How we teach: Chemical Engineering Thermodynamics

AIChE 2018

The AIChE presentation is the preliminary presentation of these results. For the "archival" version of results, please reference the forthcoming proceedings paper from ASEE 2019; because that version of the results will incorporate any late survey responses, results may change slightly

Overview

- Survey Results - Margot Vigeant
- Perspectives on Thermodynamics - Don Visco
- Audience participation & Discussion - Everyone! Facilitated by David Silverstein

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Survey Results - AIChE EdDiv Survey Committee Report

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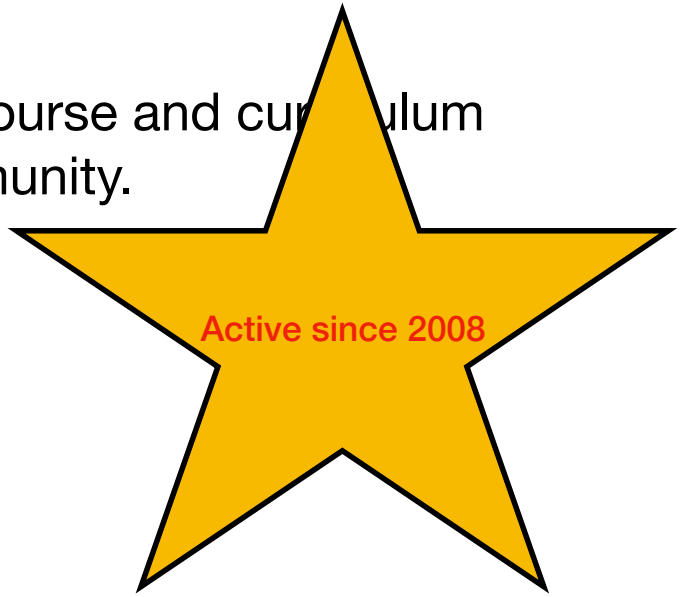
Mission - AIChE EdDiv Survey Committee

- The AIChE EdDiv Survey Committee is a volunteer group that seeks to compile, analyze, and broadly share timely and comprehensive information with the chemical engineering community on the content, pedagogy, and implementation of undergraduate chemical engineering courses and curricula.

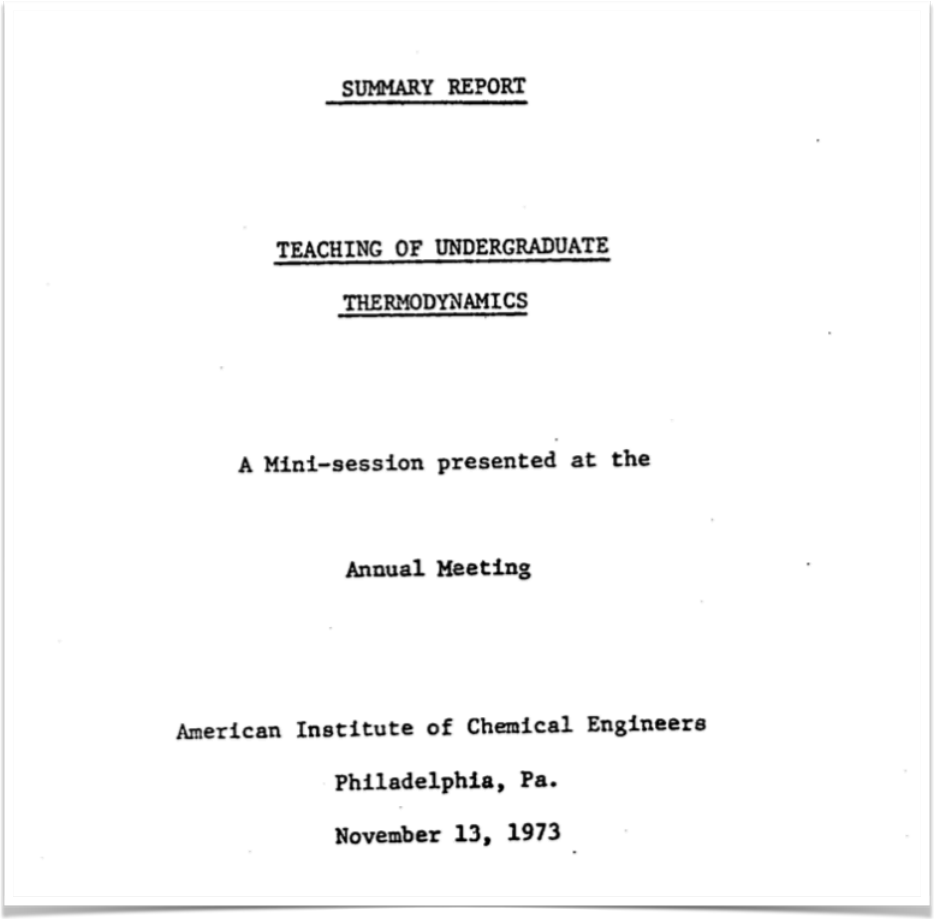
- The goal of our work is to enable more informed course and curriculum design throughout the chemical engineering community.

ALL past surveys linked here!



Previous Thermo Surveys

- 1973
- 1976
- 1982
- 1992 <—- Used for comparison here, where possible



SUMMARY REPORT

TEACHING OF UNDERGRADUATE

THERMODYNAMICS

A Mini-session presented at the

Annual Meeting

American Institute of Chemical Engineers

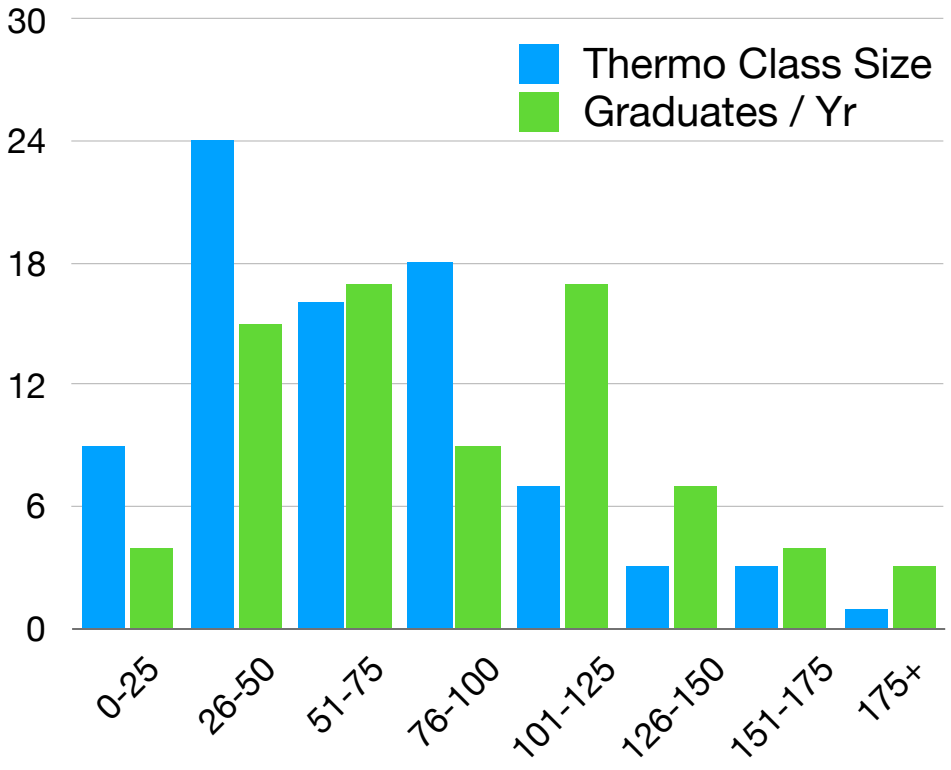
Philadelphia, Pa.

