Simulation Solutions, Inc.

Minds-On/Hands-On Training for Operators™

"Process Safety Education Using Simulators"

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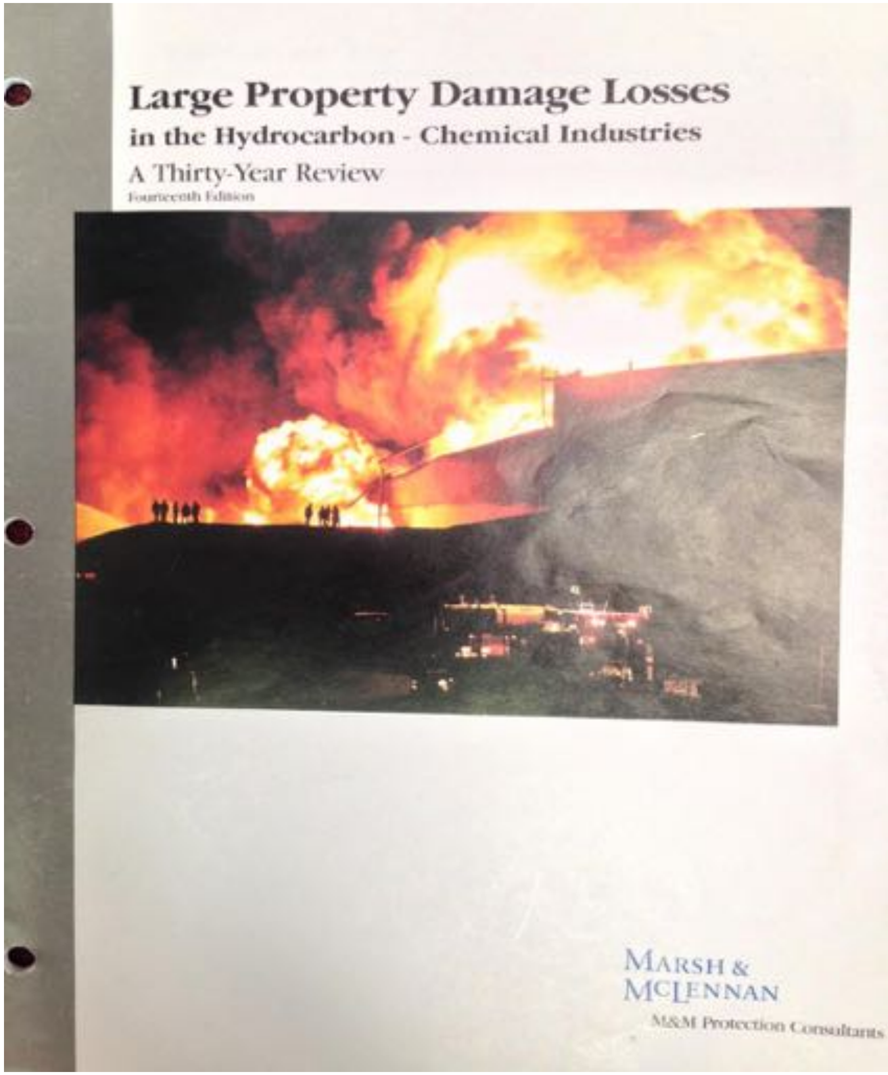
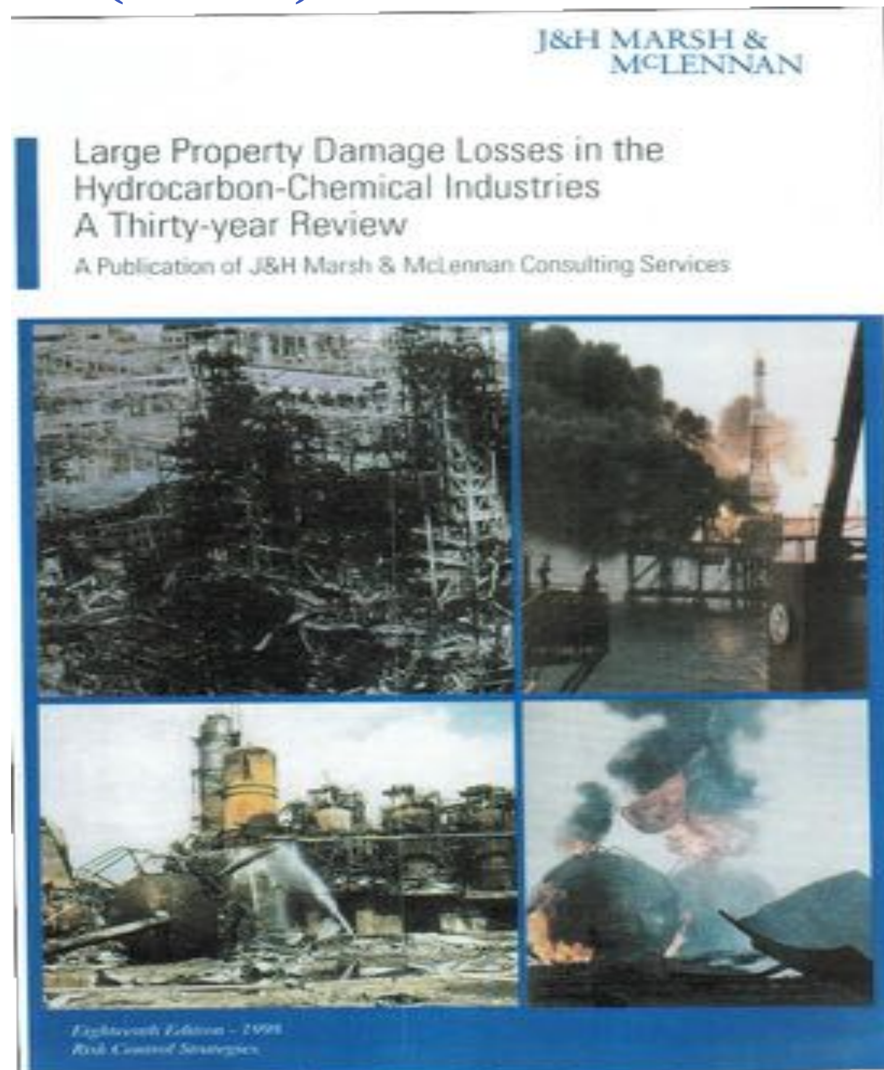
COLUMBIA ENGINEERING
The Fu Foundation School of Engineering and Applied Science

