A Process Systems Approach to Teaching Distillation

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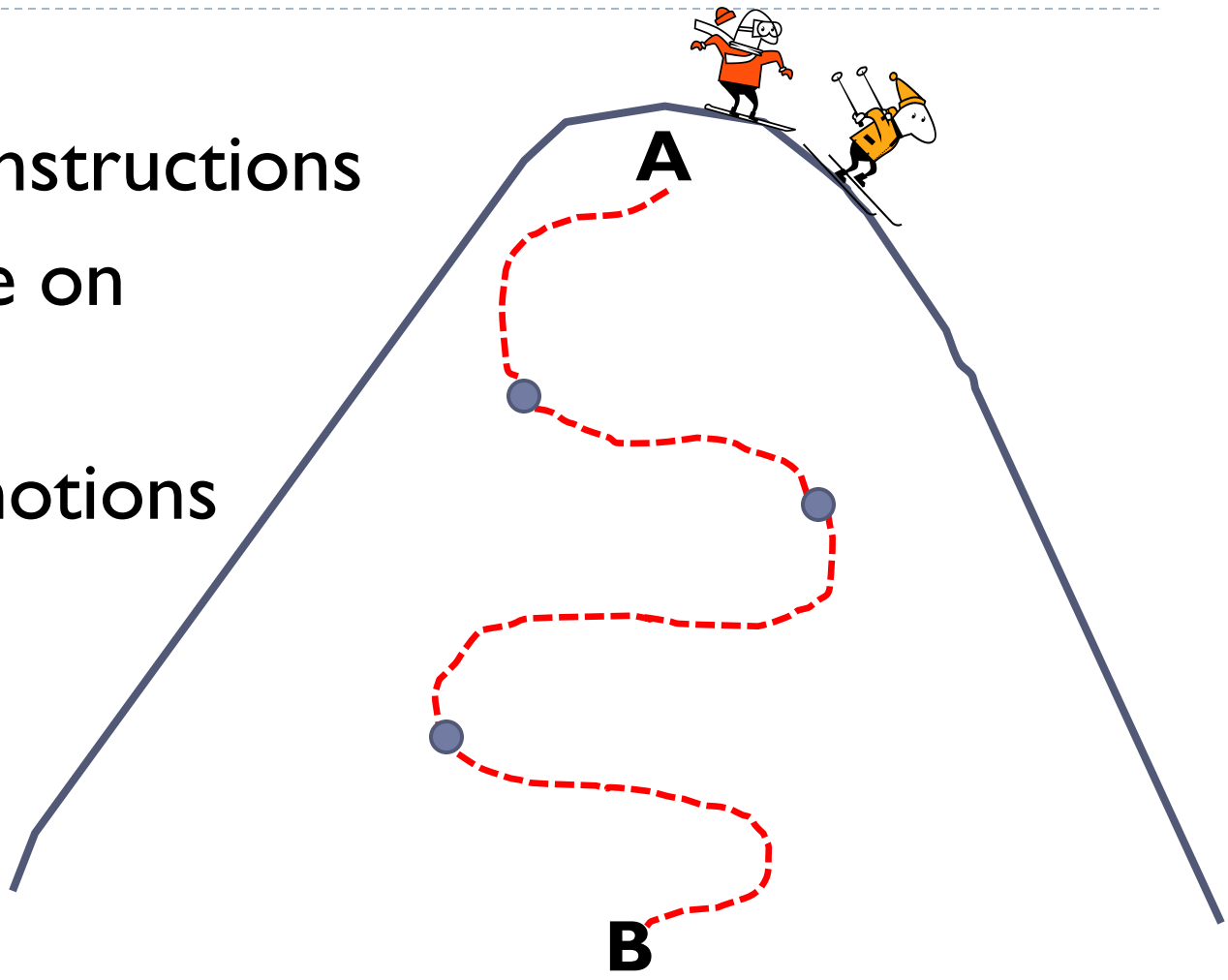
Background

- Objectives
  - Experimental
  - Analytical
  - Writing
  - Creativity
  - Depth and Breadth
  - Challenge students
    - Open-ended projects
  - Close teacher/student interaction

- Challenges
  - Over 100 undergraduates per year
  - High throughput required
    - One week for lab
    - One day running experiment
  - Teaching assistant turnover
    - Leads to instructor-driven assignments

Instructor-Driven Assignments

- Step-by-step instructions
- Heavy reliance on instructor
- Go through motions
- Cover a lot
- Efficient