November 13, 1973

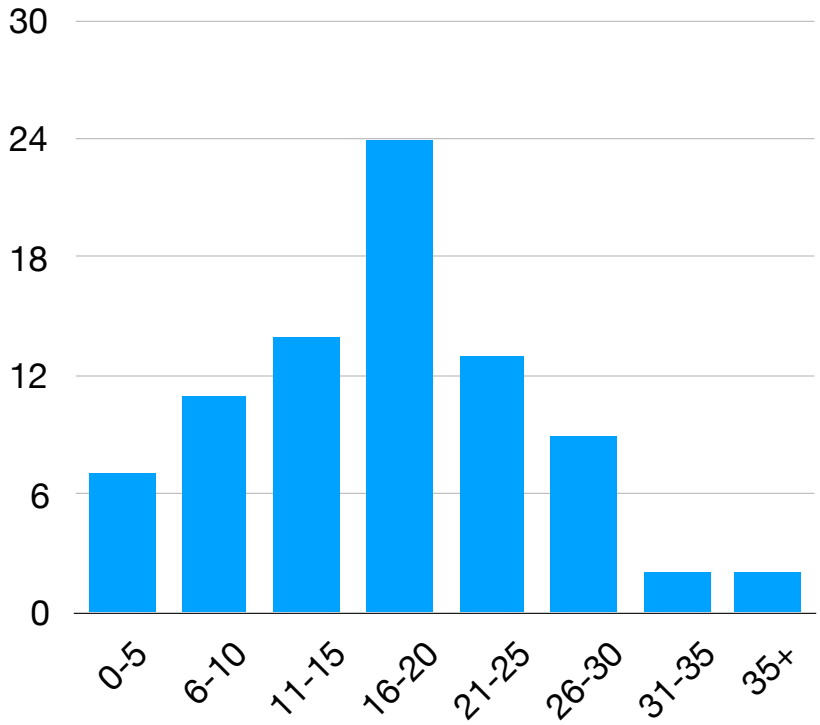
Department Demographics

81 Programs Reporting

Students

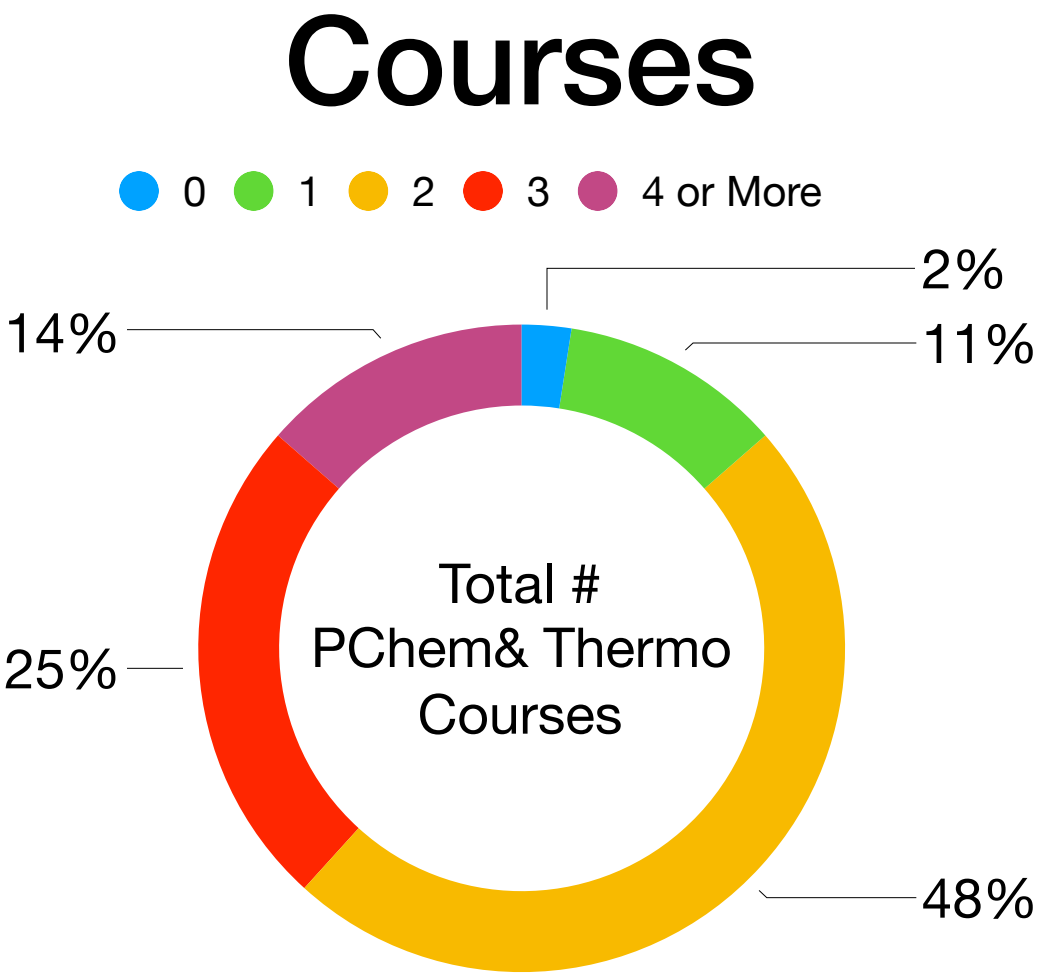


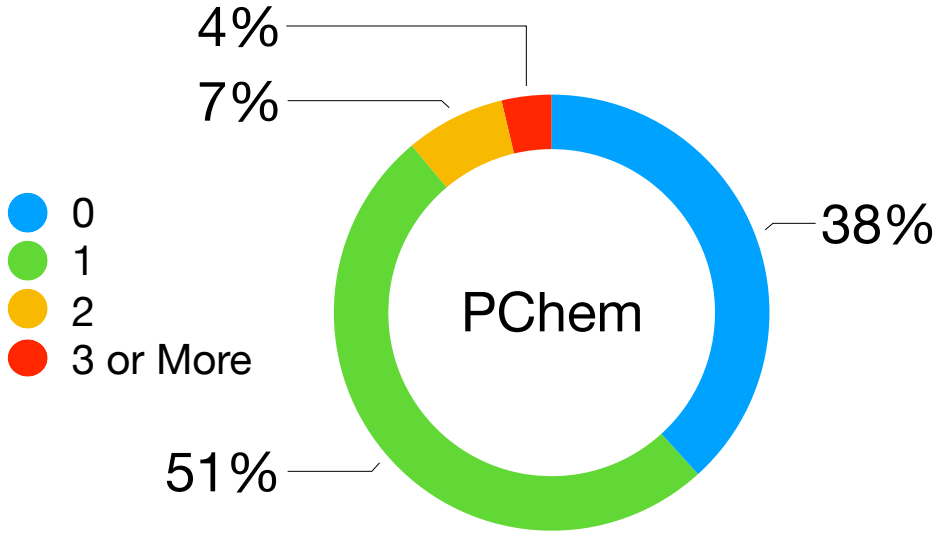
Faculty / Instructors

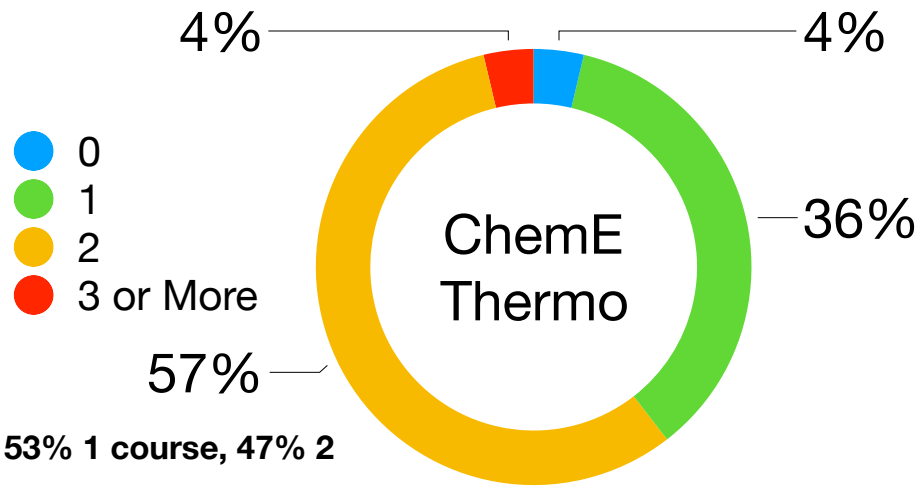


Courses and Credits

Courses







1992: 53% 1 course, 47% 2

We like home cooking!

