The Teaching of Process Control

Preliminary Results from the 2015 AIChE Education Division Survey

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Education Division

Survey Background

- AIChE Education Special Projects Committee conducted surveys from 1965-1993
  - Examined demographics/statistics
  - Probed for innovative and effective teaching methods
- Topics were curricular and pedagogical
- Surveys resumed in 2009 following that model
  - Freshman Introduction (2009), Kinetics and Reactor Design (2010), Material & Energy Balances (2011), Design (2012), Electives (2013), Transport Phenomena (2014)
  - The curriculum as a whole is planned for 2016, with Safety to follow in 2017

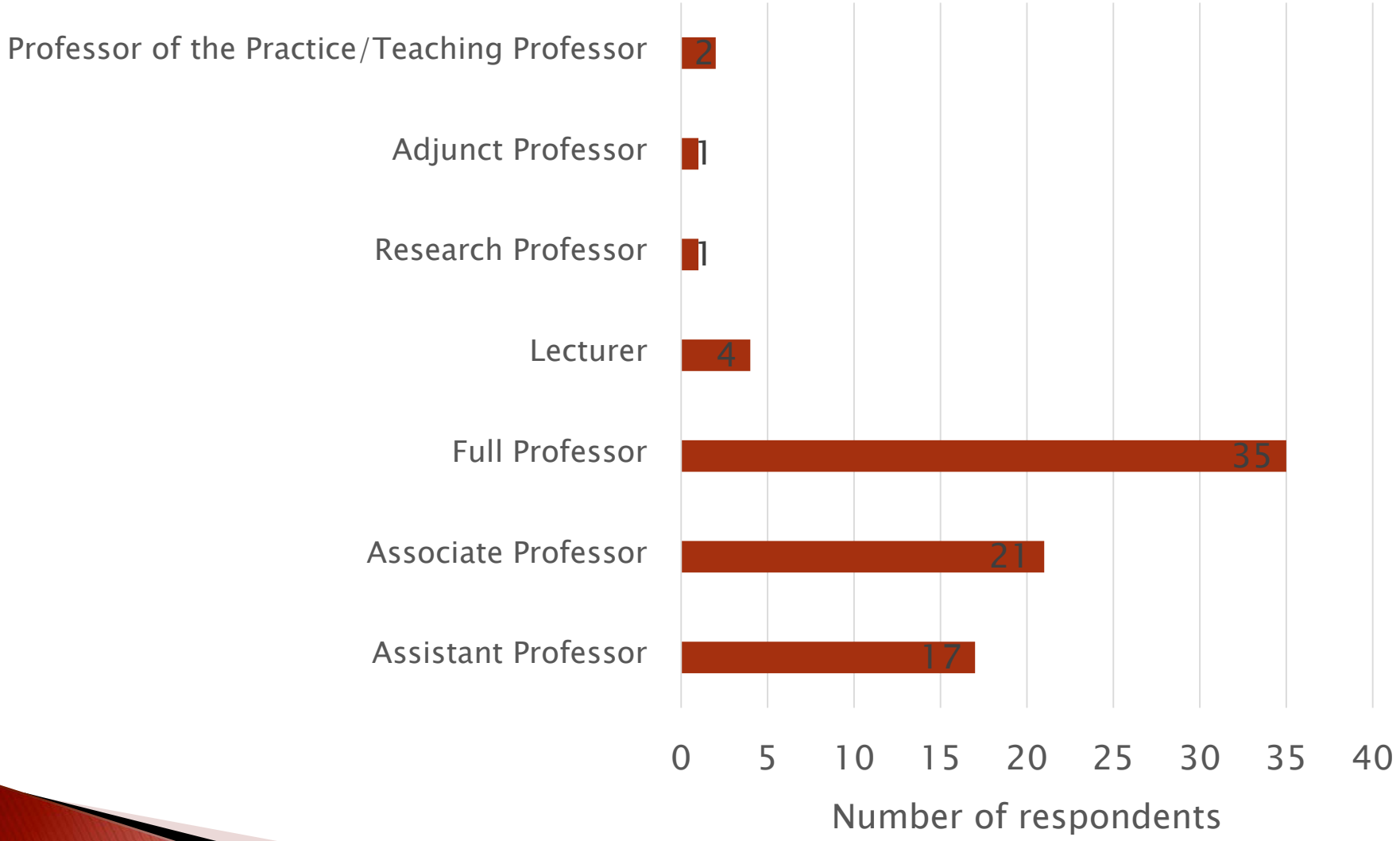
Methodology

- Implemented via the Web using LimeSurvey, an open source survey software package
- Questions designed to generate
  - Statistical demographic data
  - Examples of effective teaching methods in use
- Department chairs asked to request appropriate faculty members to respond
- Faculty members teaching the course in 2014-2015 based on public records asked to respond

Summary

- 158 schools in the U.S. invited to respond
  - 81 usable responses
    - 4 institutions had multiple responders
- 77 U.S. institutions represented
  - 48.7% US Institutional Response Rate
    - 37% in 2012
    - 42% in 2011
    - 38% in 2010

Who's Teaching?



