Do this first

- Please logon here

  learningcatalytics.com
- Click on "create student account" → "I have a signup code" and provide your information – you can use a dummy email address etc.
- For signup code use:

  ZQA9M4P
- Once you are on the next page, use this session number:

  929606

Active Learning and Hardware Projects in (Microwave) Engineering Education

B. Pejcinovic & R.L. Campbell
Electrical and Computer Engineering
Portland State University
FER 23.10.2013

Before we begin

- “Learning results from what the student does and thinks and only from what the student does and thinks” - Herbert Simon (Nobel laureate in economics, etc)

Word of caution …

- Based on experience within US higher education system, but many conclusions are relevant for European and other contexts
- Not a review, but this work was influenced by many previous contributions: C. Furse, W. Heyward, D. Rutledge, K.C. Gupta, R.H. Caverly, Z. Popovic, and many others …
- A word about my own experience …

Organization

- Background and motivation
- Projects: why and how
- Lectures vs. active learning
- Implementation
- Results (work in progress)
- Suggestions and conclusions
- What can we do?

What’s up?

- Why can’t we do what we’ve always done?
- We are no longer in the business of information transfer
- Plenty of research → we can radically improve our students’ learning
- Many effective pedagogical approaches have been proposed and tested, but adoption of these methods in engineering is sporadic
- Engineering is very well suited for many techniques involving problem-solving and project-based learning

Opportunities and challenges

Research Based Instructional Strategies (RBIS)

- Active Learning
- Case-Based Teaching
- Collaborative Learning
- Concept Tests
- Cooperative Learning
- Inquiry Learning
- Just-In-Time Teaching
- Peer Instruction
- Problem-Based Learning
- Service Learning …
- (Q for audience)

- **"… engineering faculty members indicate that time to apply these approaches is the largest barrier to use."**

What’s up with MOOCs?

- Massive Open Online Courses – an online course aimed at large-scale interactive participation and open access via the web. In addition to traditional course materials such as videos, readings, and problem sets, MOOCs provide interactive user forums that help build a community for the students, professors, and TAs. MOOCs are a recent development in distance education. (Wikipedia)
- What’s all the hype about?
- More important: higher education system is scrutinized and serious alternatives, including MOOCs, are being developed at amazing speed
- **“Higher education must innovate in order to remain viable” (Moody’s)**

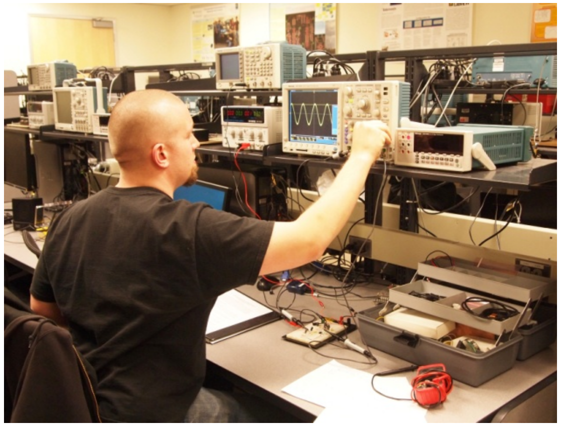
How do we capitalize?

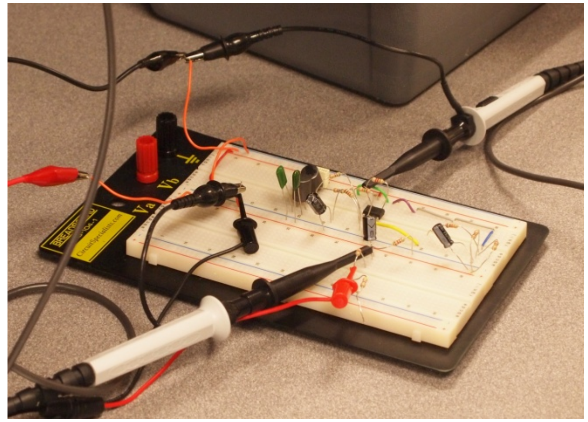
- Put student learning at the center
- Learn about instructional state-of-the-art
- Decide which instructional strategy is most appropriate for a given circumstances
- Give up lecturing as we know it (search for Eric Mazur's "Confessions of a converted lecturer")
- Implement assessment – demonstrate success
- Take advantage of technology – especially for hands-on and design