- Only four respondents indicated they require a “thermodynamics” class that is not “chemical engineering thermo” class
- (X2) “Students Take General Engineering Thermodynamics and then Chemical Engineering Thermodynamics”
- “Thermo 1 is through the dean of engineering, Thermo 2 is co-offered with materials thermodynamics, Thermo 1 is not a pre-req for Thermo 2 (unfortunately)”
- “General Thermo, then ChemE Thermo, then ChemE Thermo Lab (1 unit)”

When is each course typically taken?

	First/Only P-Chem	First/Only Thermo
First Year	6	0
Second Year	11	54
Third Year	31	22
Fourth Year	1	0

1992: 85% in 3rd year

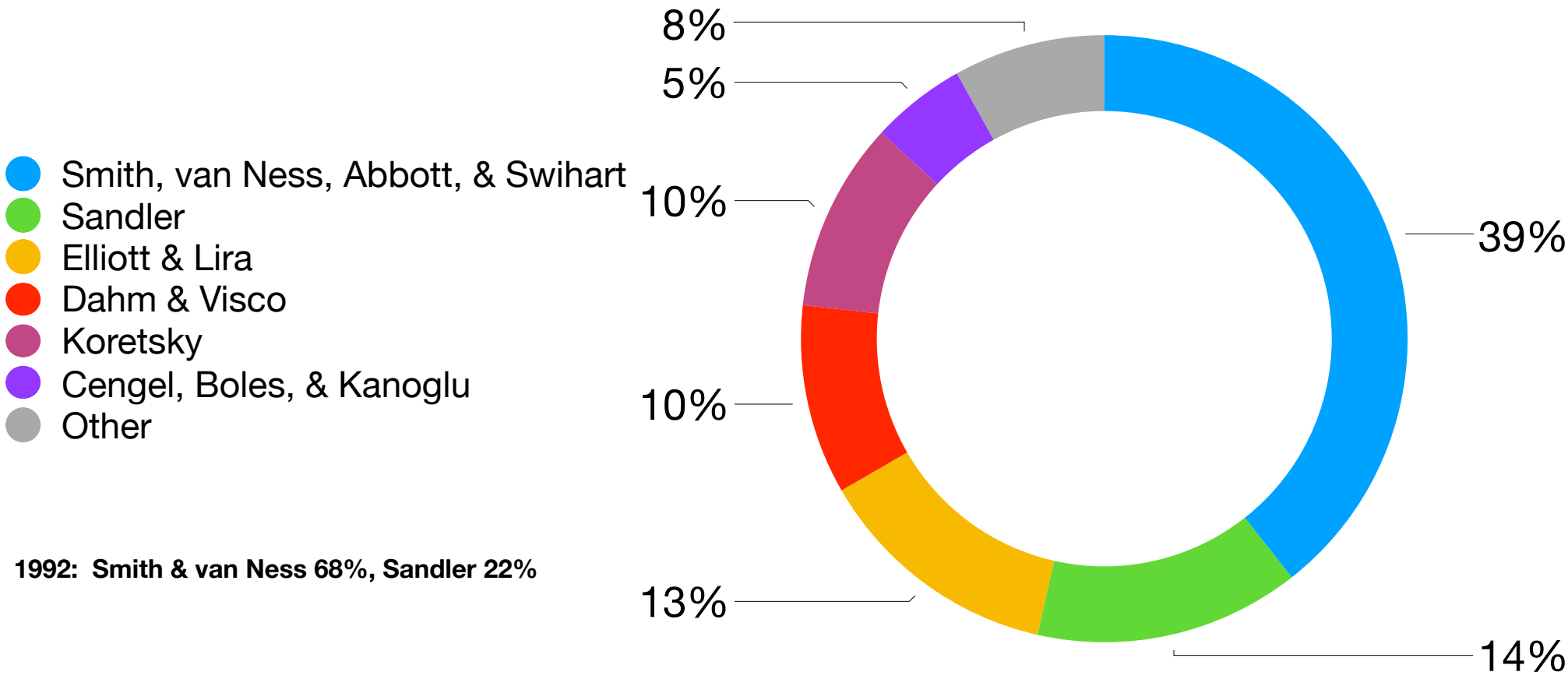
How many credit hours does your CHE Thermo course(s) receive?