Got Experience?

- 81 instructors responded
  - 18 indicated no industrial experience (22%)
  - Average industrial experience
    - 4.1 y amongst all instructors
    - 5.2 y amongst those with experience
  - Median Experience was 2 years

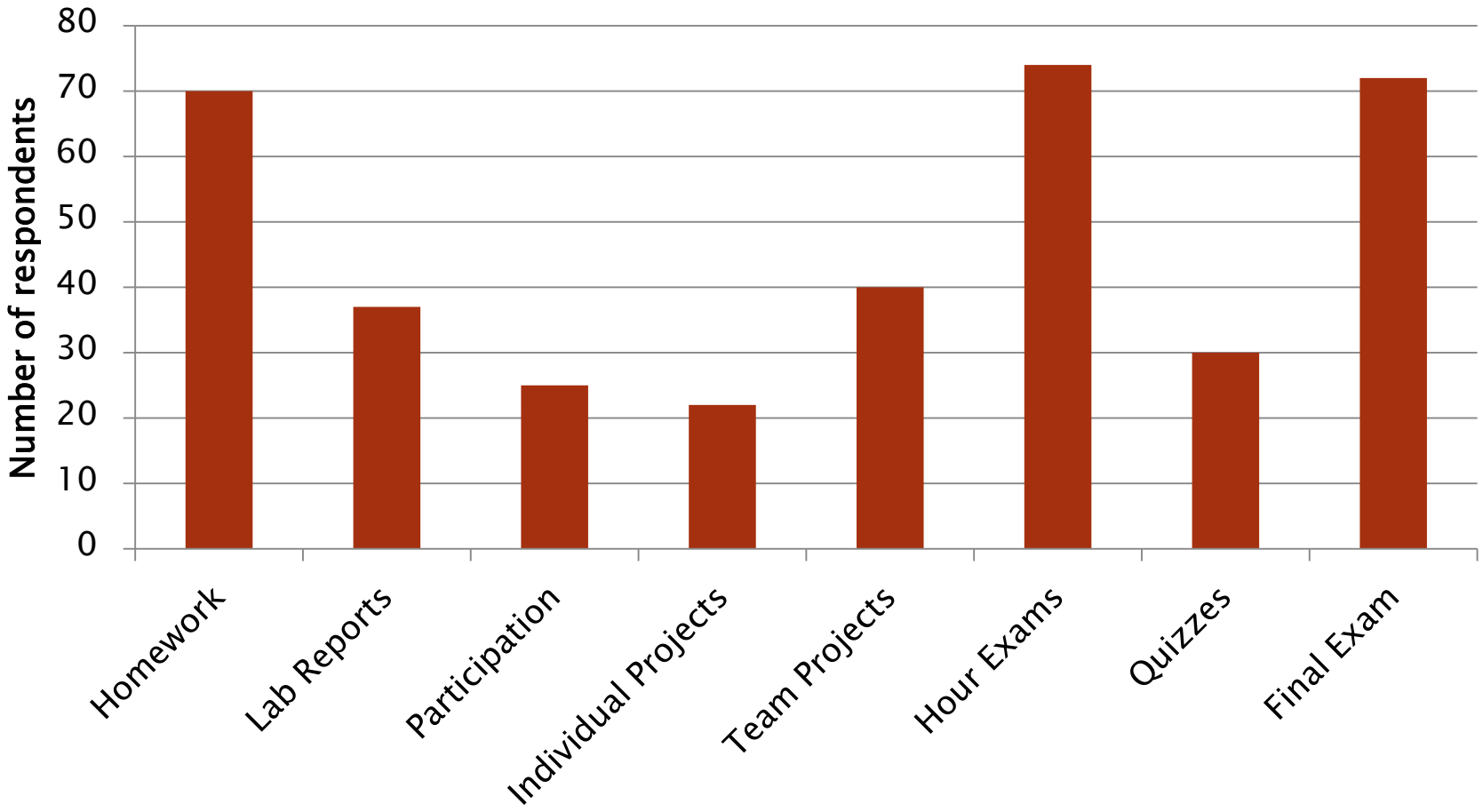
- For Design, the averages were
  - 9.0 y amongst all instructors
  - 11.3 y amongst those with experience