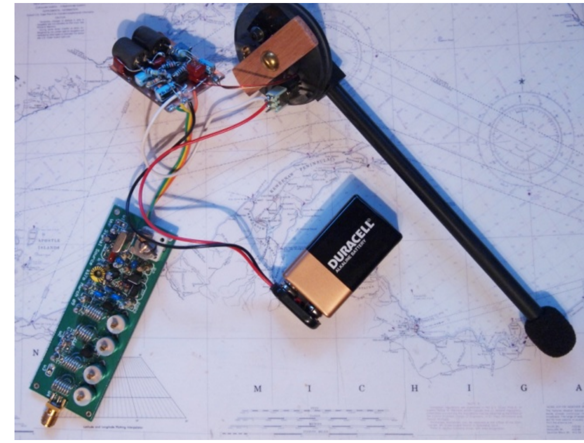
MW class projects

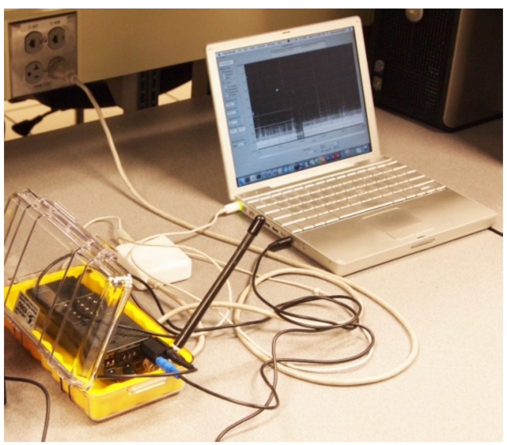
- Q for audience – what's your project? (LC)
- Least controversial – everyone (?) thinks that students should practice what they learned by implementing it in a more comprehensive, challenging way
- **Pros**: "real world", comprehensive, motivating, teamwork…
- **Cons**: can be difficult to implement well, require additional resources and time, teamwork, etc.
- Providing feedback and scaffolding is critical → more time
- Get to hardware ASAP – ~~perhaps~~ even before full theoretical understanding is developed
- Do not penalize students for failure!

Hardware projects - Style 1



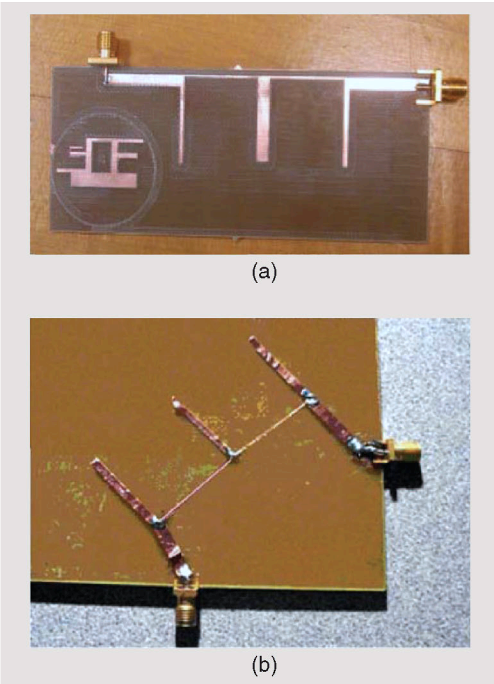




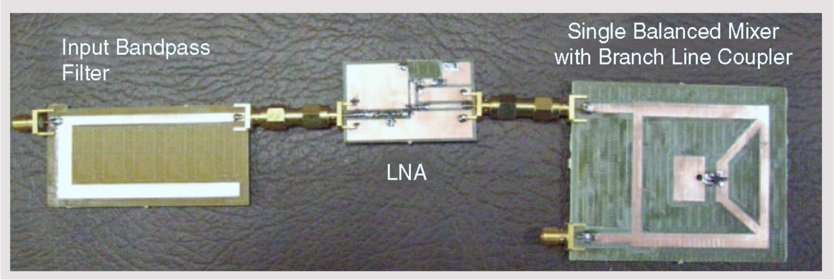


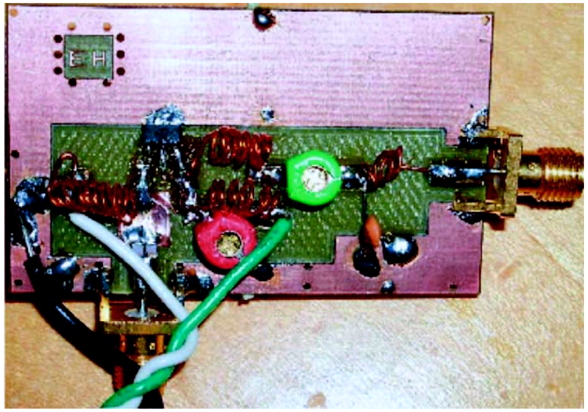
- R.L. Campbell, PSU, Instrumentation course, 2013
- Choose an instrumentation problem that complements current departmental research
- start with a basic need, make a few assumptions and initial measurements, and then draw up a set of specifications → provides a sense of authenticity
- Deploy it as part of a system
- Iterate: design – build – test