Outline

- Background/Motivation
- Safety Recommendations for ABET Feb 2010
- CHEN E4501 Chemical Engineering Process Safety
- Trade Show Experience
- Learning from History (Case Study & Design)
- Using Simulations to Teach and **Evaluate Process Safety Education**
- **Operations Center Experience**
- Acknowledgements and References
- Conclusion and Future Work

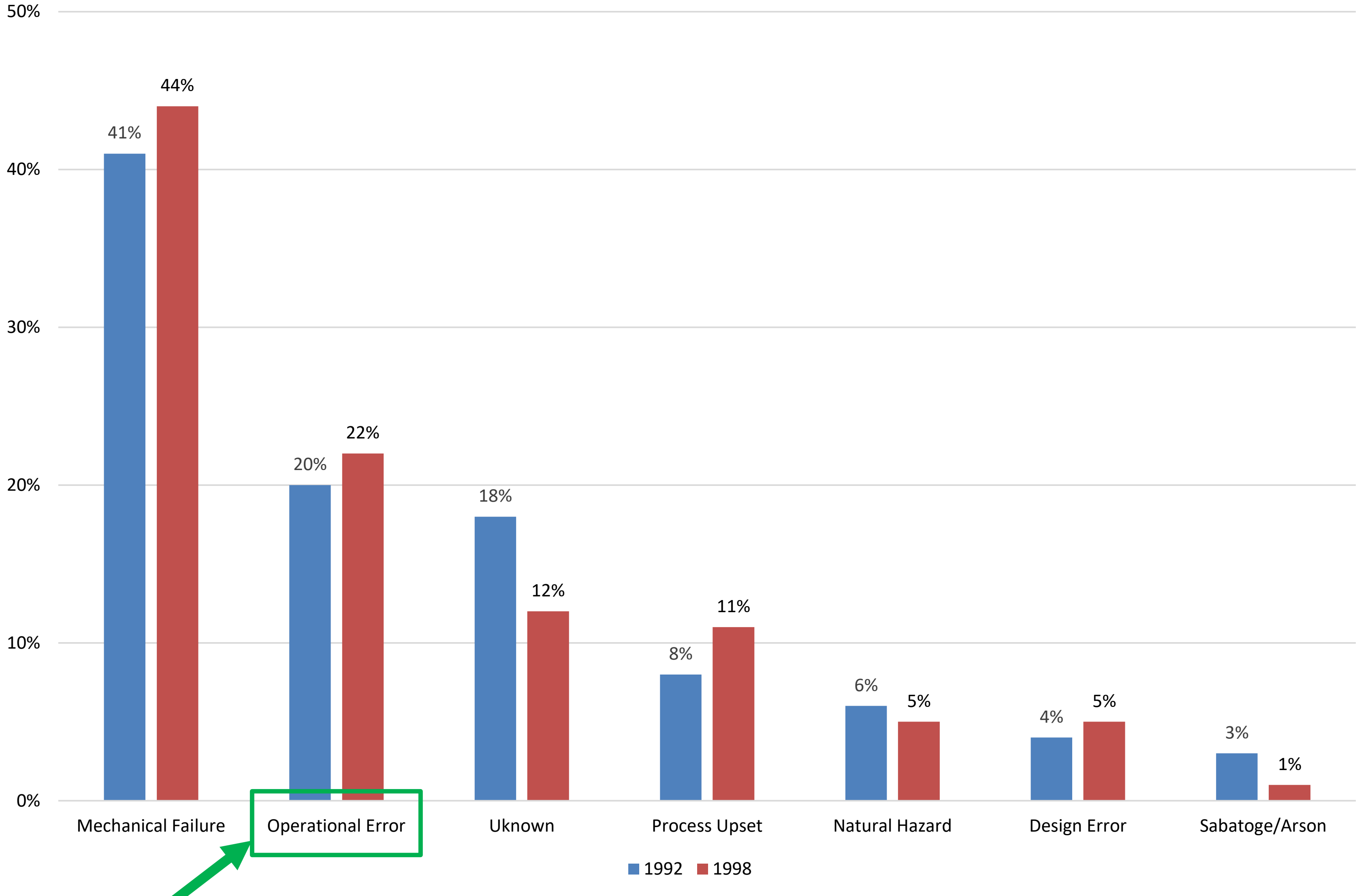
Case Study: Marsh and McLennan Reports 14th (1992) and 18th (1998) Editions





https://www.marsh.com/us/insights/research/the-100-largest-losses-in-the-hyrdocarbon-industry-1974-2015.html

Cause of Losses by Percent



Case Study: Marsh and McLennan Reports 14th (1992) and 18th (1998) Editions

Background and Motivation

“SAChE Recommendations for ABET Safety Content in Chemical Engineering February 18, 2010”
“The Safety and Chemical Engineering Education (SAChE) Committee makes the following recommendations with regard to student understanding to meet ABET curriculum requirements.

1. The graduate must understand the importance of process safety and the resources and commitment required. This should include the important incidents that define process safety, and how these incidents affected the practice of chemical engineering.

2. The graduate must be able to **characterize the hazards** associated with chemicals and other agents. This must include toxic, flammable, and reactive hazards.

3. The graduate must understand and be able to apply concepts of **inherently safer design**.

4. The graduate must understand how to **control and mitigate hazards to prevent accidents**. This should include generally accepted management systems, plant procedures and designs to prevent accidents.

5. The graduate should be **familiar with the major regulations** that impact the safety of chemical plants.

6. The graduate should **understand the consequences of chemical plant incidents** due to acute and chronic chemical releases and exposures.

7. The graduate should be reasonably proficient with **at least one hazard identification procedure**.

8. The graduate should have an introduction to the process of **hazard evaluation and risk assessment**.
Resource materials to assist in meeting these requirements can be found on the SAChE web.”

(www.sache.org accessed 13 Apr 2015)

Background and Motivation

"ABET Curriculum Statement approved in October 2011"

"1. Curriculum
The curriculum must provide a thorough grounding in the basic sciences including chemistry, physics, and biology, with some content at an advanced level, as appropriate to the objectives of the program. The curriculum must include the engineering application of these basic sciences to the design, analysis, and control of chemical, physical, and/or biological processes, including the hazards associated with these processes."