# Credits	# Respondents	% Respondents
3	38	46.9
4 (or 4.5)	20	24.7
6	20	24.7
7-9	3	3.7

1992: 76% were 3.0 hr courses, no lab

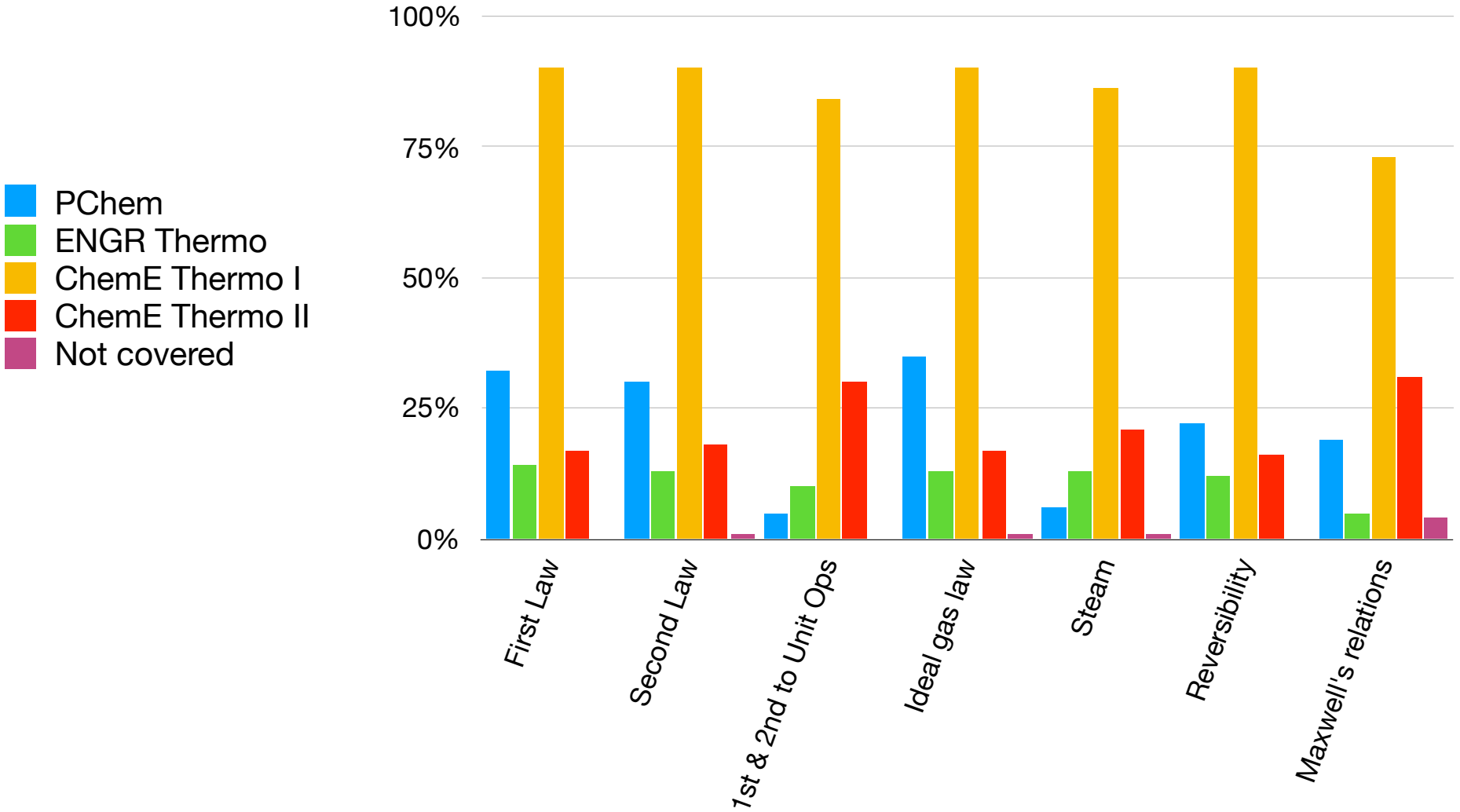
Content

Textbook

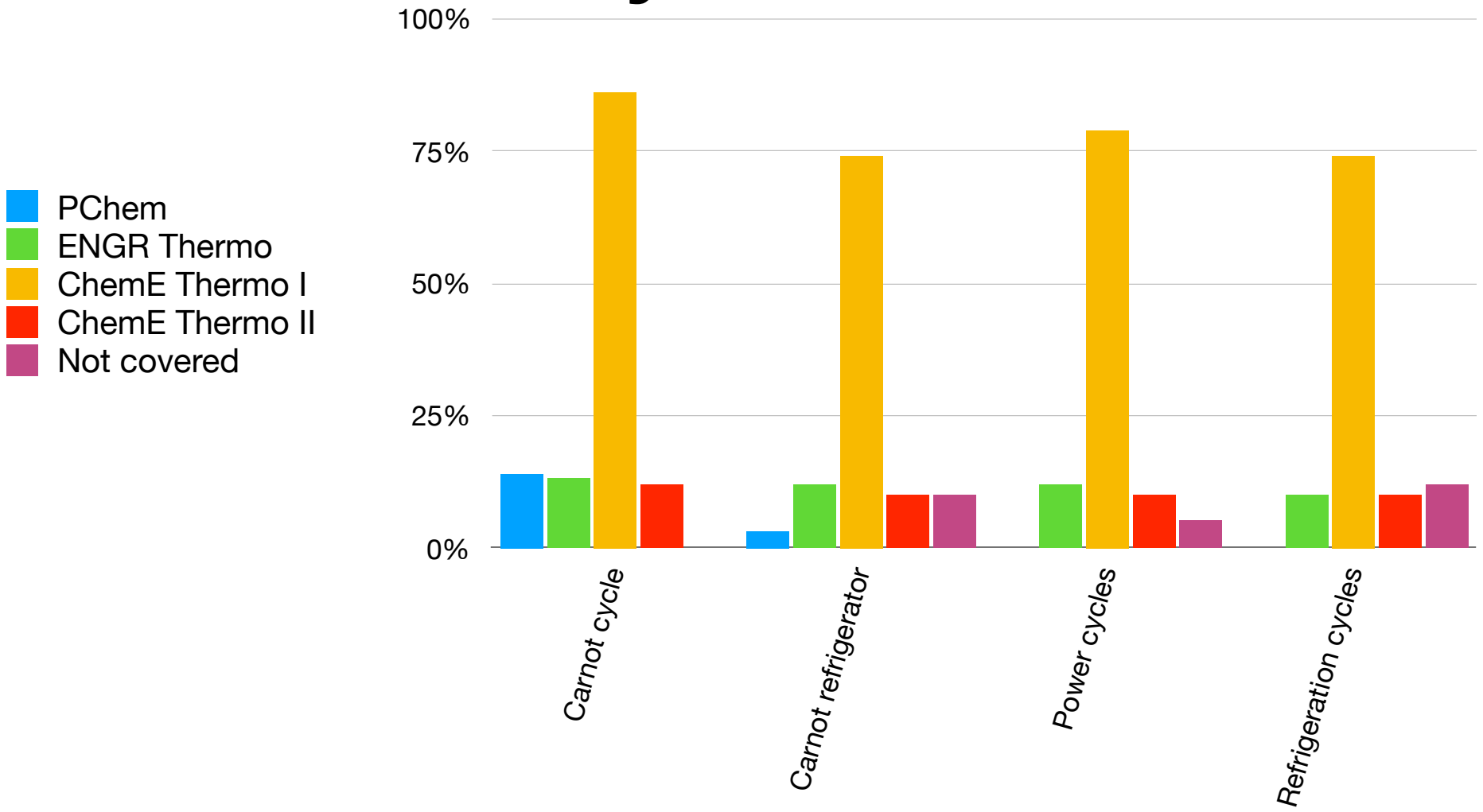


1992: Smith & van Ness 68%, Sandler 22%