Hardware projects - Style 2

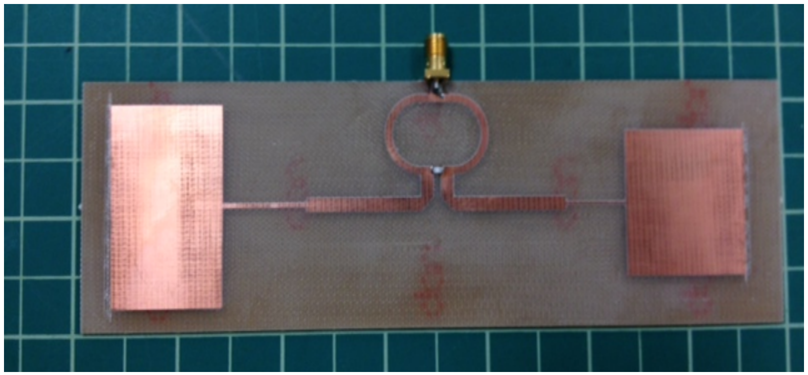


- R. Caverly, Villanova, RF Circuit Design course
- Uses "sticky-tape" technology for quick turn-around
- Design from components to systems
- Design-build-test
- (Ref. [9] in paper)

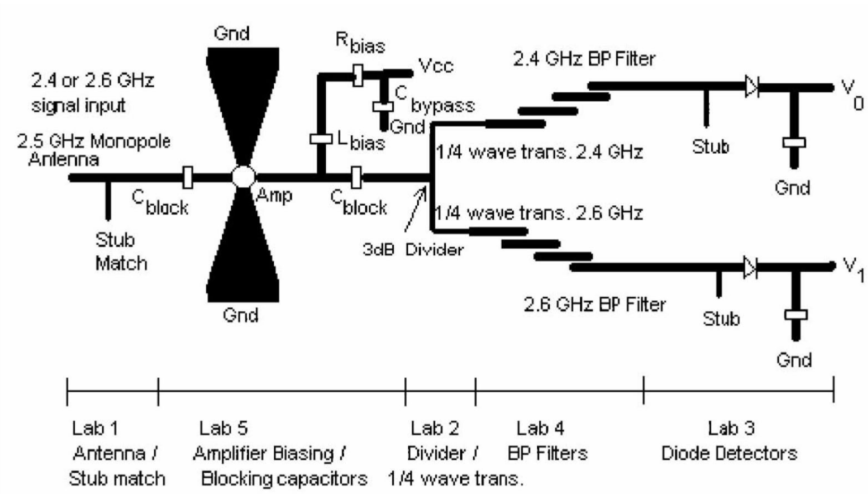


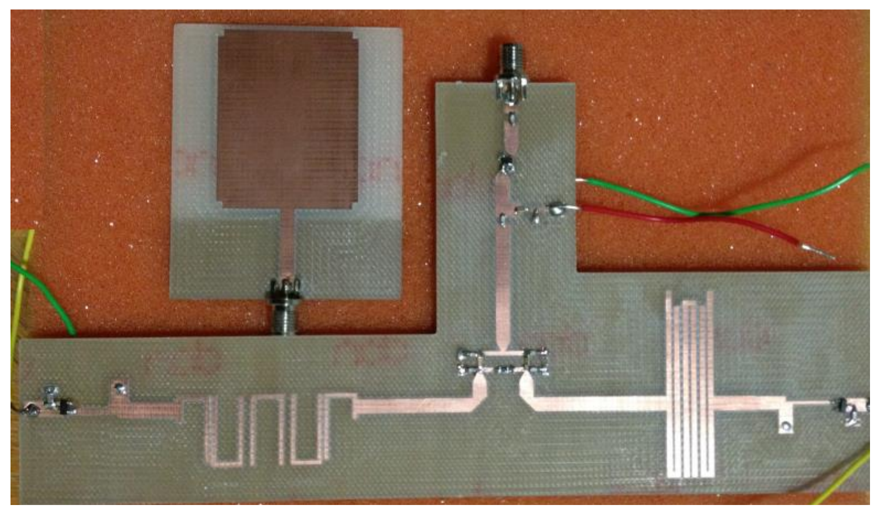


Hardware projects - Style 3



- C. Furse et al. (Utah, 2004) & B. Pejcinovic (PSU, 2013)
- FSK receiver
- Component and system design-test-build
- Entire system is student-designed and student built using EPL facility





Where & how is this happening?