(www.abet.org accessed 13 Apr 2015)

CHEN E4501 Chemical Engineering Process Safety Course Description

"Aimed at seniors and graduate students. Provides classroom experience on chemical engineering process safety as well as Safety in Chemical Engineering certification. Process safety and process control emphasized. Application of basic chemical engineering concepts to chemical reactivity hazards, industrial hygiene, risk assessment, inherently safer design, hazard operability analysis, and engineering ethics. Application of safety to full spectrum of chemical engineering operations.“

((http://www.columbia.edu/cu/bulletin/uwb   accessed 27 Sep 2015)

CHEN E4501 Chemical Engineering Process Safety Course Significance

"Chemical Engineering Process Safety will be used anywhere in the world across the complete range of chemical engineering operations. Process Safety is current recommended ABET curriculum content by the Safety in Chemical Engineering Safety Committee. Academia and industry contributed to the content of applying chemical engineering concepts to chemical reactivity hazards, industrial hygiene, risk assessment, inherently safer design, and hazard operability analysis. With the ultimate aim of safer operations in the chemical engineering profession, the applications of the Chemical Engineering Process Safety will make the world safer."

(Fall 2017 Course Proposal)

CHEN E4501 Chemical Engineering Process Safety Course Objectives

1. **Learn about the importance of process safety and the resources and the commitment required. This should include the important incidents that define process safety, and how these incidents affected the practice of chemical engineering.**

2. Learn how to characterize the hazards associated with chemicals and other agents to include toxic, flammable, and reactive hazards.

3. Learn how to apply concepts of inherently safer design.

4. **Learn how to control and mitigate hazards to prevent accidents.**

5. Become familiar with the major regulations that impact the safety of chemical plants.

6. Learn about the consequences of chemical plant incidents due to acute and chronic chemical releases and exposures.

7. **Become familiar with the process of hazard identification and evaluation, and risk assessment**

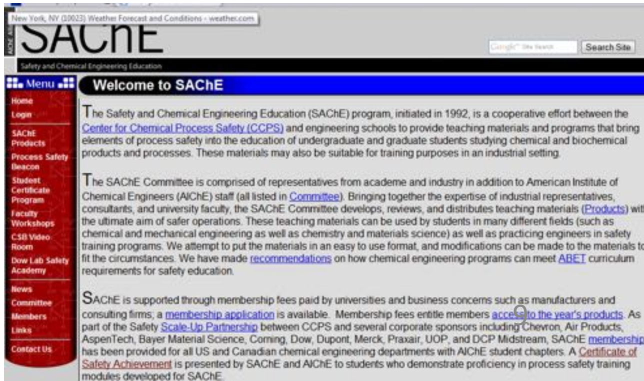
8. Become familiar with engineering ethics.

(Spring 2017 CHEN 4501 Syllabus)

Course Design and SAChE Integration

Week 1: Chemical Engineering Process Safety Course Overview
Intro to Process Safety (Chp 1) / Intro to SAChE (www.sache.org)
Lab Safety / Chemical Reactivity (Chp 8) / Hazard Identification (Chp 11)
SAChE Chemical Reactivity Hazards (Robert Johnson)
Week 2: Chemical Reactivity (Chp 8) and Hazard Identification (Chp 11)
SAChE Chemical Reactivity Hazards
Industrial Chemical Hygiene (Chp 3) and Toxicology (Chp 2)
Risk Assessment (Chp 12)
Week 3. Design/Safety Project Start Up
SAChE Chemical Process Safety in the Chemical Process Industries (Dan Crowl)
Week 4: SAChE Risk Assessment (Ralph Pike)
Prevention of Fires and Explosions (Chp 6 and Chp 7)
SAChE Dust Explosion Control (Louvar)
Week 5: Chemical Reactor safety
Safety Procedure and Designs (Chp 13)
SAChE Runaway Reactions (Amy Theis)
Week 6: Inherently Safer Design and Engineering Ethics
Intro to Reliefs (Chp 9), Relief Sizing (Chp 10), Order of the Engineer.
SAChE Inherently Safer Design certificate
Week 7: Design/Safety Project Progress Review 1
Week 8: Design/Safety Project Progress Review 1
HAZOPS