Quantity of Instruction

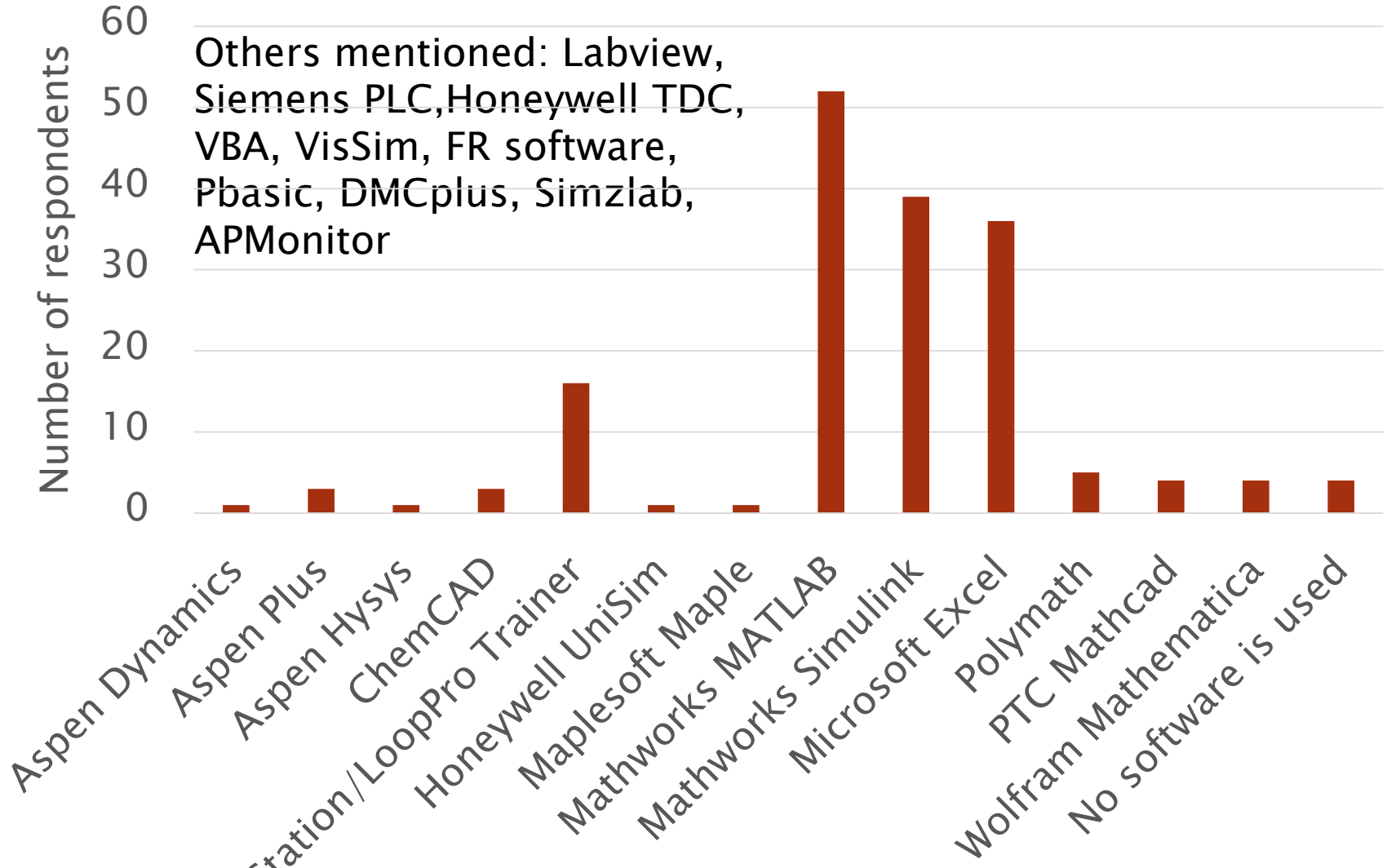
- Number of courses
  - 68 institutions had 1 required course
  - 7 had more than 1 required course
  - 2 reported coverage in a required course plus 1 or more electives
  - 2 reported only elective coverage

- Hours coverage
  - 40 on lecture
  - 10.8 on simulation/problem laboratory
  - 7.1 on experimental laboratory
  - When integrated into other courses, coverage was 18.8 hours lecture