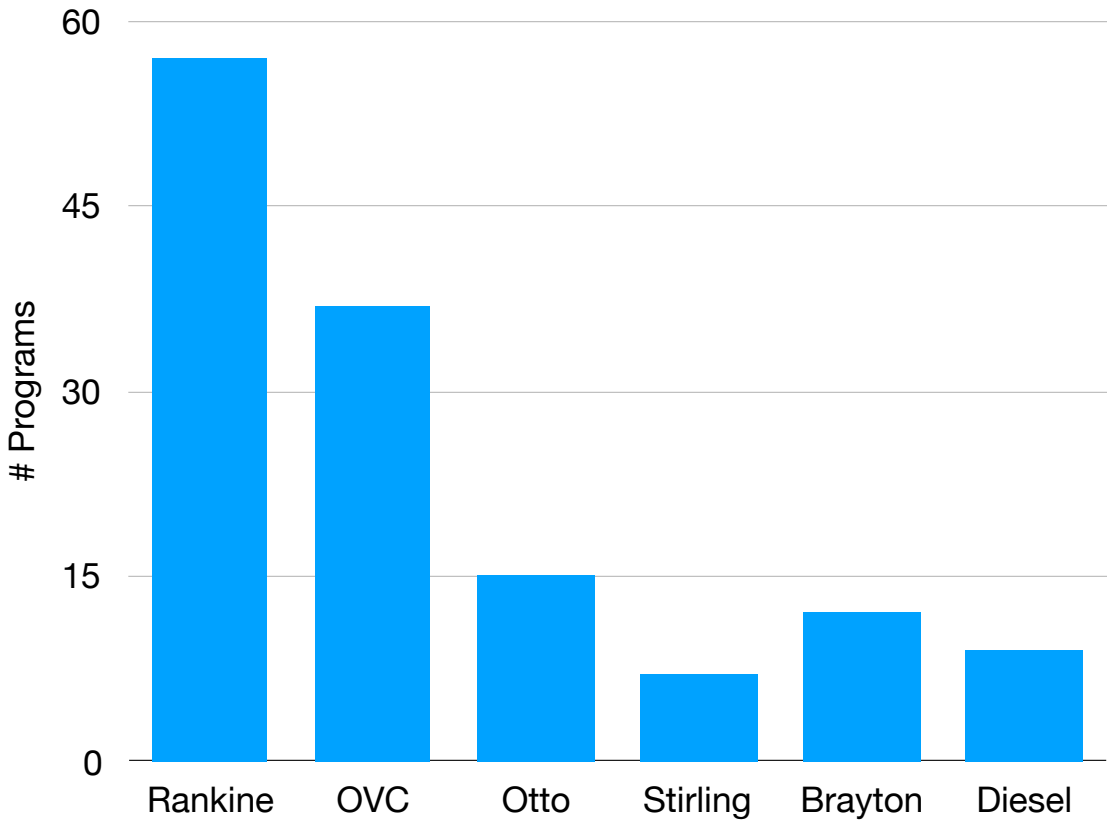
Thermo Fundamentals



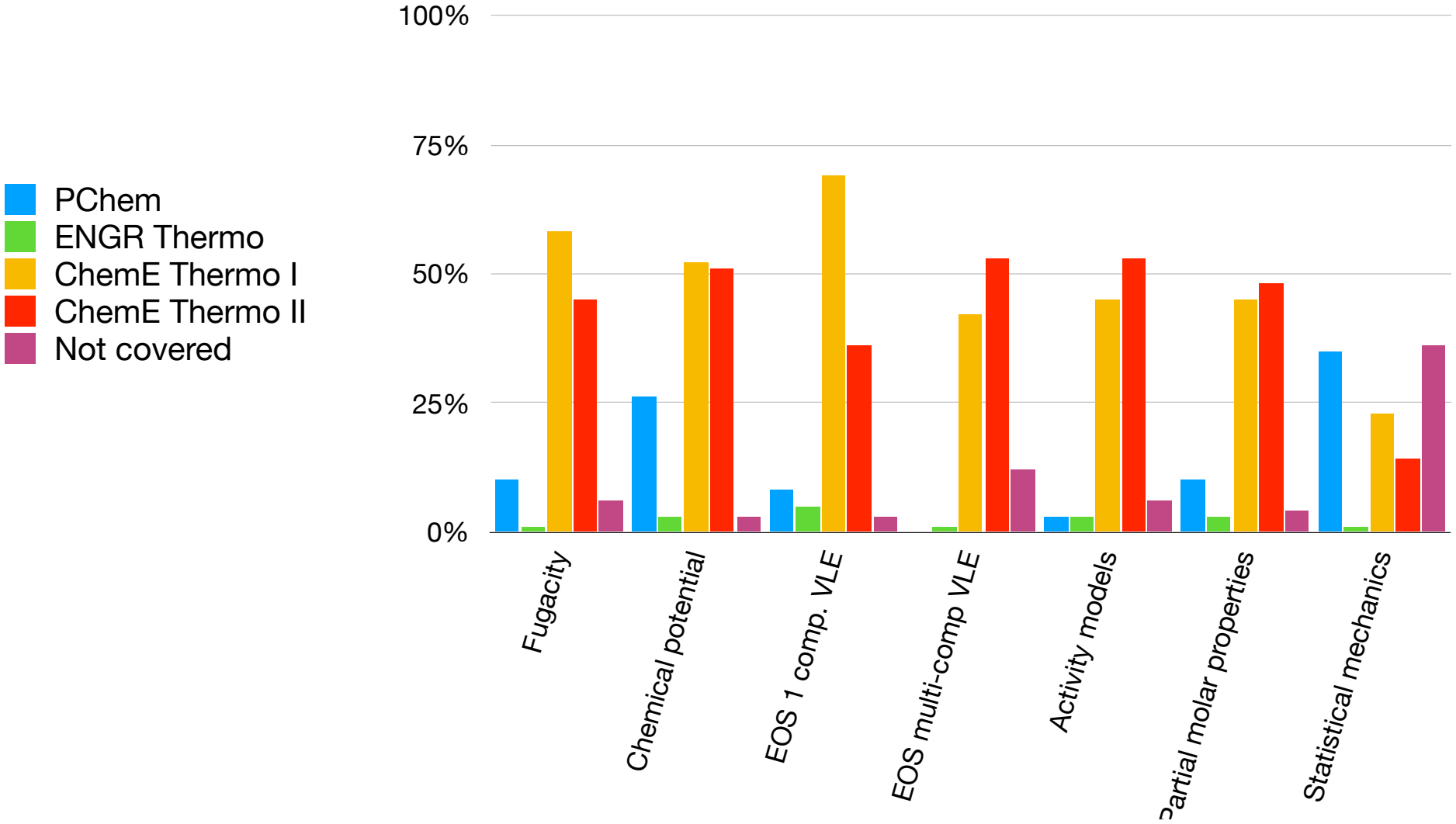
Cycles


PChem
ENGR Thermo
ChemE Thermo I
ChemE Thermo II
Not covered
100%
75%
50%
25%
0%
Carnot cycle
Carnot refrigerator
Power cycles
Refrigeration cycles