Situational Awareness

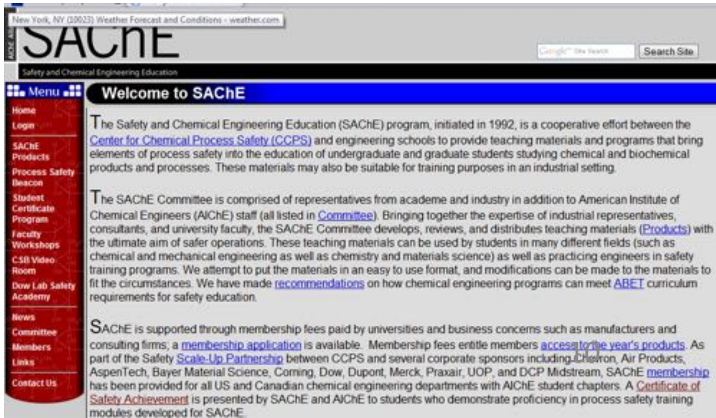


(www.sache.org 27 Sep 2015)

Course Design and SAChE Integration

Week 9: INTERPHEX Exhibition assignment at Javits Center, New York, NY
Guest Lecture Simulation Solutions Inc
Week 10: Guest lecture: Simulation Solutions Inc
Operations Center Exercise
Week 11: Operations Center Exercise- After Action Review
HAZOPs Review
SAChE Process Safety Lessons Taught from Experience (Wiley)
Week 12: Design/Safety Project Progress Review 2
Week 13: Design/Safety Project Progress Review 2
Presentation of Accident Investigation Case Studies
Week 14: Presentation of Accident Investigation Case Studies
Week 15: Study Days
Week 16: Final Design/Safety Project Due

Situational Understanding



(www.sache.org 27 Sep 2015)

Trade Show Assignment INTERPHEX 2017

Javits Center 655 W 34th St, New York, NY 10001

(Photo by R.G. Bozic)

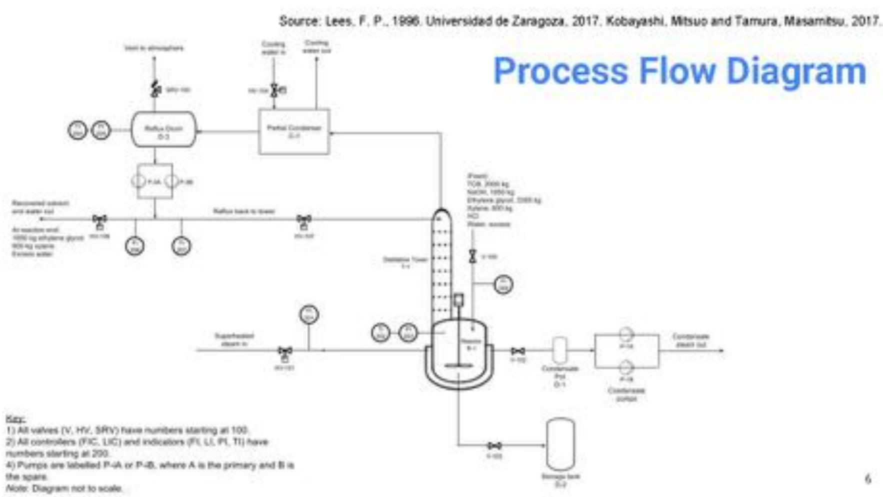
1. Emphasis on inherently safer design

-A one page report on **one** vender you visit at the INTERPHEX

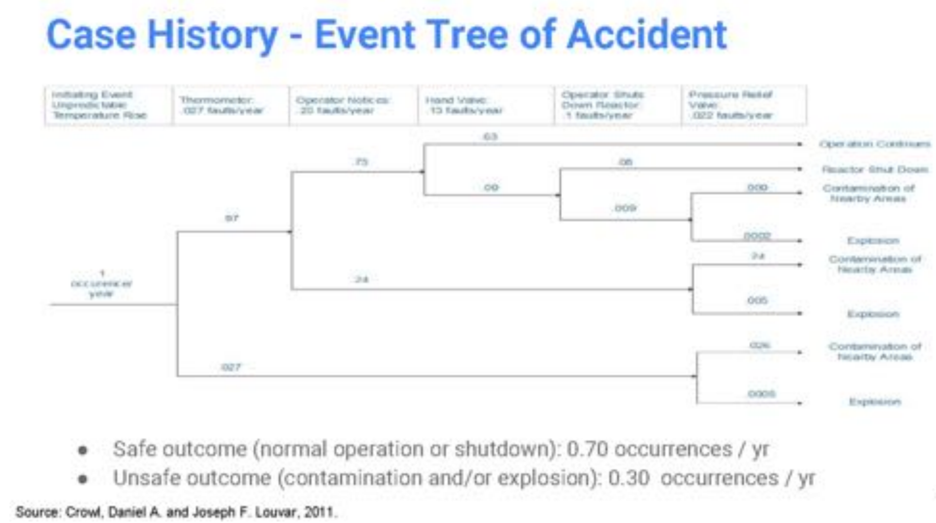
-The structure of your INTERPHEX report should be as follows: title page, an executive summary, results, discussion of what you learned addressing the areas of Inherently Safer Design: Moderate, Substitute, Minimize, and Simplify, and your conclusions.