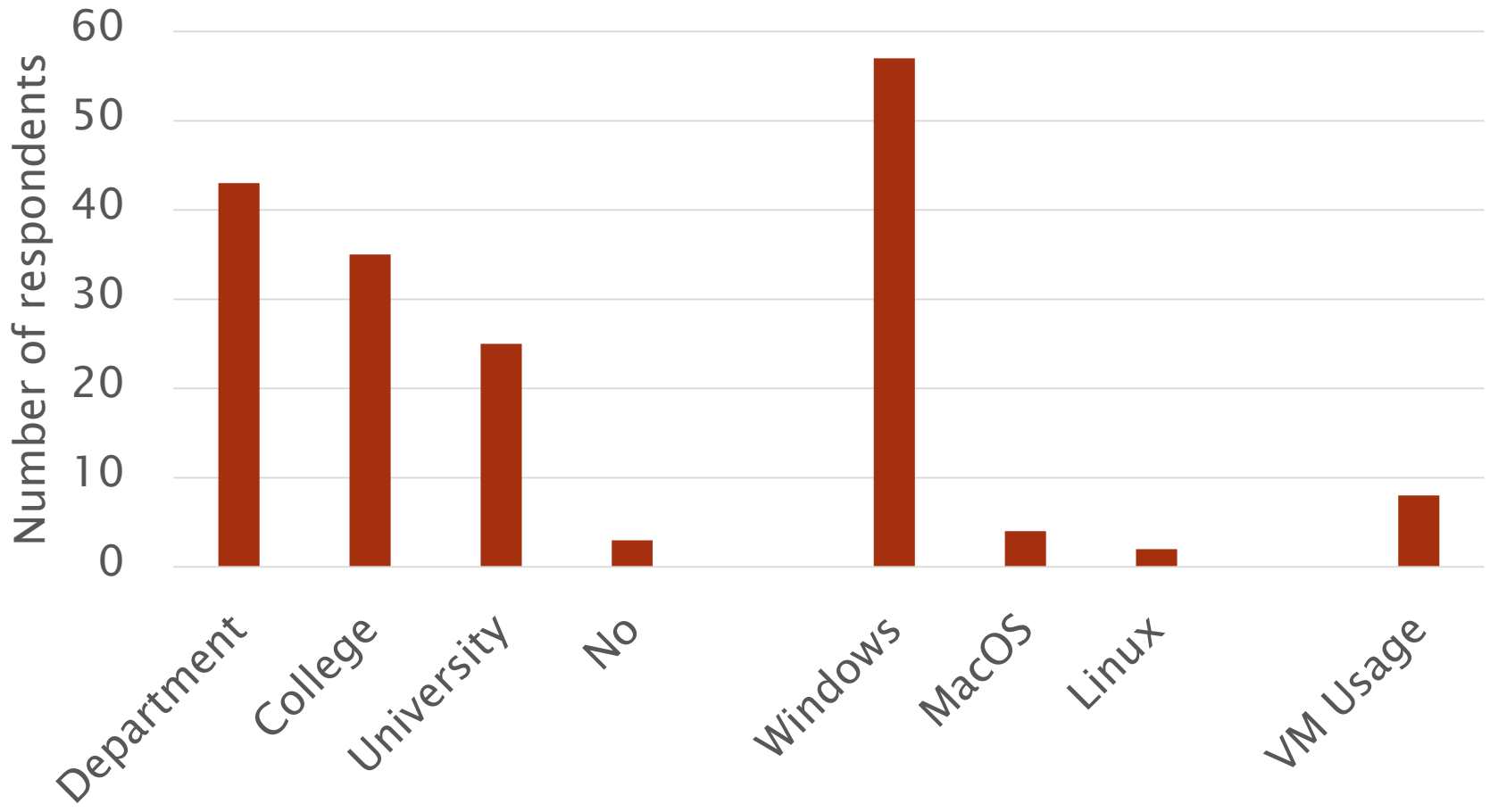
Grade Components



Software Usage



Computing Facilities

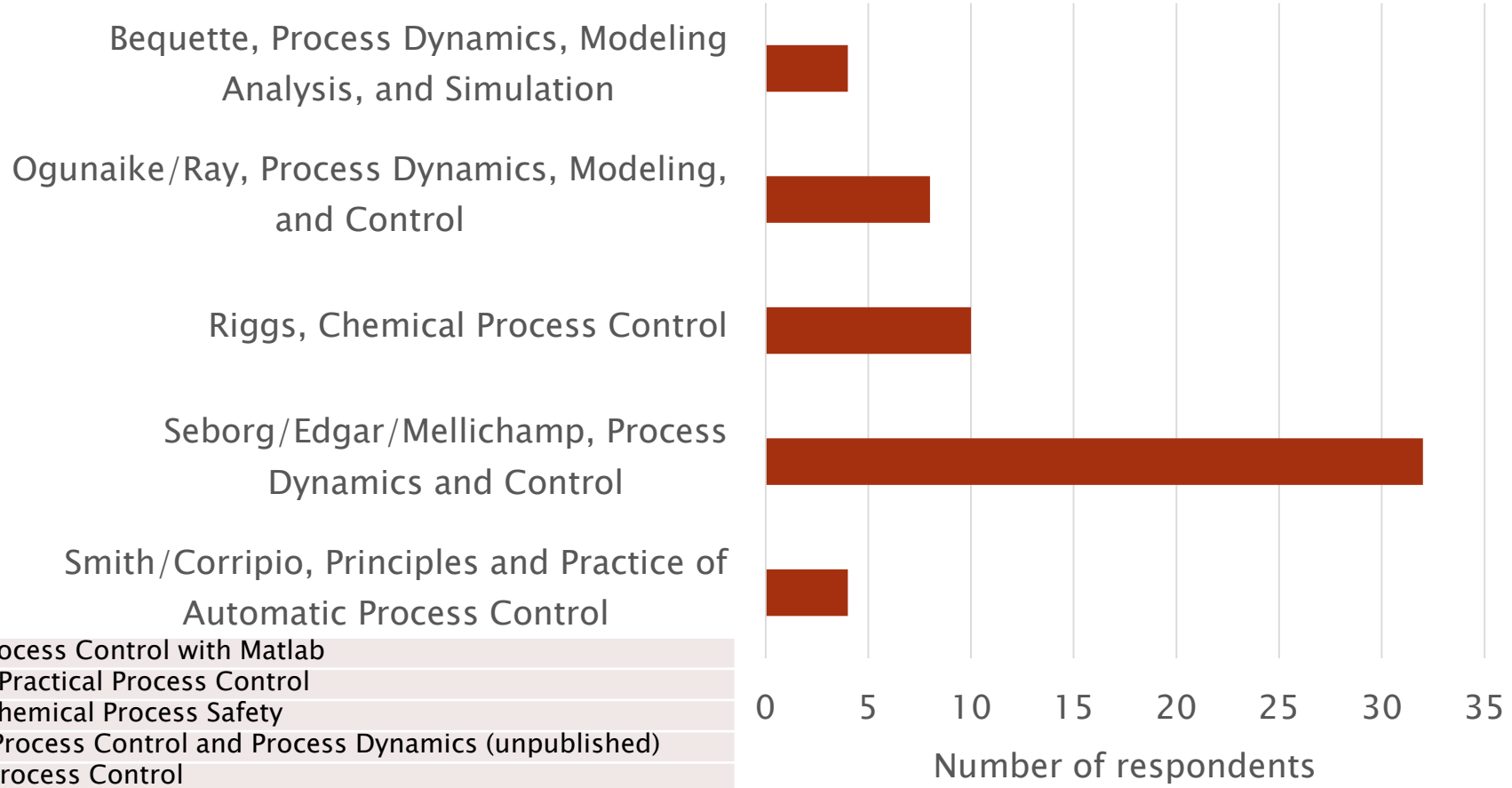


Beyond the Instructor

- 19 (23%) respondents indicated TA's played an instructional role (lectures, recitations)
  - Average 20% of lectures given by TA
- 17 (21%) respondents indicated use of industrial partners or adjuncts
  - Consultant to instructor
  - Guest lecturer
  - Project source
  - Feedback via advisory board