- Labs can be an issue (cost, space, staffing)
- We have the luxury of state of the art EMAG lab with 4 TDR scopes and 4 20 GHz VNA-s + other equipment
- BIG addition - Electronics prototyping lab:
  - Volunteer run, open to all students
  - Walk in with gerber files and walk out with a packaged circuit
  - http://psu-epl.github.io/

Labs at PSU

EPL:
- PCB router
- laser cutter,
- reflow oven,
- 3D printer
- Etc.

EMAG:
- 4x 20 GHz VNA
- 4x 20 GHz TDR
- 6x MW Spectrum analyzers
- 2x LCR meters (SMD)
- Optics
- Etc.

What about cost?

- Not all of this equipment is required to set up a "design-build-test" cycle – there are cheap(er) options:
  - Reduce no. of instruments; buy cheaper versions of instruments; work with sticky-tape; work at lower frequencies and scale up; build your own instruments, use PCB foundries, …
- Set up a volunteer run, "open-access" hardware lab (some seed funding is needed)
- Have students in class help "manage" this lab

Active learning in classroom

- What's wrong with lecturing?
- Let's examine how we got here …
- And look at one implementation example

Classroom instruction: 1910

http://www.takepart.com/photos/classroom

1930

1960


Marco Polo
Leif Ericson
Americus Vespucius
Christopher Columbus
Bartholomew Dias

1990

2012

One example

- Two-quarters (10+10 weeks) of Microwave Circuit Design
- Course objectives:
  - Design, build and test passive circuits (microstrip and SMD)
  - Design, build and test active circuits (low-noise amplifier, mixer, power amplifier)
  - Design circuits using simulation tools
  - Measure real circuits at microwave frequencies and apply de-embedding and calibration
  - Write good quality reports
  - Read, comprehend and explain technical literature