Learning from History
Case Study and Design

Case study presentations Spring 2017



1. Emphasis on Process Flow Diagram to develop a common operating picture



2. Emphasis on Probability of Failure

Learning from History
Case Study Format

Oral Communication Skills- (Briefing During Class)

Written Communication Skills- (Slides turned in to the instructor)

Process Flow Diagrams

Case History (the accident, the event that produces injury/death/damage, and the hazard, the chemical or physical condition that can cause damage. Identify and evaluate the hazards involved. Determine what controls were used, and what should or could have been used. Define the scenario, a description of the events that result in an accident; the indecent, the loss of cantonment of material/energy, the consequence, result of accident, and the likelihood, expected probability of the event. Remember to address, risk- as defined, Risk = f(frequency, consequence) of the accident and determine what aspects of inherently safer design, moderate, substitute, minimize, and simplify, could have been used in order avoid such an accident)

Lessons Learned

Documentation/References

(Crowl, Daniel A. and Louvar, Joseph, 2011, Chp1)

Learning from History
Design

Oral Communication Skills - (In Class Progress Review)

Written Communication Skills- (Report turned in to the instructor)

Process Flow and Process Control Block Diagram Diagrams

Design Results (Outline what you recommend as a replacement and what your major conclusions are from your design and safety analysis. Design Results include summary of ASPEN simulation results, your safety analysis results from the Process Hazard Analysis Risk Assessment, Event Tree Analysis, Layer Of Protection Analysis, HAZOPS Analysis. Make sure you address aspects of Inherently Safer Design: Moderate, Substitute, Minimize, and Simplify. In this project, use Aspen Plus 8.6 for simulating your material and energy balances. As appropriate, make use of good engineering assumptions in order to complete this design project. Remember to assume, check, and validate assumptions. Keep a record of your assumptions and include them in your presentation.)

Discussion (Discussion of major decisions for your design results and your safety analysis)

Documentation/References

(Crowl, Daniel A. and Louvar, Joseph, 2011, Chp1)

Learning from History
8 Significant Disasters (Case Studies)

Photo courtesy of Morganton Department of Public Safety

Morganton, NC Jan 2006 (explosion)

Anacortes, Washington Apr 2010 (explosion)

Flixborough, England, June 1974 (pipe rupture)

Jacksonville, Florida, Dec 2007 (explosion)

Texas City, Texas May, 2005 (explosion)

Patterson, NJ Apr 1998 (explosion)

Bhopal, India, Dec 1984 (toxic release)

Seveso, Italy, Jun 1976 (runaway reactor, toxic release)

(www.csb.gov accessed 31 Jan 2016)

(Crowl, Daniel A. and Louvar, Joseph, 2011, Chp1)

Evaluating Chemical Engineering Safety Training Results

Donald C. Glaser & Matthew Garvey
Simulation Solutions, Inc.