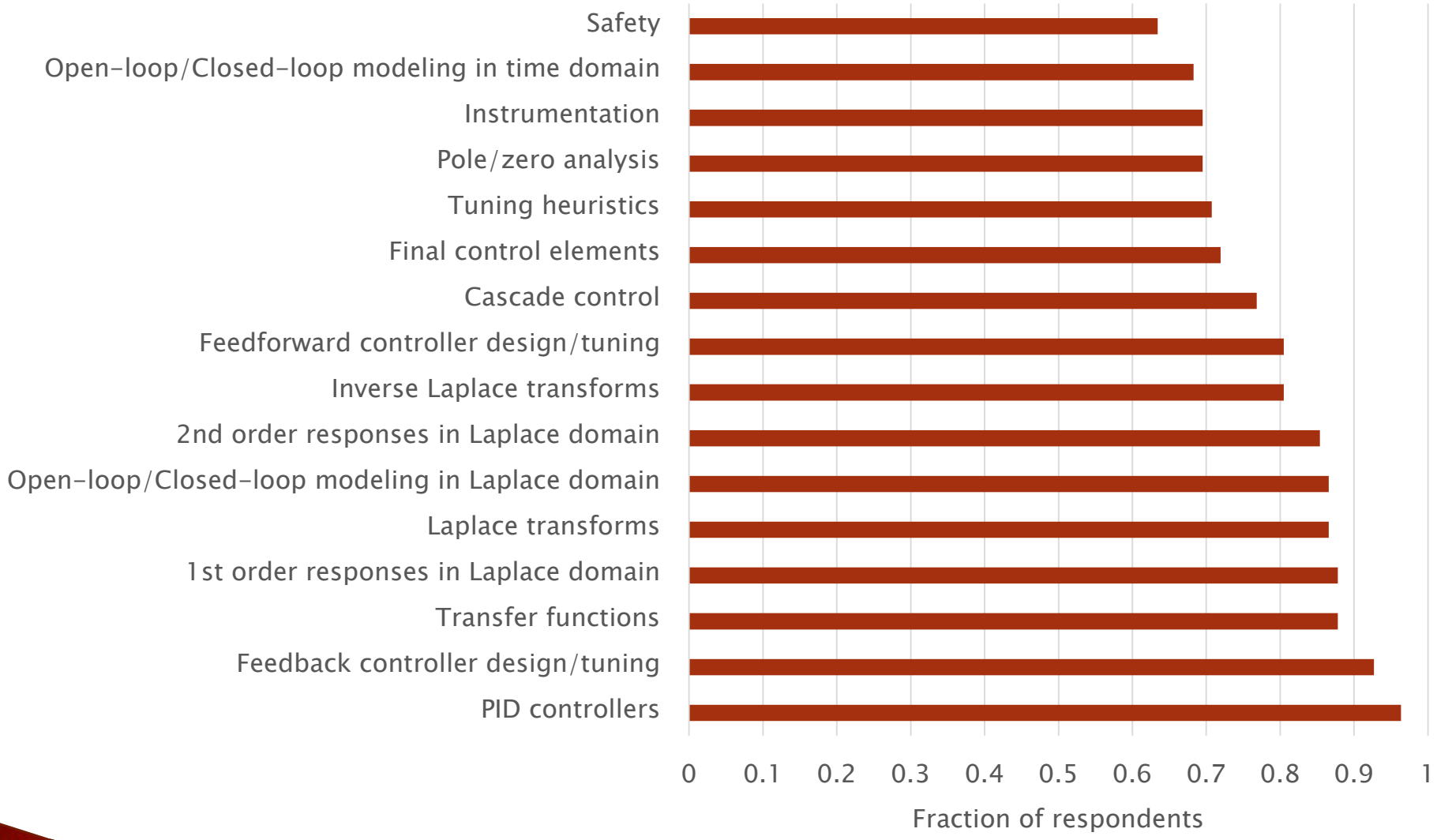
  - 10% of lectures by industrial guests among those reporting