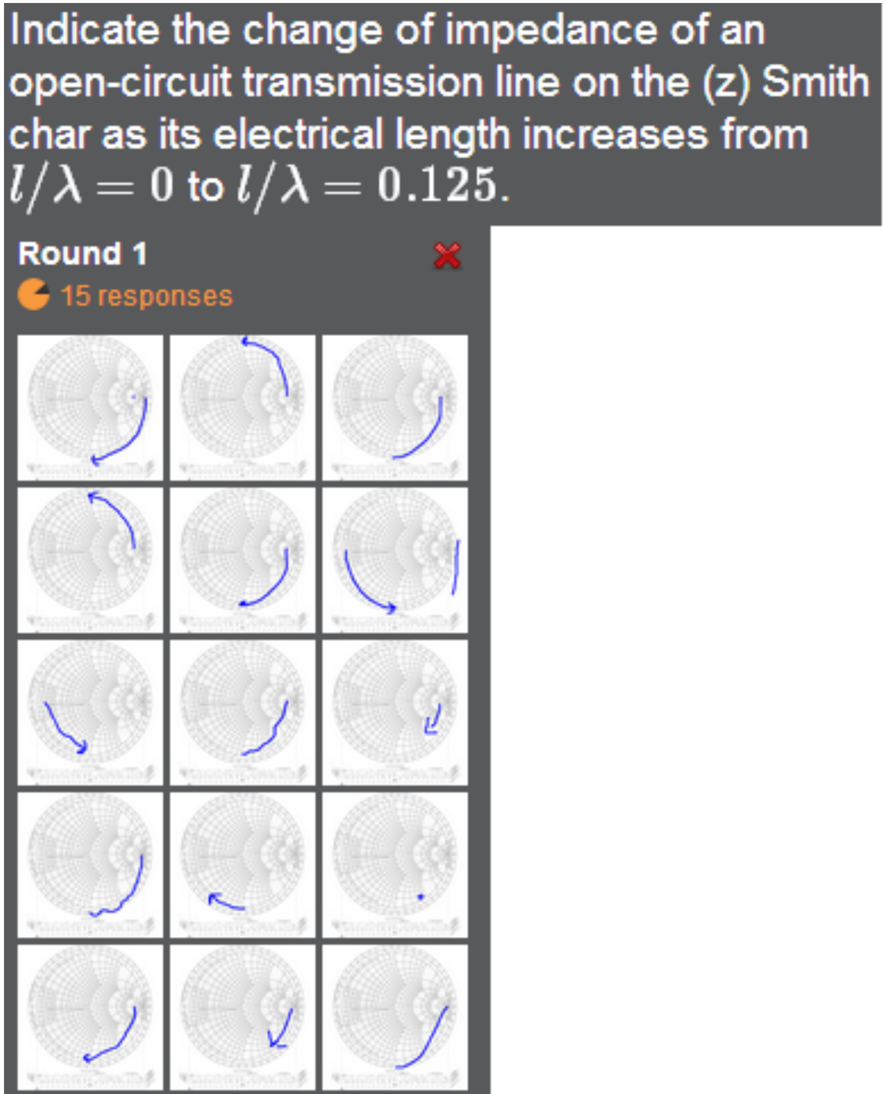
Redesign

- Emphasis on:
  - **Doing should replace listening during face-to-face classroom time**
  - Students should produce something tangible
  - Students should be engaged in their learning
  - Make immediate feedback a priority
  - Provide multiple ways to retrieve recently learned concepts
  - Push students into using higher cognitive functions, but
  - Provide appropriate scaffolding
  - Have multiple opportunities for design cycle: design → build → test → redesign
- Expectations: attendance & participation, 3 hour weekly “labs”, weekly activity reports, HW, project reports
- Effort: (guess) 15-17 hours a week

Q for audience

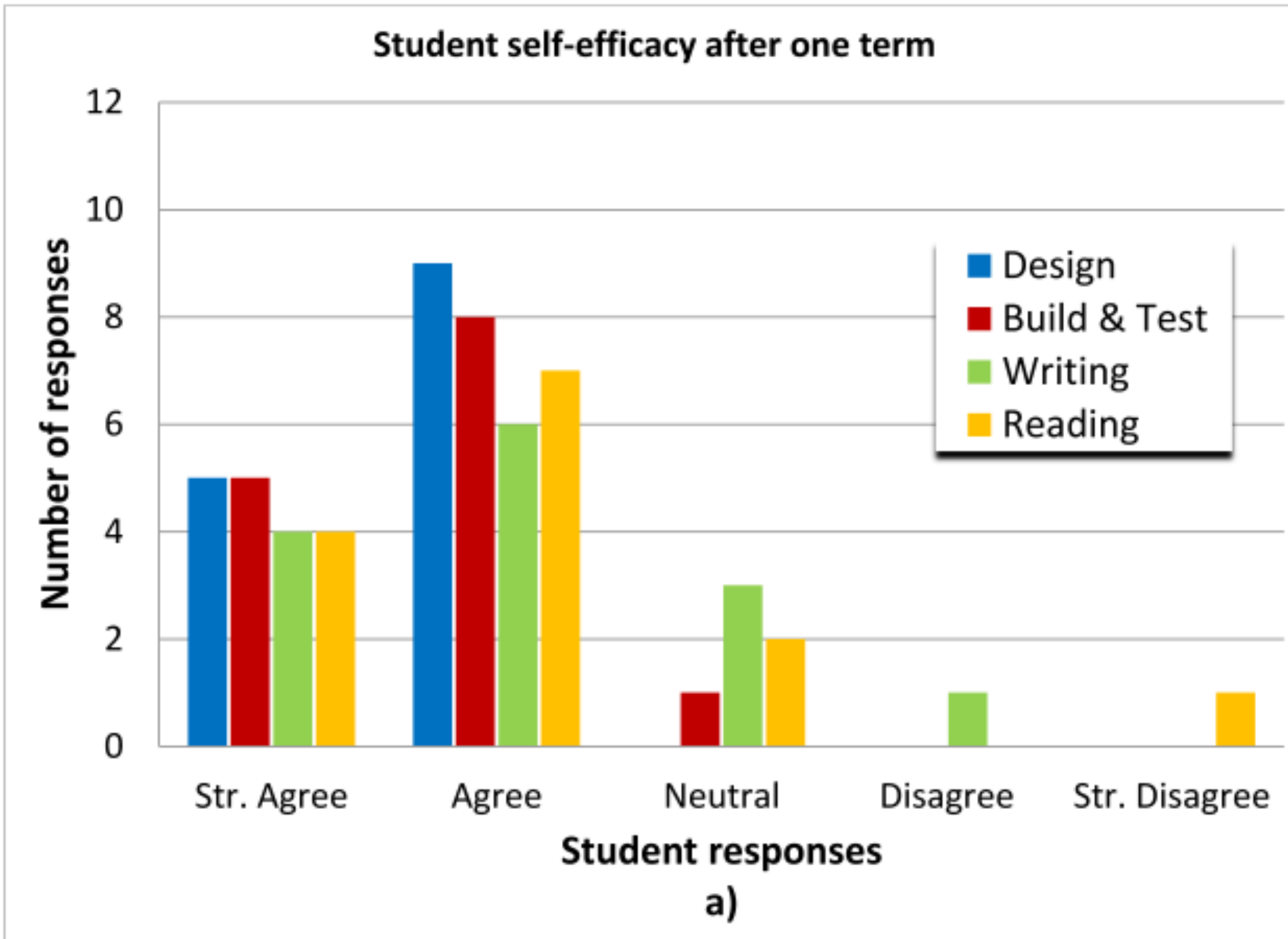
- What are one or two misconceptions that you have observed in your students?
- Couple more examples from LC