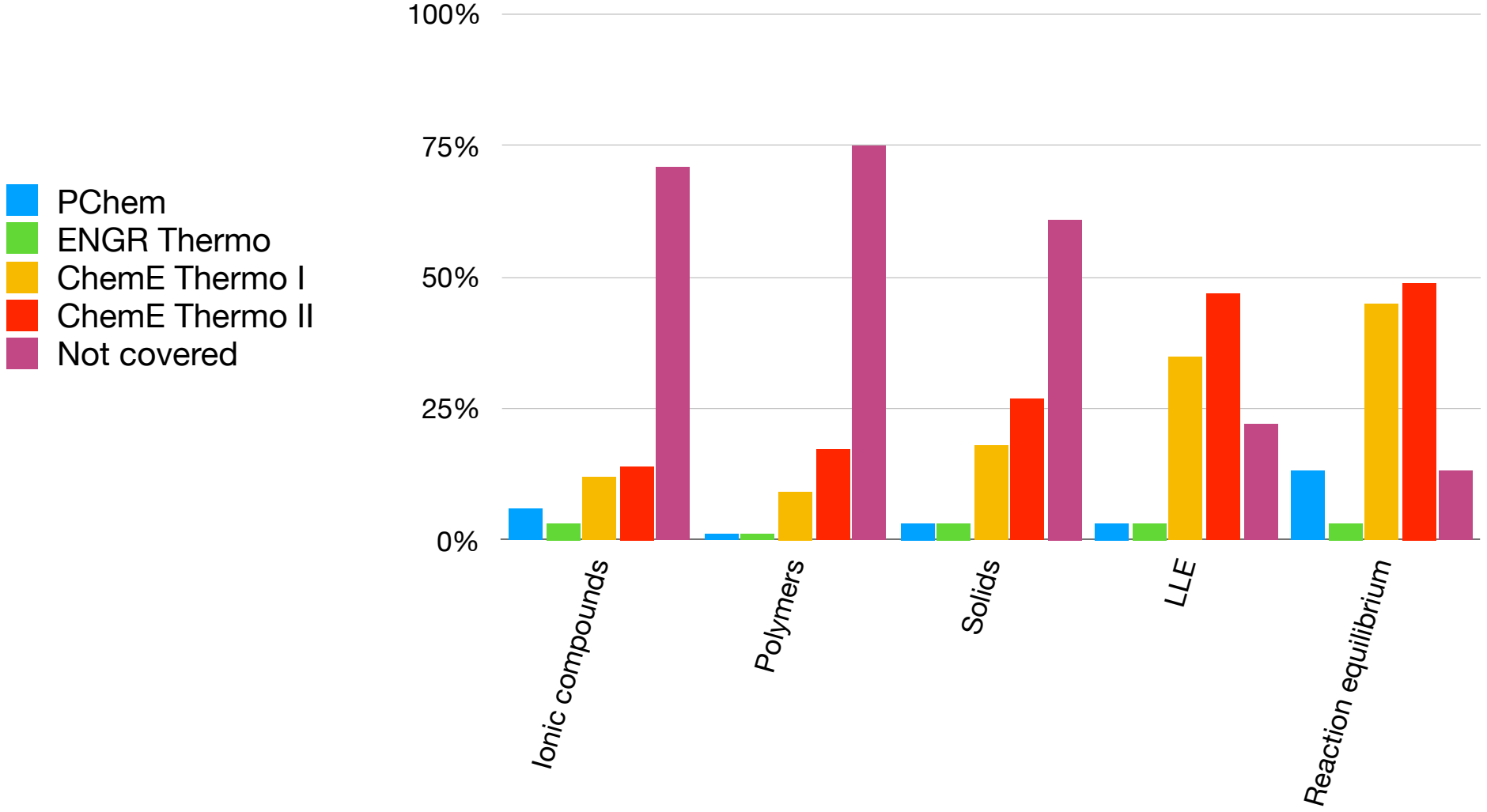
More on cycles



Molecular Thermo & Models



Other Equilibria & Phase Behavior

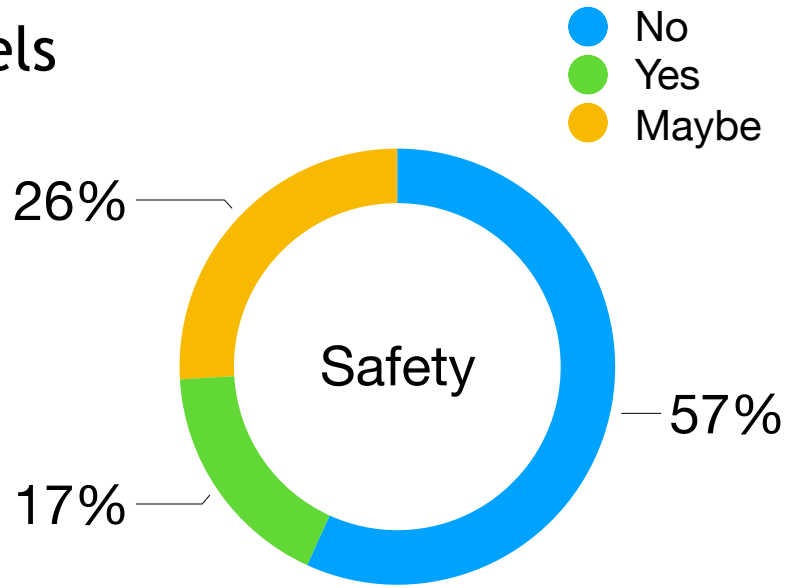


Other topics covered

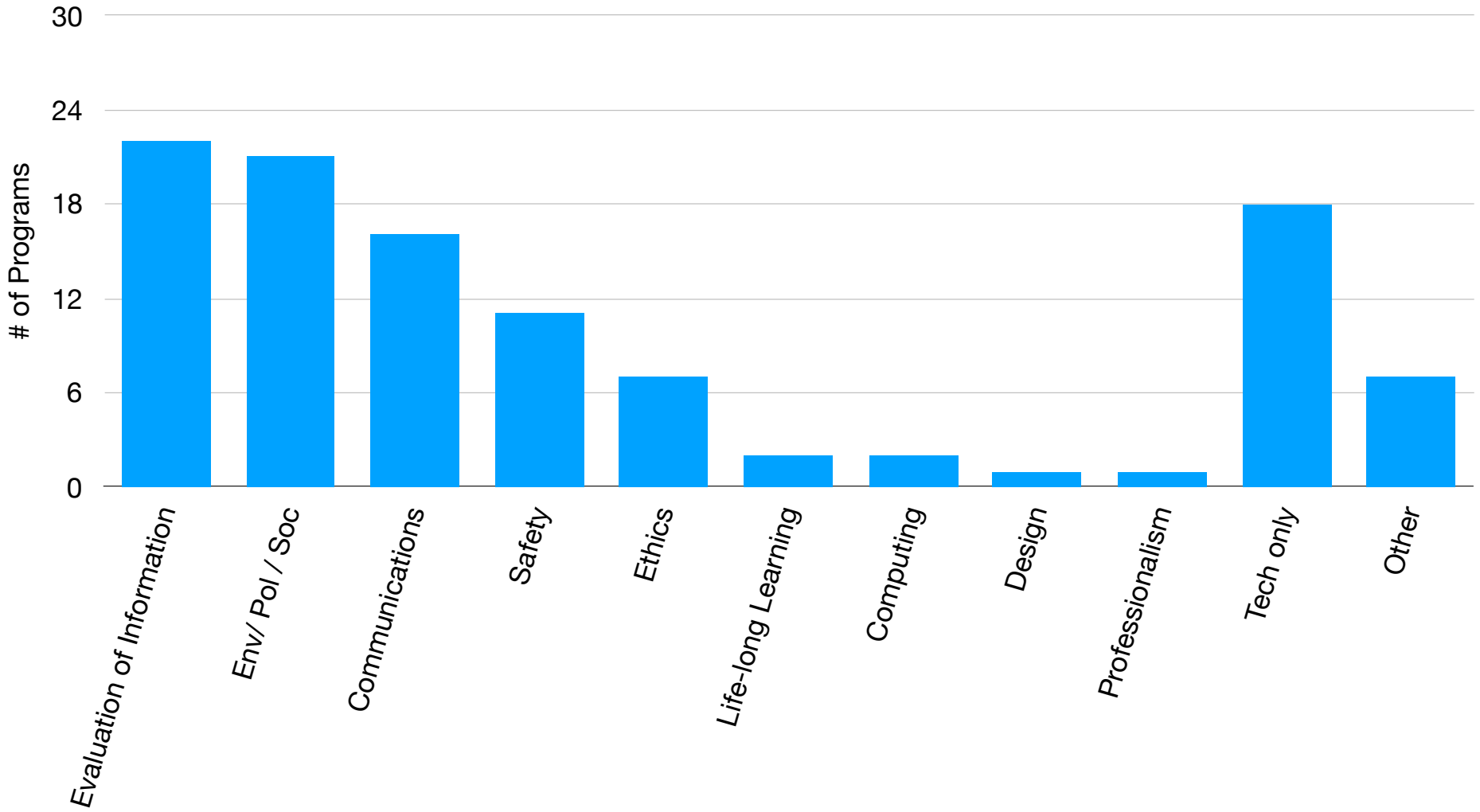
- Three-phase systems or VLLE (2)
- Distillation columns or separations technology (2)
- Electrochemical equilibria (2)
- Supercritical fluids (1)
- Kinetic theory of gases (1)
- Complex reaction mechanisms (1)
- Surface tension (1)
- Quantum mechanics (1)
- Activity models use for describing the behavior of food (1)
- Inclusive teaming (1)

What safety is included in ChE thermo courses?