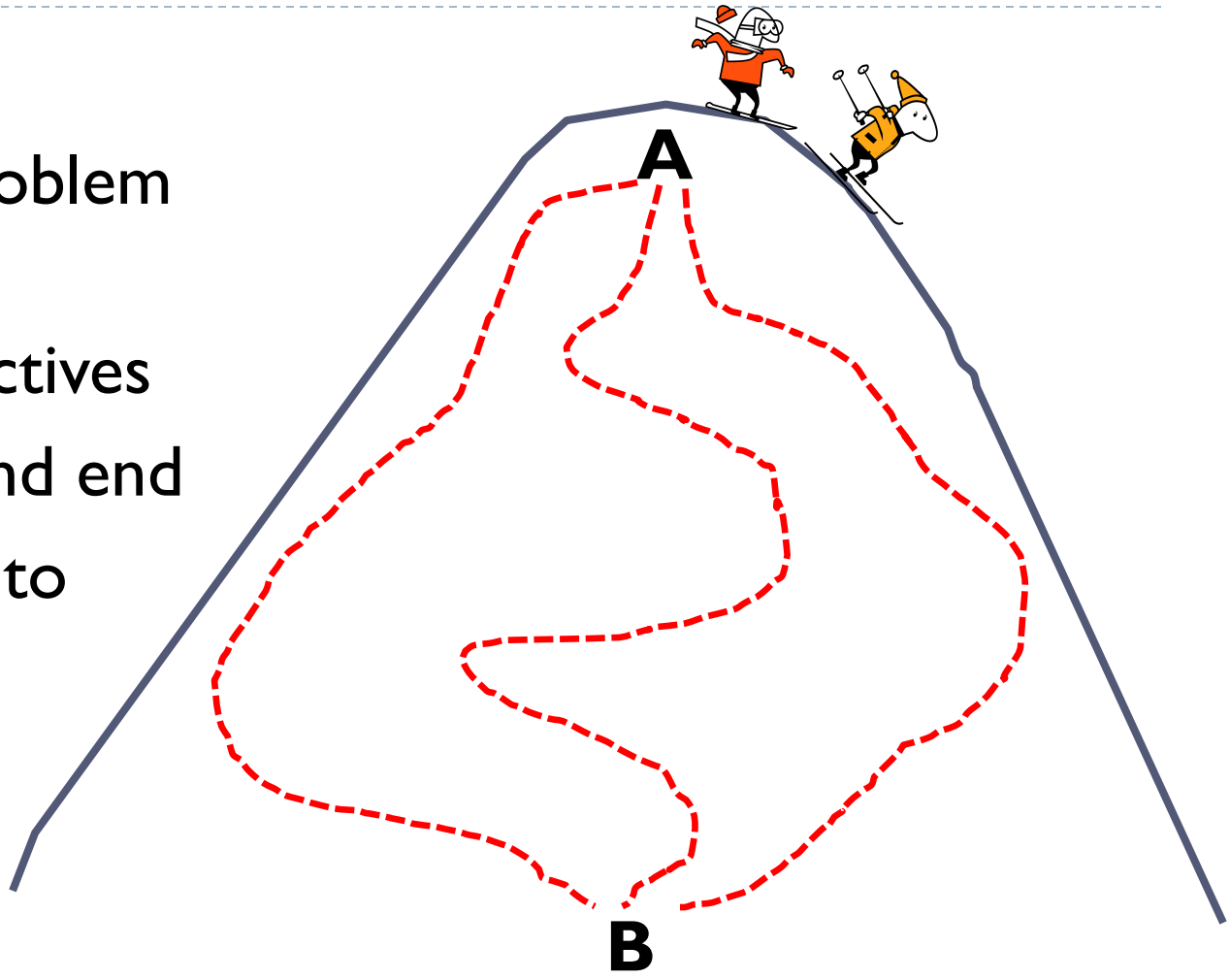


Distillation Lab

- Lab Assignment 1:
  - Adjust steam rate
  - Watch for signs of flooding
    - Visual
    - Pressure drop
    - Temperature gradient
  - Design: Size column diameter
- Lab Assignment 2:
  - Collect samples
  - Analyze on GC
  - Determine average tray efficiency
  - Design: Size column height (# of trays required)