Learning Catalytics for in-class activities

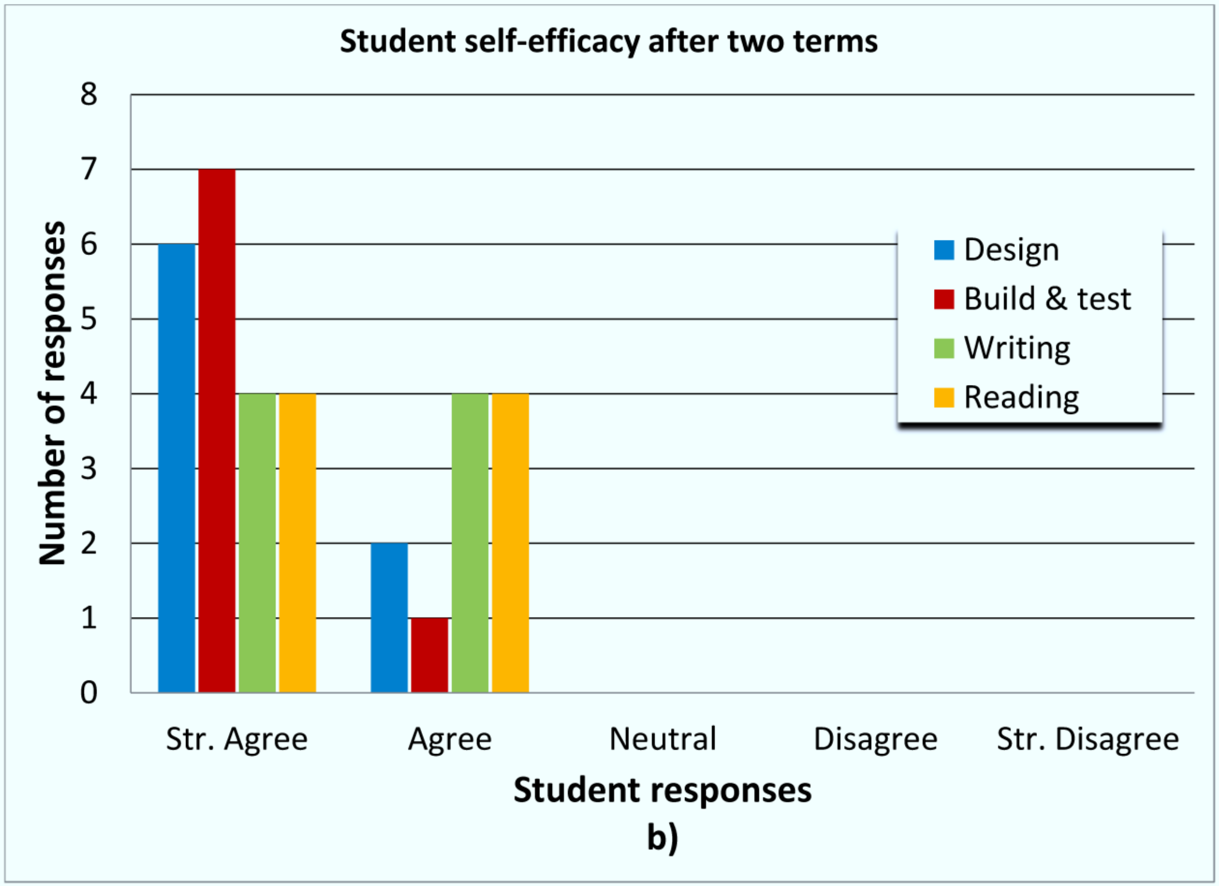


- "clickers" are very sophisticated classroom interaction systems
- All students participate
- Immediate feedback to you and students
- Adjustments
- Wide variety of questions and tasks