Textbooks

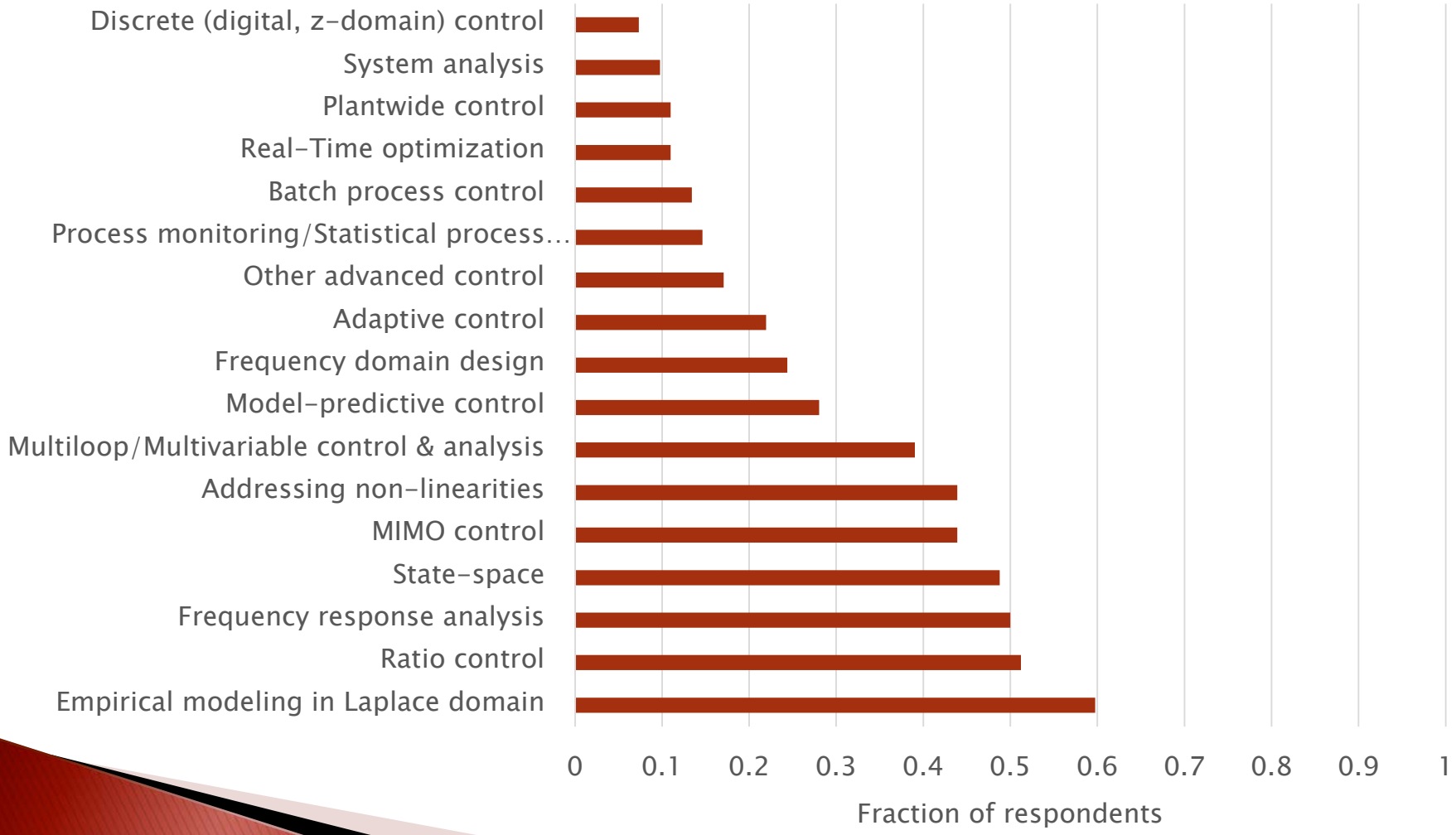


- Chau, Process Control with Matlab
- Cooper, Practical Process Control
- Crowl, Chemical Process Safety
- Larsen, Process Control and Process Dynamics (unpublished)
- Marlin, Process Control
- Ogata , Modern Control Engineering
- Simon, Control of Biological and Drug-Delivery Systems for Chemical, Biomedical, and Pharmaceutical Engineering
- Stephanopoulos, Chemical Process Control An Introduction to Theory and Practice
- Svrcek/Mahoney/Young, A Real-Time Approach to Process Control
- Class notes