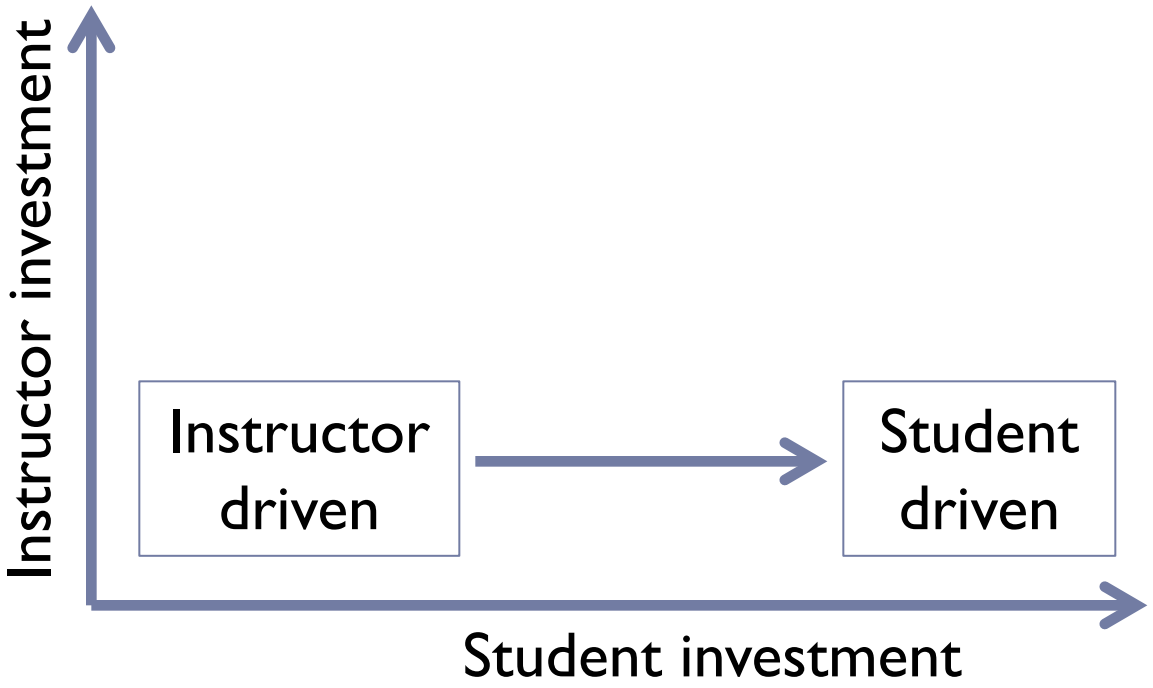
Student-Driven Assignment

- Make students independent problem solvers
- Give clear objectives
- Distinct start and end
- Leave methods to students
- Open-ended