- Pressure calculations for sealed vessels
- Flash point
- Flammability limits
- Emissions
- BLEVE
- SAChE certificates
- Purging



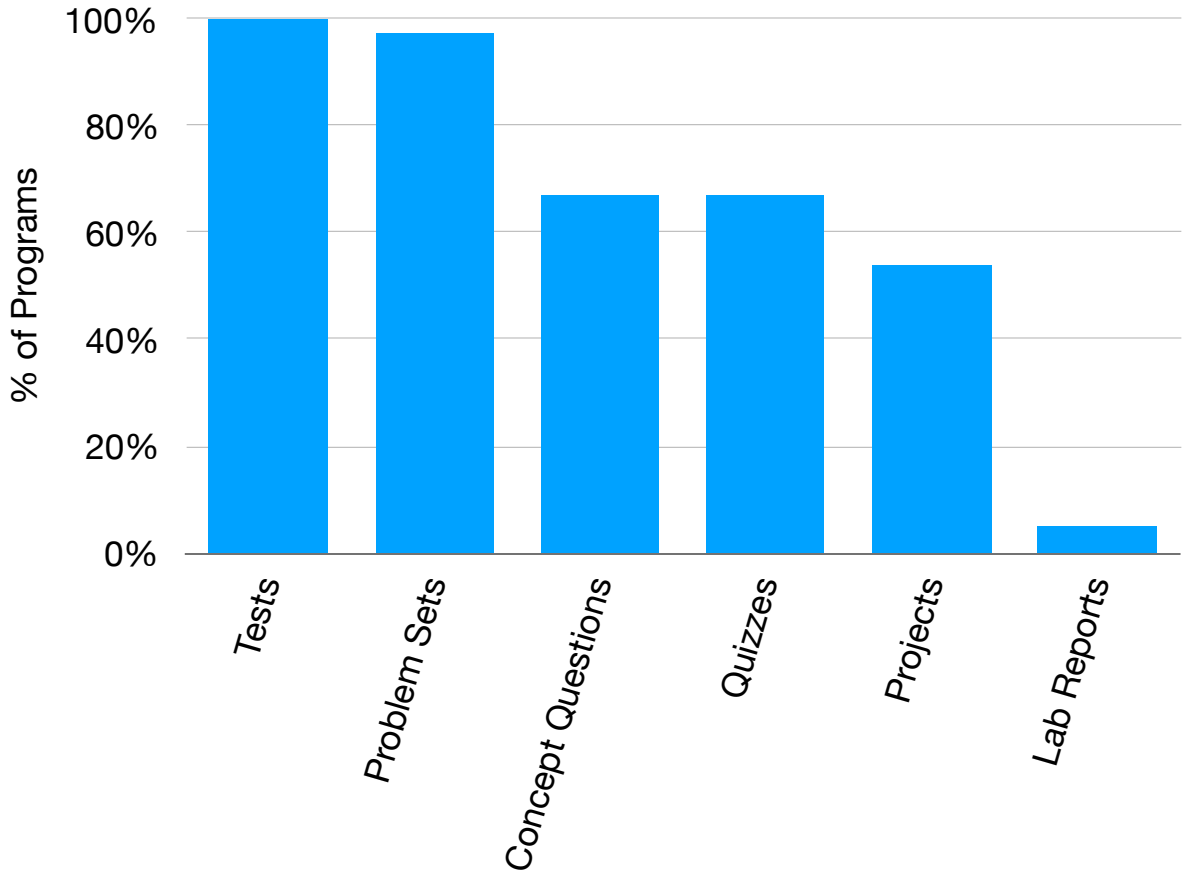
ABET Assessments



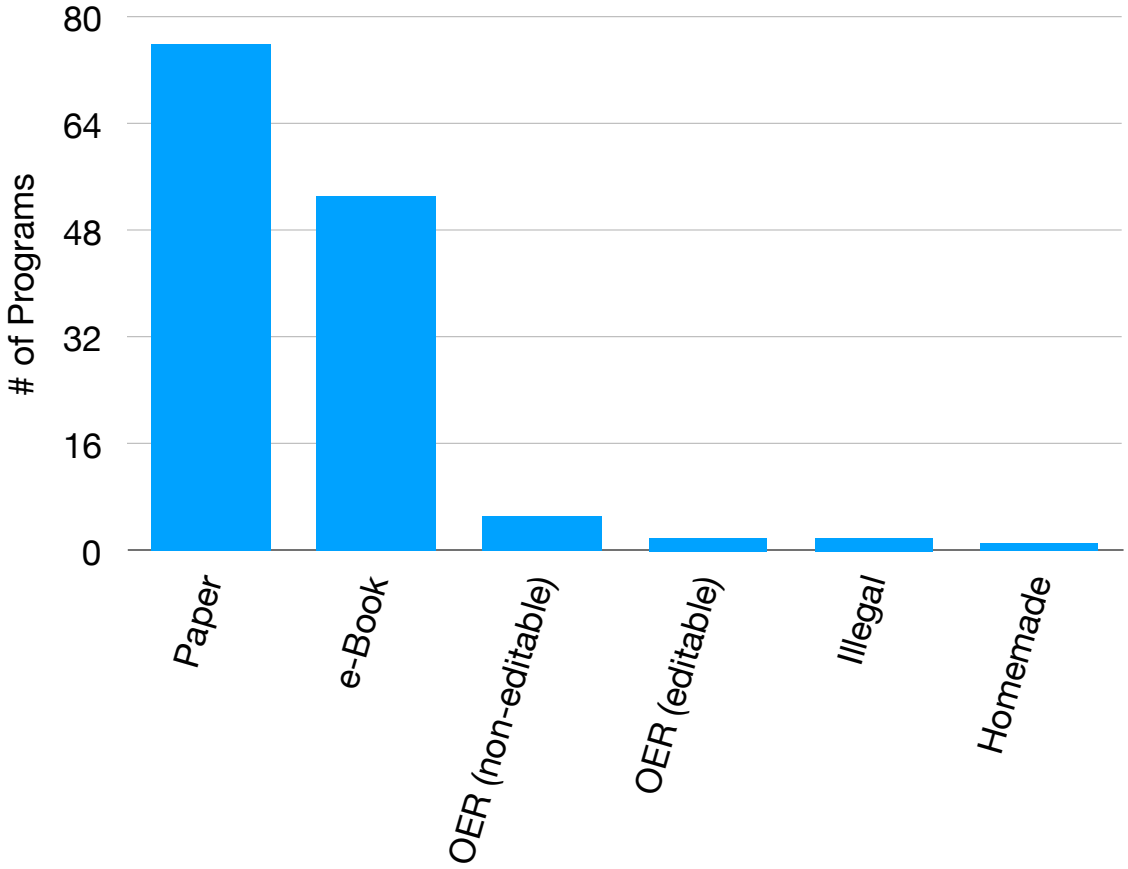
Process

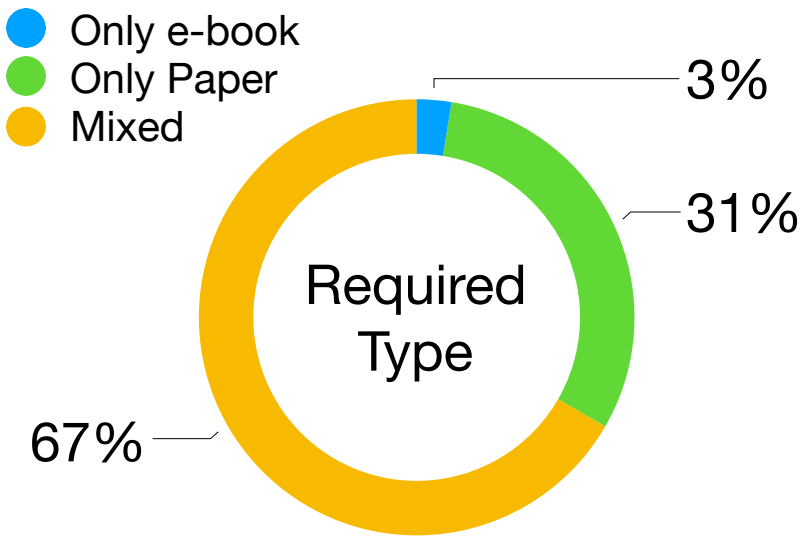
Assessment Types

- Project Types
  - 1/3 computer-based
  - 28% involve calculations too complex for a test/quiz
  - 7% make videos
- 1/3 are 1-month to 1-semester long