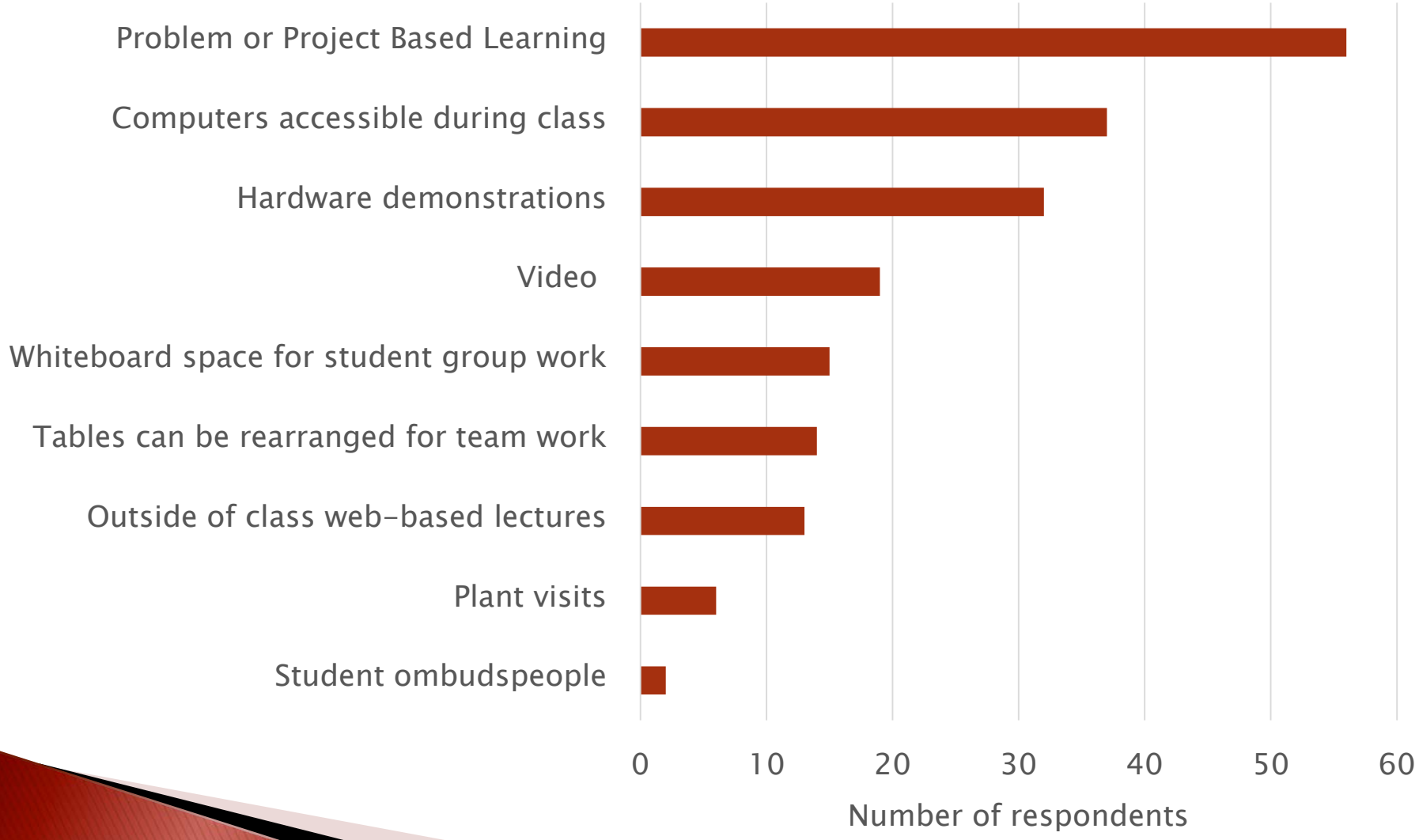
Topics Covered



Bottom Topics Covered



Learning Activities



Additional Courses and Tracks

- Most common answer: None
- Nine schools said there was at least one upper level / grad elective course
- A number of schools mentioned control concepts appearing in design or UO/other stand-alone lab courses

Text Improvements Sought

- Less emphasis on Laplace (outnumbers “more emphasis on Laplace” 7:1)
- More laboratory and “real world”
- More computational laboratory

Best Examples

"Day 1 – I ask if students have ever used a process controller. Several typically raise their hand and describe industrial experiences (great!). I think ask the class to stand up – woh! How did the steady state of the class change, I ask. I talk through the process of how some sounds are heard by their ears (sensor) which is converted into a signal sent to their brain (controller) which interpreted that signal and sent a new one to their legs/muscle (valves), which changed the state of the system. So we are all feedback process controllers!"

Biggest Teaching Challenges

- MATH (by far most comments)
- The need for more connections to the “real world”
- Time and timing (senior year, often; one semester only, often)
- Class size
- “Students with co-op/internship experience seem to be WELL ahead of those that lack it.”

Recent Changes to Teaching

- Exclusively time-domain instruction
- Increased use of simulations
- Fewer experiments (mostly due to increased enrollment)
- Flipped classroom approach (mixed reviews)

Use of the Internet

- Videos for “real-world connections”
- Course management systems
- Textbook websites
- Online software tutorials

Distinctive Features

- Practical
- Integrated lab experience (hands on or simulations)
- No Laplace
- Group/Design project
- “Class starts with a simulation game in which the students manually control the flow rate of a reactor that can blow up. The average squared error is tracked and the 3 students who complete the simulation with the lowest error receive award certificates. Approximately half of the class blows up. Then the performance of the same simulation under a well tuned PI controller is shown. It far surpasses the best manual performance. This motivates the class.”

Future Work

- Paper to be submitted for 2016 ASEE Annual Conference Proceedings with more detail and historical comparisons
- Paper with detailed responses will be sent to all survey responders requesting the report and to all Department Chairs current on the Education Division List
- A second survey in the next few months of industrial practitioners will address the same list of topics of interest
- Next year's topic will be the ChE Curriculum
  - Led by Margot Vigeant with Kevin Dahm & David Silverstein

Acknowledgments

- All of the instructors who completed the survey
- All of the department chairs who passed on the request
- CACHE Corporation (cache.org) and its Trustees who reviewed the survey
- University of Kentucky ECS
- www.limesurvey.org

AIChE Education Division

And Now We Build Out the Survey

- What is the significance of industrial experience?
- How do we address the apparent gap between what we teach and what industry expects?
- Is Laplace domain essential?
- How do we bridge theory to practice effectively?

For further information

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