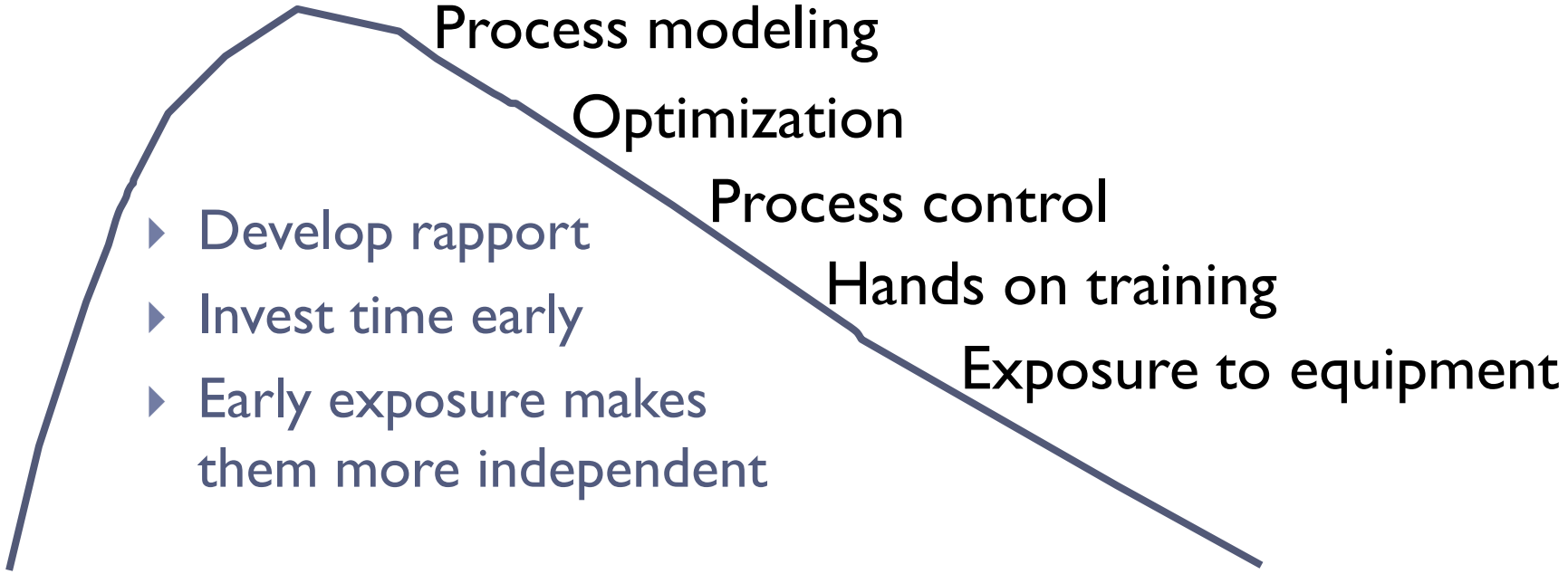


Outcome of Student-Driven Assignment

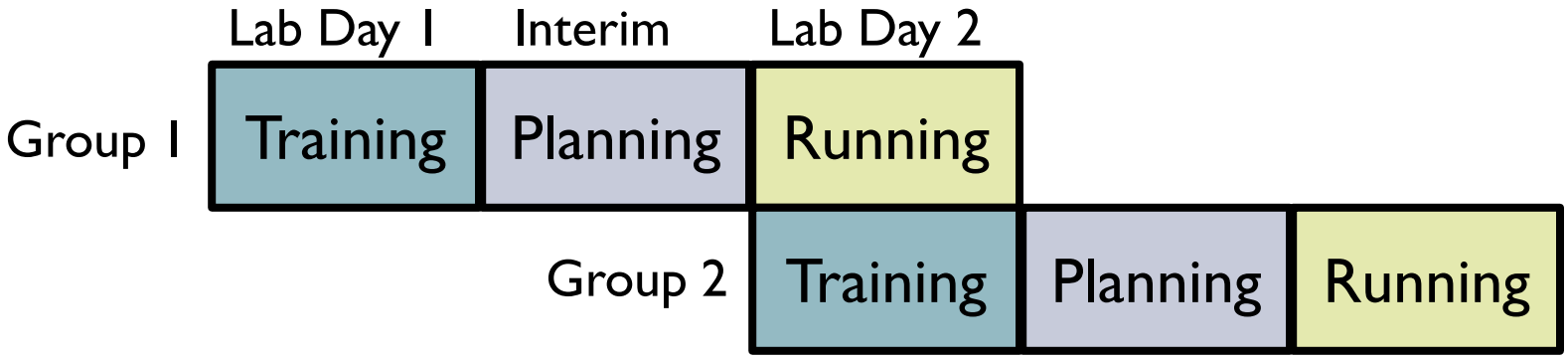
- Assignment:
  - Determine optimal column operation
    - Design & run experiment
    - Find efficiency & flooding point
- Student effort w/o instructor effort
  - Possible death threats



