“Flipping the Classroom” in an Introductory IT Course

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MOTIVATION
Active learning

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

How active are my lectures?

90 minute in-class lecture

30 minutes of questions (33%)

10 minutes of student questions (11%)

20 seconds per student (0.04%)

30 minutes answering questions $\rightarrow$ **99.6% passive** for students
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.
FLIPPING THE CLASSROOM
Flipping the Classroom

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Wasting a great resource

Much better use of the teacher

Ultimate goal: Fully active, Peer teaching
What is an “Interactive Lecture”?

Short lecture segments + self-assessment quizzes

Do interactive lectures help learning?

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

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
What Do 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 an Uppsala course
(Platform is a joint development project with the Swedish Institute for Computer Science.)
MAKING LECTURES INTERACTIVE
Making lectures interactive

1. Divide into 5-10 minute chunks
Making lectures interactive

1. Divide into 5-10 minute chunks
2. Organize
Making lectures interactive

1. Divide into 5-10 minute chunks
2. Organize
Making lectures interactive

1. Divide into 5-10 minute chunks
2. Organize
3. Add questions

This is the hard part.
- Choosing questions
- Writing questions
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

Speeding up branches

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

Correct

We access the register file in the ID stage, so we cannot move the branch calculation (which needs those values to know if it should branch) any earlier.
Interactive lectures

**Economics: supply and demand**

Draw an arrow showing what happens to the price as the demand changes as shown below.

Correct:
The price goes up because the supply is not completely elastic
Economics: supply and demand

Draw an arrow showing what happens to the price as the demand changes as shown below.

Increased demand increases the quantity sold for this demand curve

Correct:
The price goes up because the supply is not completely elastic.

History: The start of the First World War

Put the following events in order:

- July Ultimatum
- Russia mobilizes
- Austria-Hungary declares war
- Ferdinand assassinated
- Britain declares war on Germany
- Germany invades Belgium
- France mobilizes

Archduke Ferdinand assassinated
July Ultimatum
Austria-Hungary declares war
Russia mobilizes
Ferdinand assassinated
Britain declares war on Germany
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Germany invades Belgium
**Economics:** supply and demand

Draw an arrow showing what happens to the price as the demand changes as shown below.

![Diagram showing supply and demand](image)

**Increased demand increases the quantity sold for this demand curve.**

**Correct:** The price goes up because the supply is not completely elastic.

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**History:** The start of the First World War

*Put the following events in order*

- Ferdinand assassinated
- July Ultimatum
- Austria-Hungary declares war
- Russia mobilizes
- France mobilizes
- Germany invades Belgium
- Britain declares war on Germany

**Incorrect:** France initially redrew its troops from the border to avoid any incidents. It was only after Germany invaded Belgium that France mobilized.
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
Interactive lectures

**Economics:** supply and demand

**History:** The start of the First World War

**Art:** The Rococo color palette

**Computer Science:** Speeding up branches

- 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.

But now we need some extra hardware...

Many fields, many types of questions
IMPROVING IN-CLASS TEACHING

Using the information from the online lectures.
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.
Teacher’s View: Where did students have trouble?
Teacher’s View: Where did students have trouble?

Register in MIPS

- 32 General Purpose Registers
  - R0...R31 or $0...$31
  - Each is 32 bits wide
  - Values for instructions must come from registers
- Some are special
  - R0 is always zero
  - R29/R31 are used for function calls

Questions

Understand where students are confused and have questions
Teacher’s View: Responding to student feedback

Multiple choice

Free text
**Teacher’s View: Responding to student feedback**

Show the students you care about their feedback and questions.

- **Hide inappropriate/repeated questions**
- **Send the same answer to multiple questions at once**
- **Reply to anonymous questions and comments**
In-Class: Using the data to help teaching

In-Class View: Quiz Results

Memory and register file

How many memory locations do we need to fill a register in the Register File?

Student quiz results

Step through the question and solution
In-Class: Using the data to help teaching

In-Class View: Questions

Registers in MIPS

- 32 General Purpose Registers
  - Each is 32 bits wide
  - Values for instructions must come from registers
- Some are special
  - R0 is always zero
  - R29/R31 are used for function calls
- A few special registers
  - PC (Program Counter): current instruction

May I just point out that you showed R29/R31 (which sounds right) and immediately proceeded to say ‘R29 and R30, the last two registers’, which is also incorrect as R31 is the last register and R29 is thus obviously the third last register. Just saying.

Is R30 a usable register?

You say 29 and 30, the two last registers, but the text says 29/31... im confused.

R29/R31 the two last? What happened to R30?

Questions grouped by 30 second intervals

4 student had questions at the same place

Use online information easily in class
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

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

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

**This is the goal:**
Spend the in-class time working with the material, not lecturing!
In-Class: Peer learning with practice problems

2) How far does a loop branch?

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.

```assembly
addi $t0, $zero, 10  # j = 10
addi $t0, $t0, 1     # i++
slt $t2, $t0, $t1     
```

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

10 minutes to work, then walk through the solution

Provide printed out copies of the questions

Active learning with peers
Future: Connecting outcomes and teaching

72 short questions: test knowledge across every lecture

Quantitatively tie exam performance to lecture content
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**
5 LESSONS LEARNED

(although I don’t have all the answers)
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

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 mandatory to go through lectures and participate in practice exercises which essentially doubled the time spent on the course.
I would benefit more from traditional exercise sessions = handouts + teacher solves the given problems.
2. Amazing 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
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.
4. Producing questions is hard

1 minute questions (online quizzes)
(10-20 per 90 minute online lecture)
- Identify key concepts from lecture
- Produce good short 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)
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
THE FUTURE & CONCLUSIONS
Moving forwards

More teachers and courses (and move outside of IT)
  – Today: 10 courses, 500 students at UU, SU, KTH

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

Reduce teacher overhead
  – Funding for teacher time is key
  – Better tools for teachers
  – Best practices guide
  – Enable sharing courses/content (between teachers, departments, campuses, universities)
Key questions

Teaching:
- How do we provide *incentives* to teachers to adopt better methods? (time and motivation)
- How do we *learn* what works from our teachers? (tools and techniques)
- How do we *disseminate* what we learn?

Strategic:
- How much of our teaching time is *active* vs. *passive*?
- How much of our teaching time can be replaced with *online content*? (Harvard/MIT/Stanford)
- How can we shift to *interactive in-class teaching by default*?
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