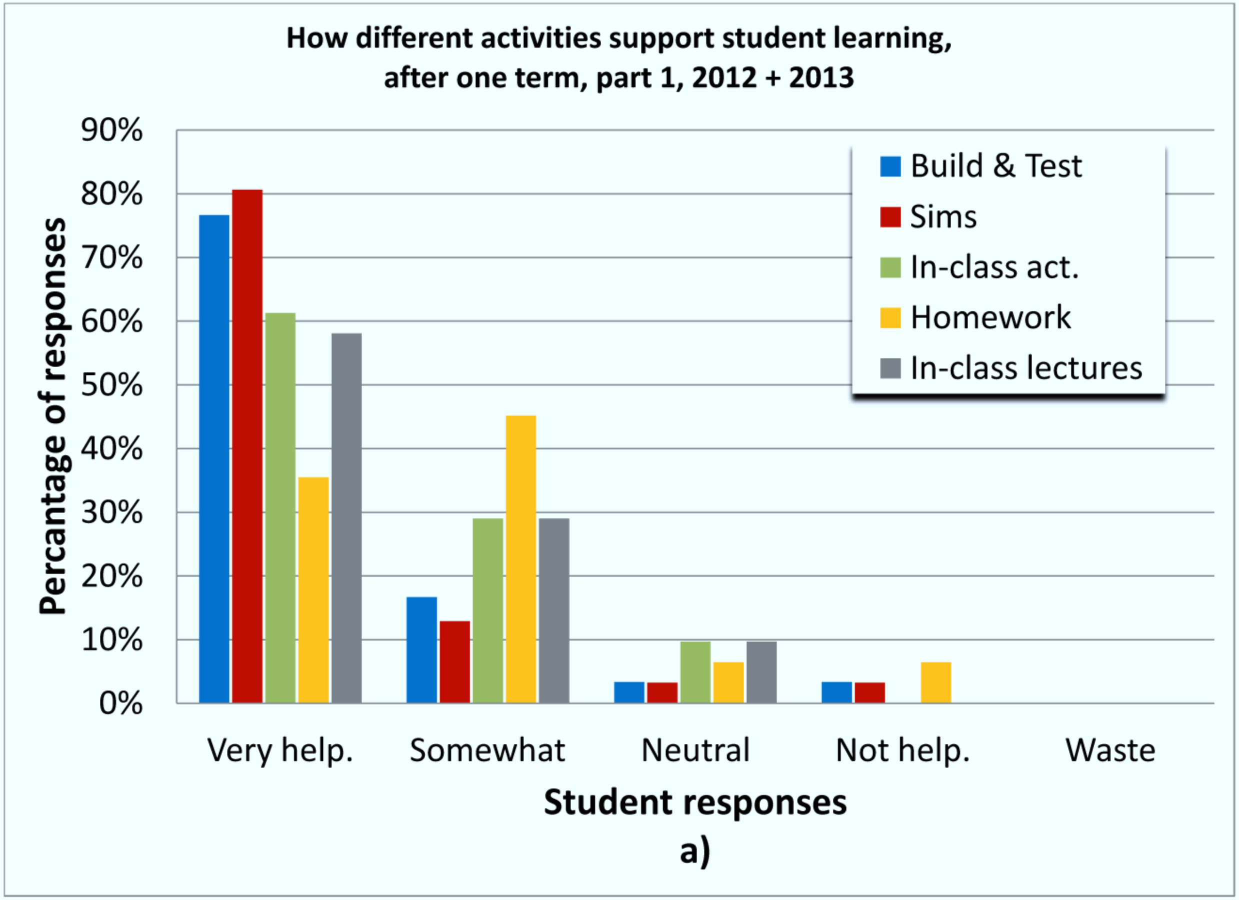
I am confident that I can: design microwave circuits, build and test microwave circuits, write good quality reports, read and understand technical publications