Student-Driven Assignment

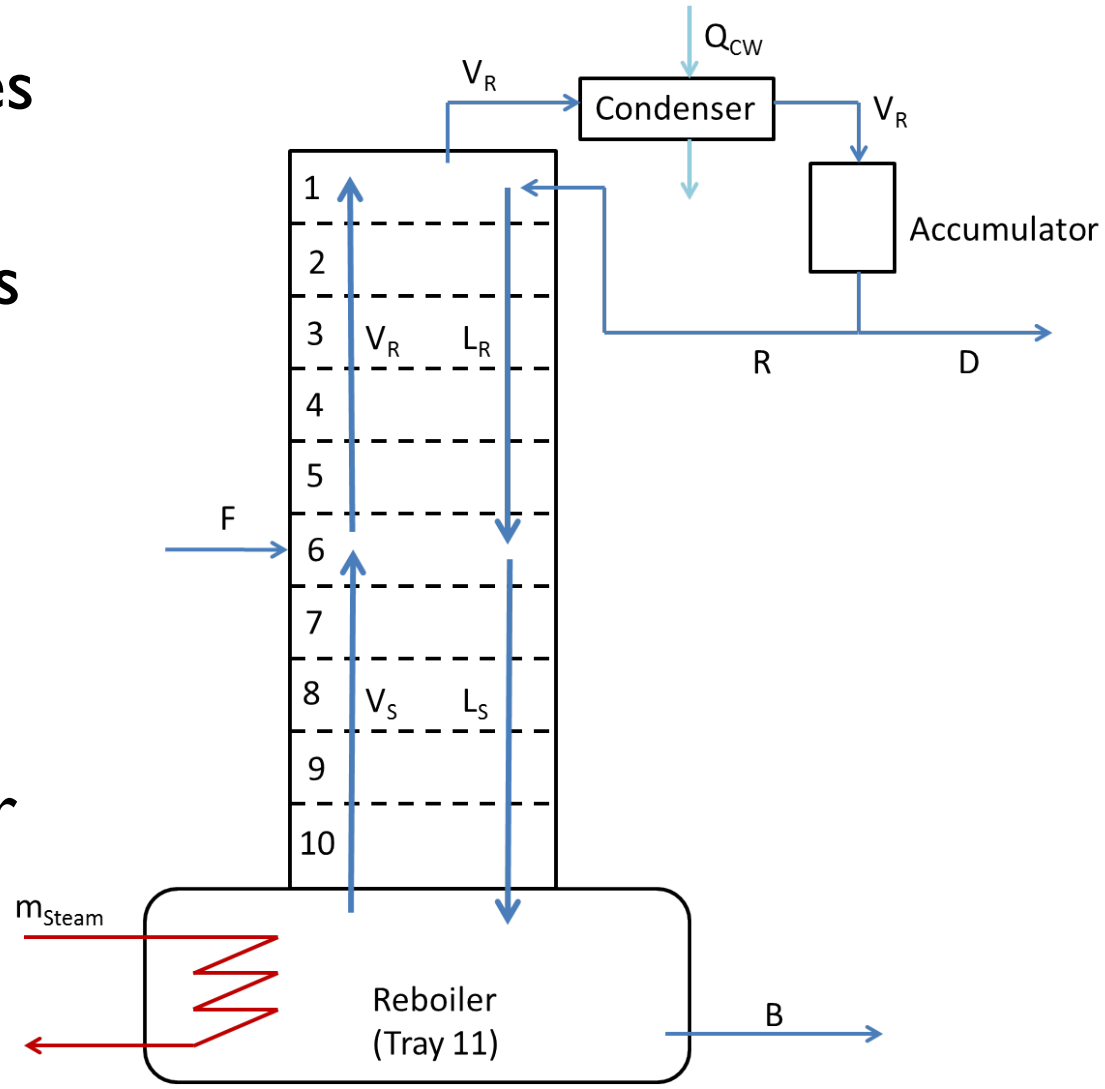


- Develop rapport
- Invest time early
- Early exposure makes them more independent



