need to uniquelu identify the data" – answers
3. One question had the same (correct) answer listed twice.
4. Q11.4-1. Same alternative is given twice but only one of them gives the correct answer.
5. Q11.4.2 What is difference between loading data into the cache and writing to the cache?
6. Q11.4: Two answers have the same text but only one of them is correct.
7. Q11.4 had two identical answers. The two last parts had an annoying sound in the background.
8. Quiz 11.4 Question 1 had two answers that were the same and only one of them was right.
9. Question 11.4.1 has two answers that say the same thing.
10. Slide 80: "% of cache misses = (#cache hits / #cache accesses)". Doesn't this formula rather give "% of cache hits"?
11. I assume that the calculation for miss ratio wasn't correct in the slide, % of cache misses =/= (#cache hits/ # memory accesses). The right part should be the hit ratio and thus the miss ratio should be 1 - hit ratio.
12. In the first examples in the last video, why was the cycle to access the cache counted twice if it was a miss? That is both hit and miss time are counted.

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THE FUTURE & CONCLUSIONS

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The Future

More teachers and courses (and move outside of IT)

Increase student interactivity

- More self-assessment quiz types (arrows, boxes, numeric, etc.)
- Peer grading
- Integration with exams (identify at-risk students early)
- Learn from other subjects what they need to teach

Reduce teacher overhead

- Better tools for teachers
- Best practices guide
- Enable sharing courses/content
  (between teachers, departments, campuses, universities)

Uppsala-Visby
Uppsala-KTH-Chalmers

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Would you like to try this in your class?

1. Contact me and we can discuss what you need

- david.black-schaffer@it.uu.se

2. Prepare a few test lectures

- Split into 5-10 minute chunks
- Develop in-lecture self-assessment quizzes
- Design in-class peer practice problems

3. Record

(Not the time-consuming part)

4. Test with your students

- Tell them why you are doing this
- Collect feedback

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Results

- **Increased student interaction:**
  - 20 seconds per lecture → 60 minutes per lecture
  - *Every* student answers 10-20 questions *for every lecture*

- **Students loved it**
  - Online lectures and questions
  - In-class problem solving
  - Tremendous feedback to/from students

- Most fun **I've** had teaching in years

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