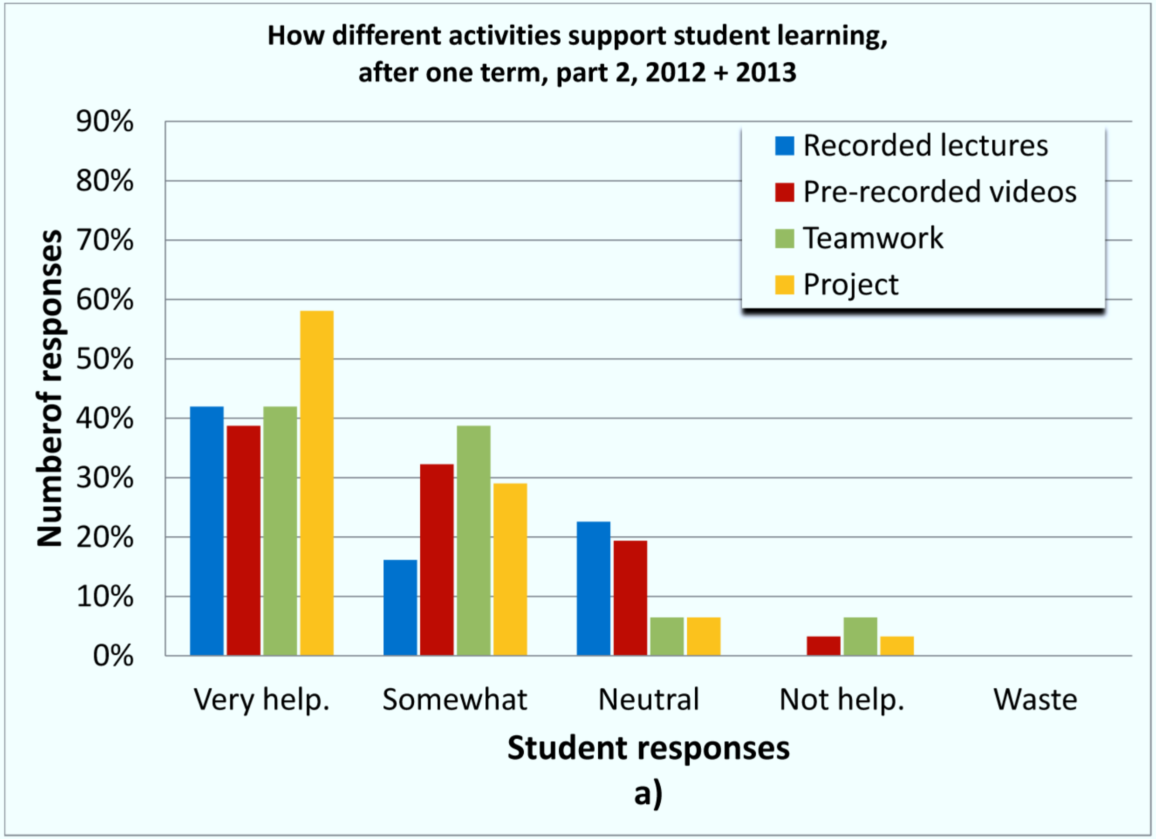
I am confident that I can: design microwave circuits, build and test microwave circuits, write good quality reports, read and understand technical publications



Effectiveness of various instructional techniques



Effectiveness of various instructional techniques



A few suggestions

- Design your course with meaningful objectives
- Incorporate projects and give students freedom to explore
- Move to active learning for face-to-face time
- Make labs interactive
- Provide immediate feedback
- Watch Eric Mazur’s talk
- Visit Richard Felder’s web site (NC State) www.ncsu.edu/effective_teaching and check his “Random Thoughts” column

Conclusions

- Introduction of active learning into lectures, redesign of labs and addition of projects has been very successful.
- This is only a (small) example of what can be accomplished, but many of the techniques used can be transferred to other courses and institutions
- In our program we will continue with even more ambitions reforms, such as introduction of project-based learning and introduction of flipped-classroom instruction.

Conclusions

- **Many good, research-based solutions exist → move to implementation**
- **This process of experimentation, continuous improvement and implementation of research-based instructional strategies is essential for continued relevance of college-based (microwave) engineering education.**

What else can be done?

- Providing support for “early adopters” is important
- “Community of practice” – what is it and why?
- Run a series of small(er) workshops discussing research-based principles of course design
- Discuss literature on education research
- Exchange of experiences and practical ideas