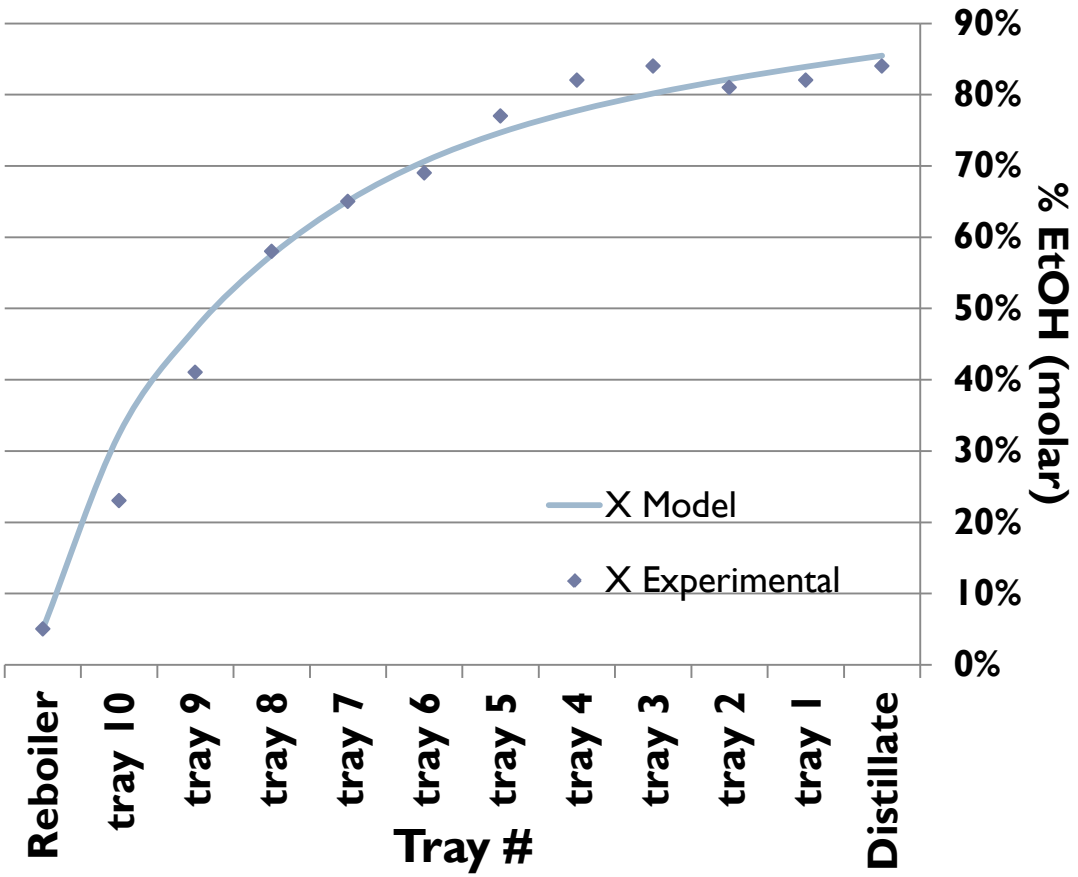
Process Modeling

- Derive first principles steady-state model
- Component balances
- Thermodynamics
- 32 variables
- 29 equations
- Run scenarios
- Develop intuition for process

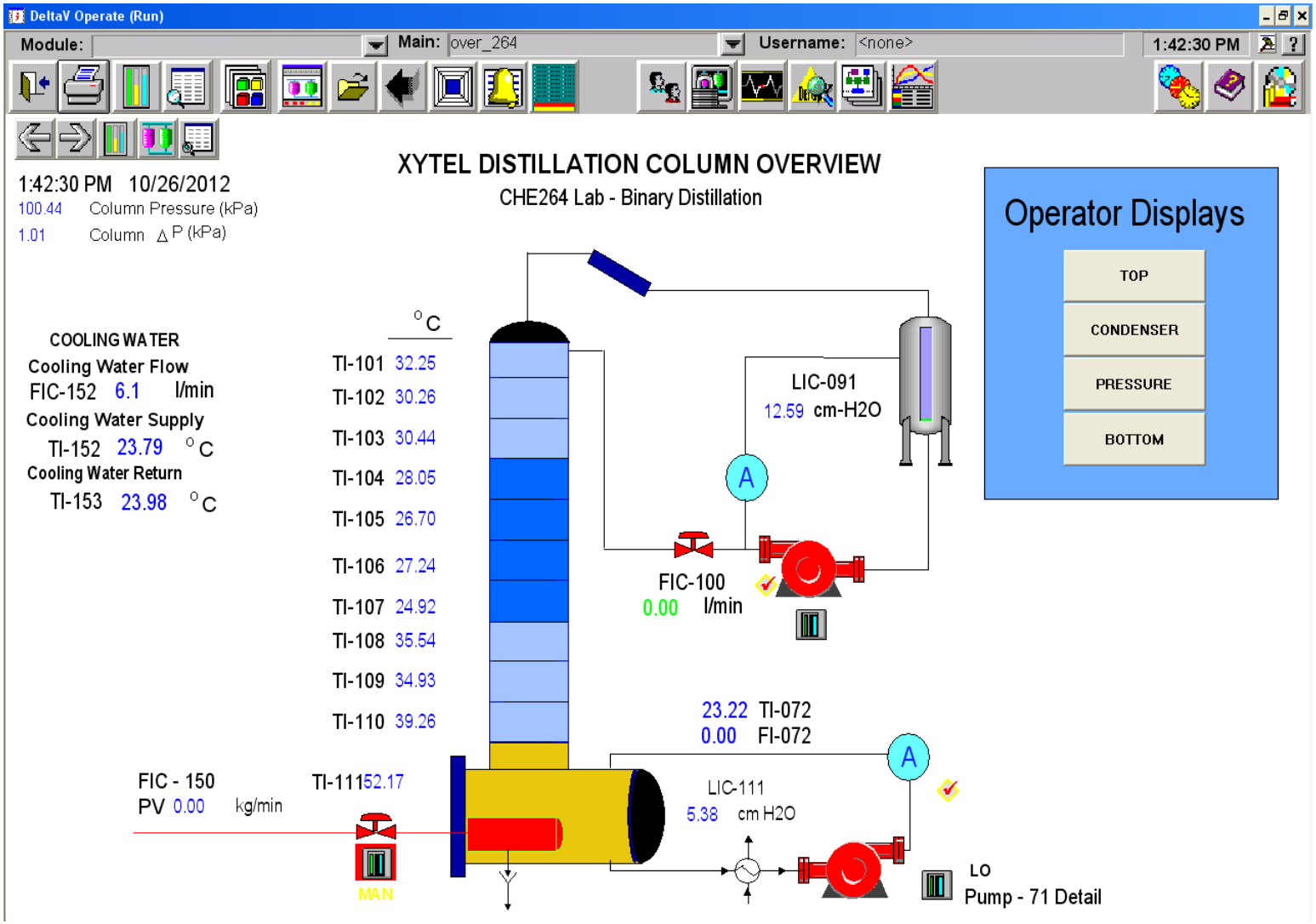


Optimization

- Model parameterization
  - Tray efficiency
- Column optimization
  - Maximize revenue
  - Use 3 DOFs
    - Feed flow rate
    - Reboiler heat duty
    - Distillate flow rate
  - Constraints
    - Flooding