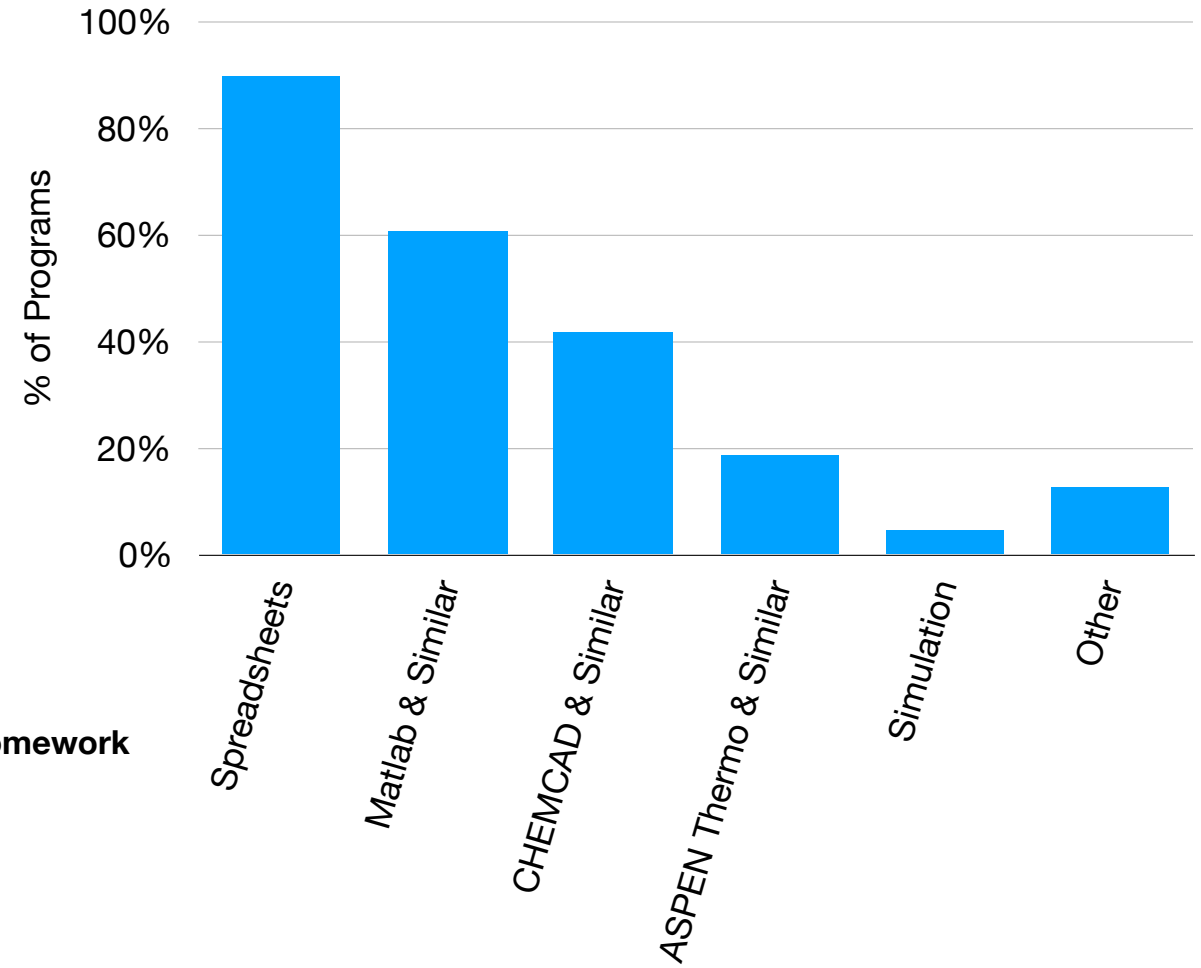
Medium


80
64
48
32
16
0
# of Programs
Paper
e-Book
OER (non-editable)
OER (editable)
Illegal
Homemade


Only e-book
Only Paper
Mixed
3%
31%
67%
Required Type

Computing

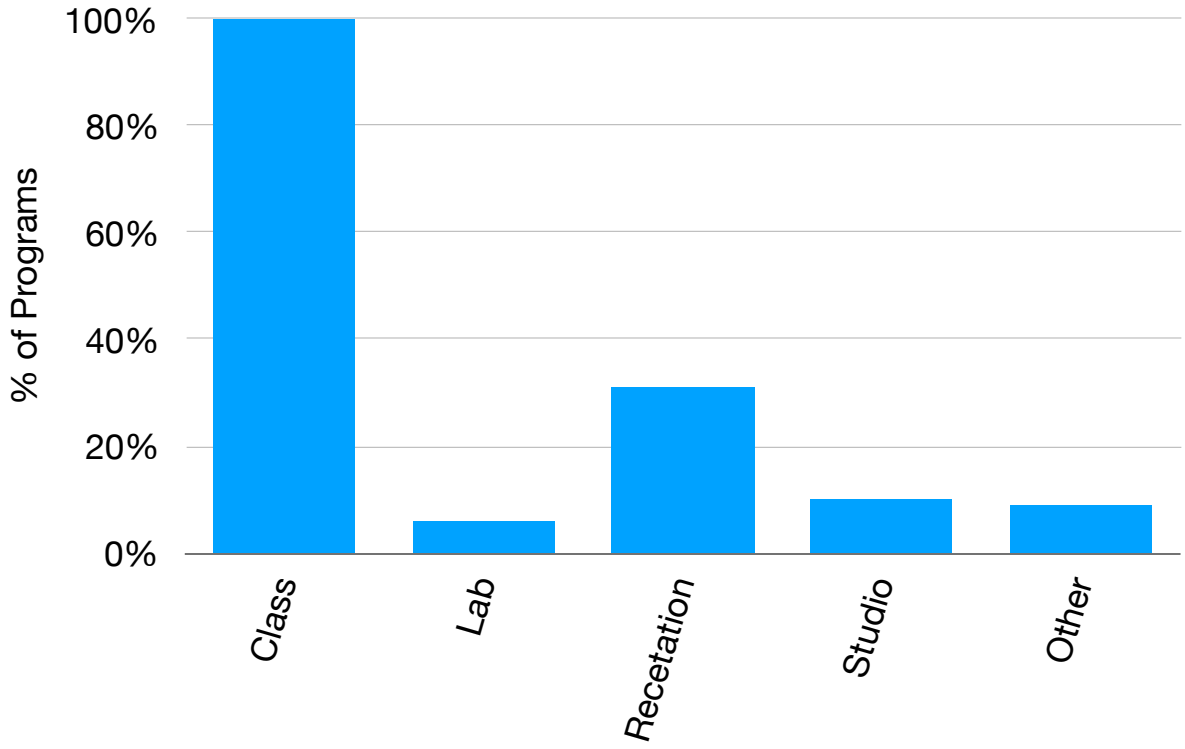
- “Other” = Software with book or homemade



1992: 2/3 programs require computer use for homework
15% use a process simulator

Instructional Settings

- Everyone teaches class
- Labs are primarily physical (one program reporting a mix of simulation and experiment)



Innovative Practice - Content

- Created direct connection between thermodynamics course and modeling/simulation course taught same semester
- Environmental-oriented applications (Environ. Eng. are required to take the course)
- Combinatorial enumeration of states of simple lattice model to give molecular description of entropy and from it other properties and driving forces for transport
- Individual presentations about food production followed by community service at food bank or urban farm, learning about food insecurity
- Interactive study modules, available on www.LearnChemE.com
- Build a Stirling engine
- Process emphasis with spreadsheet and Aspen Plus

Innovative Practices - Approach

- Non-graded concept tests to start lectures
- Mini-design project
- Spiral curriculum that spreads classical and chemical engineering thermodynamics over 4 7-week long courses
- Coaching model with in-class problems
- Wheel of Doom to choose students to call on in class
- Flipped classroom of various types, with concept tests, peer instruction, and group problem solving in class
- Homework due every class period

Conclusions

- Thermo - still core to the curriculum
- Computational emphasis
- Big Ideas: Energy/Entropy; property and equilibrium modeling (1 and multi-component)
    - Reactions, solids, LLE, ions, electricity……