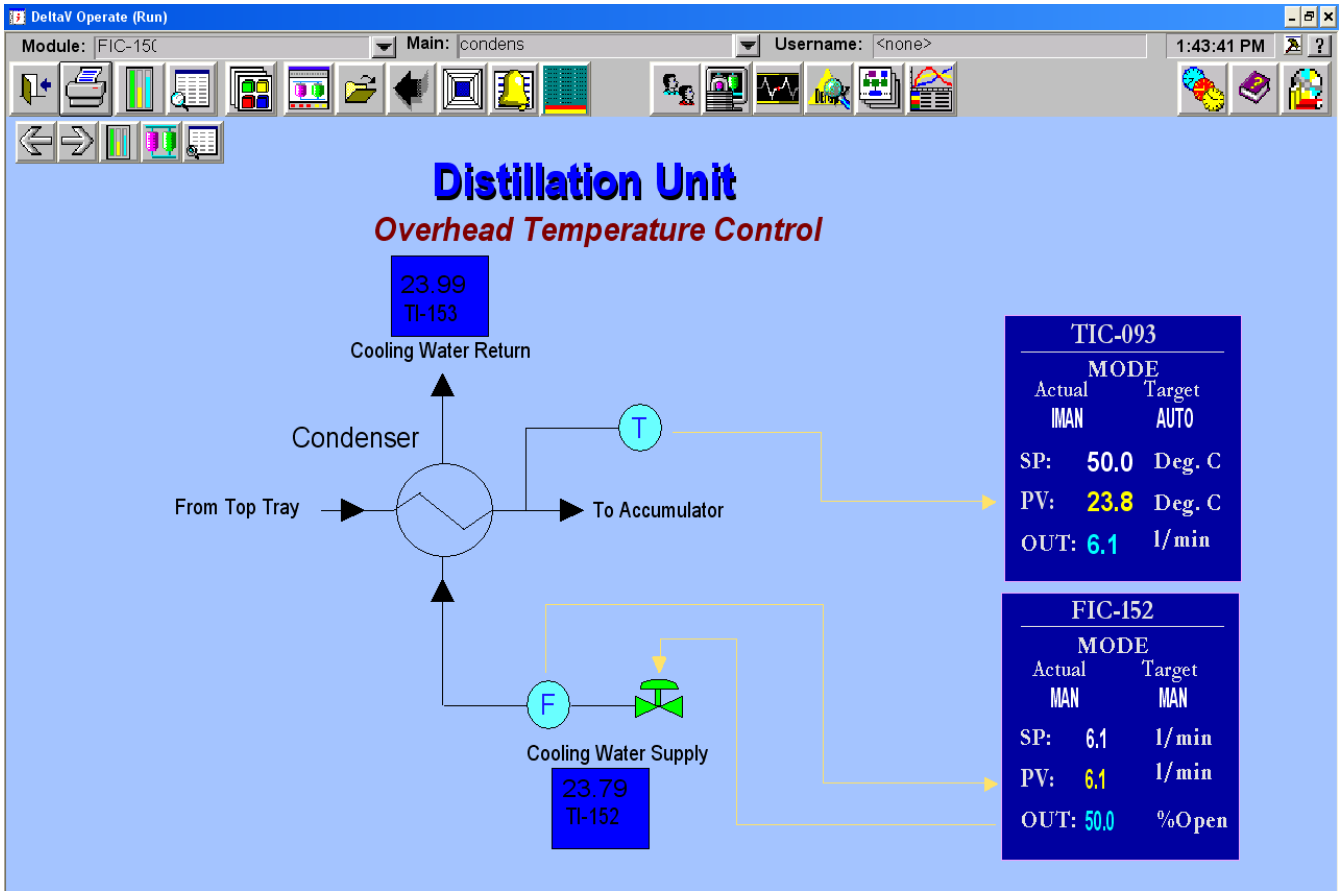


Process Control



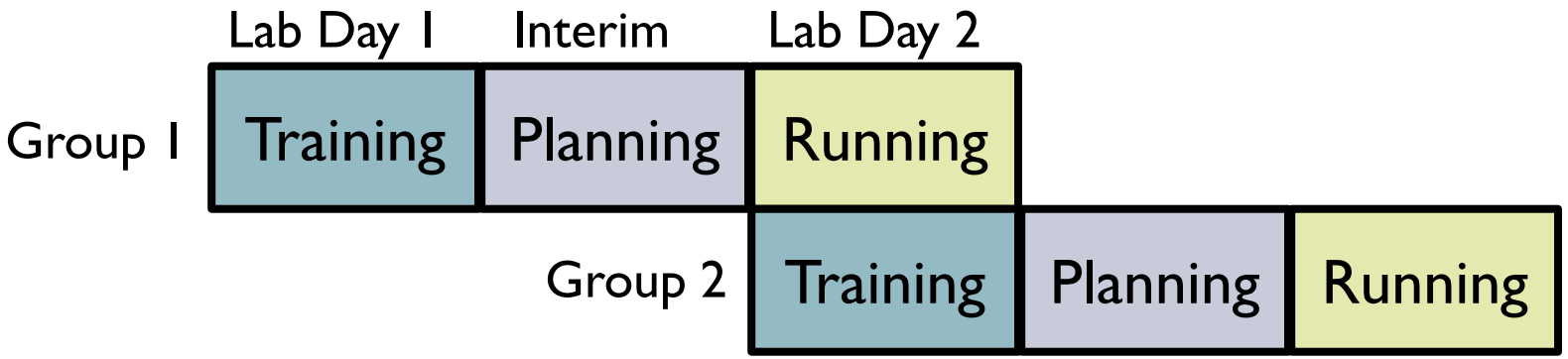
Process Control

- 1st exposure to feedback control
- Student operators
- Cascade loops
- Dynamic interaction of distillation components



Interim (Planning) Period

- Students develop and present experimental plan
  - Written document (1 page)
  - Oral quiz
- Organize themselves into roles
- Students take ownership of project

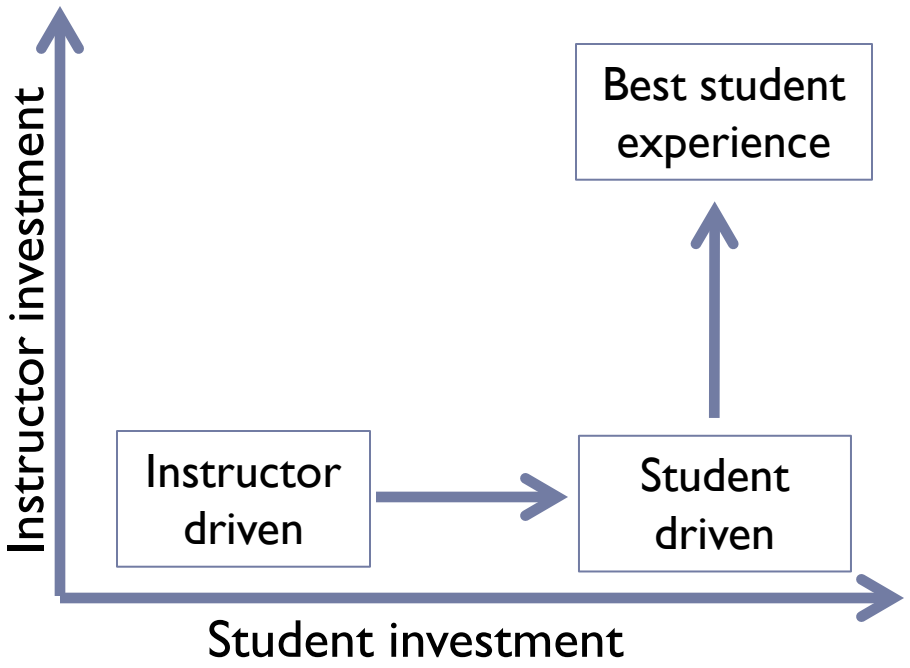


Class Feedback

- "The distillation lab was one of the toughest but you made it easy to understand"
- "Keep challenging the students. Good idea for an open-ended lab! I enjoyed it."
- "I felt like I walked out of the class with a better understanding about the experiment than I did when I first learned about it in my separations class. He allowed us to figure things out for ourselves, which helped me learn more details than I normally would have if I just followed instructions."

Conclusions

- Used PSE tools to enhance student's understanding of distillation
- Challenge students
  - Invest time
  - Be creative
  - Requires our own effort and creativity
- Investing time early pays off
  - Develop relationship with students
  - They become problem solvers



Questions?