23 Mar 2017 and 28 Mar 2017

Objectives

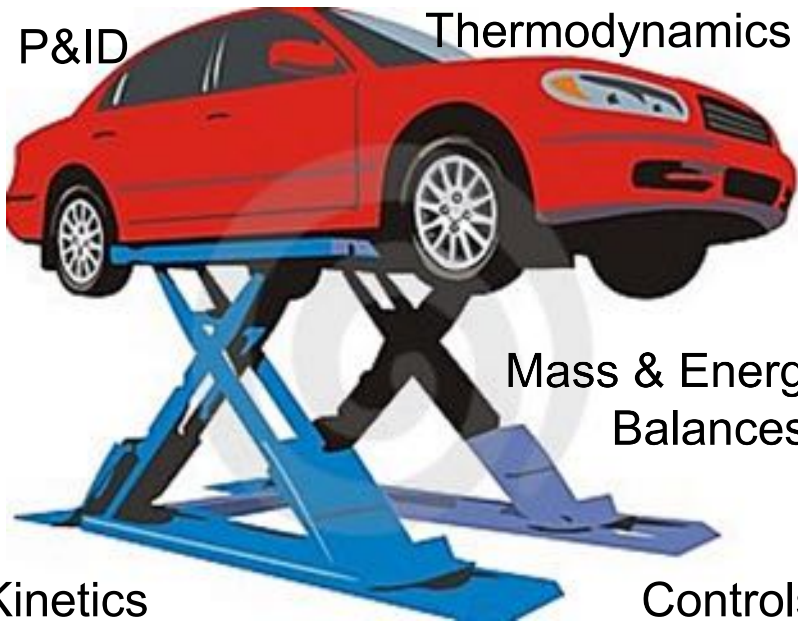
- Learn more about the importance of process safety and the resources & commitment required.
- Learn how to control and mitigate hazards to prevent accidents.
- Learn about operator training through the use of simulators.
- Review process control and chemical engineering design concepts.

Simulation Solutions, Inc.
Outline

- Overview of Operator Training
- Review of Operator Safety & INSTO™ Methodology
- Introduction to P&ID / DCS / Outside Operator
- SSI "What-If" Exercises
- SSI Troubleshooting Exercises
- Q&A for Students

Simulators provide life-like Training for New and Experienced Operators

Laboratory Experience



Real World Experience

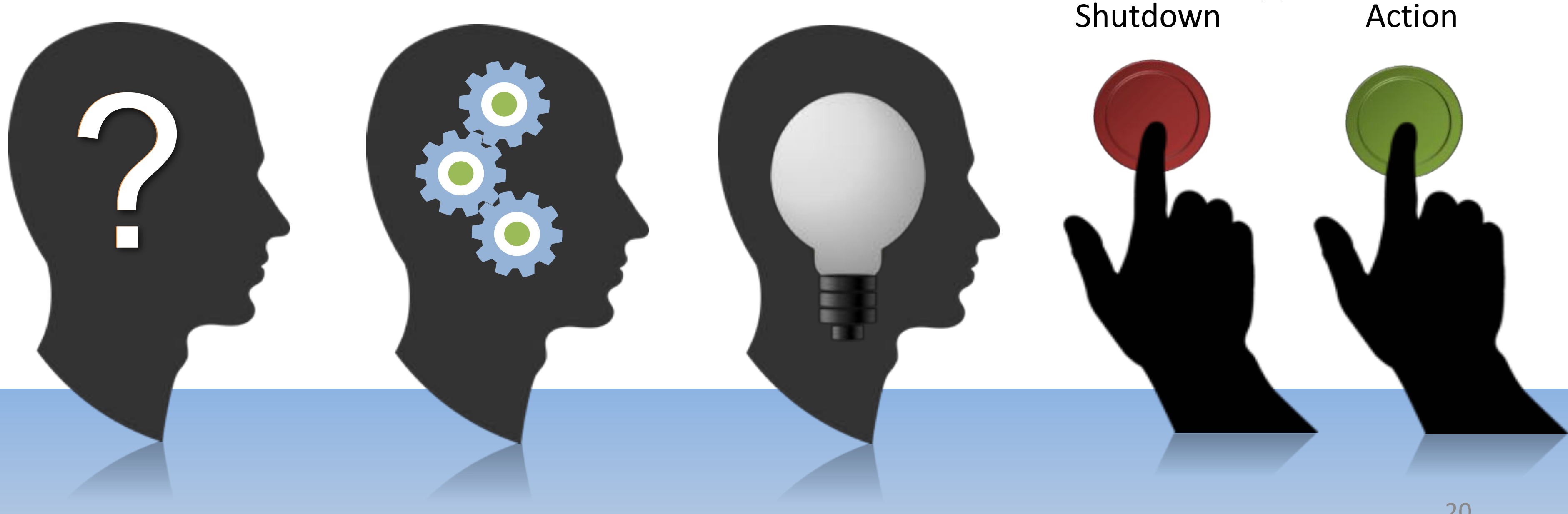
Minds-On/Hands-On Troubleshooting Process

"Minds-On"

- Identify the Problem
- Troubleshooting Process
- Propose a Cure

"Hands-On"

- Taking Action
  - Safe Shutdown Or Corrective Action

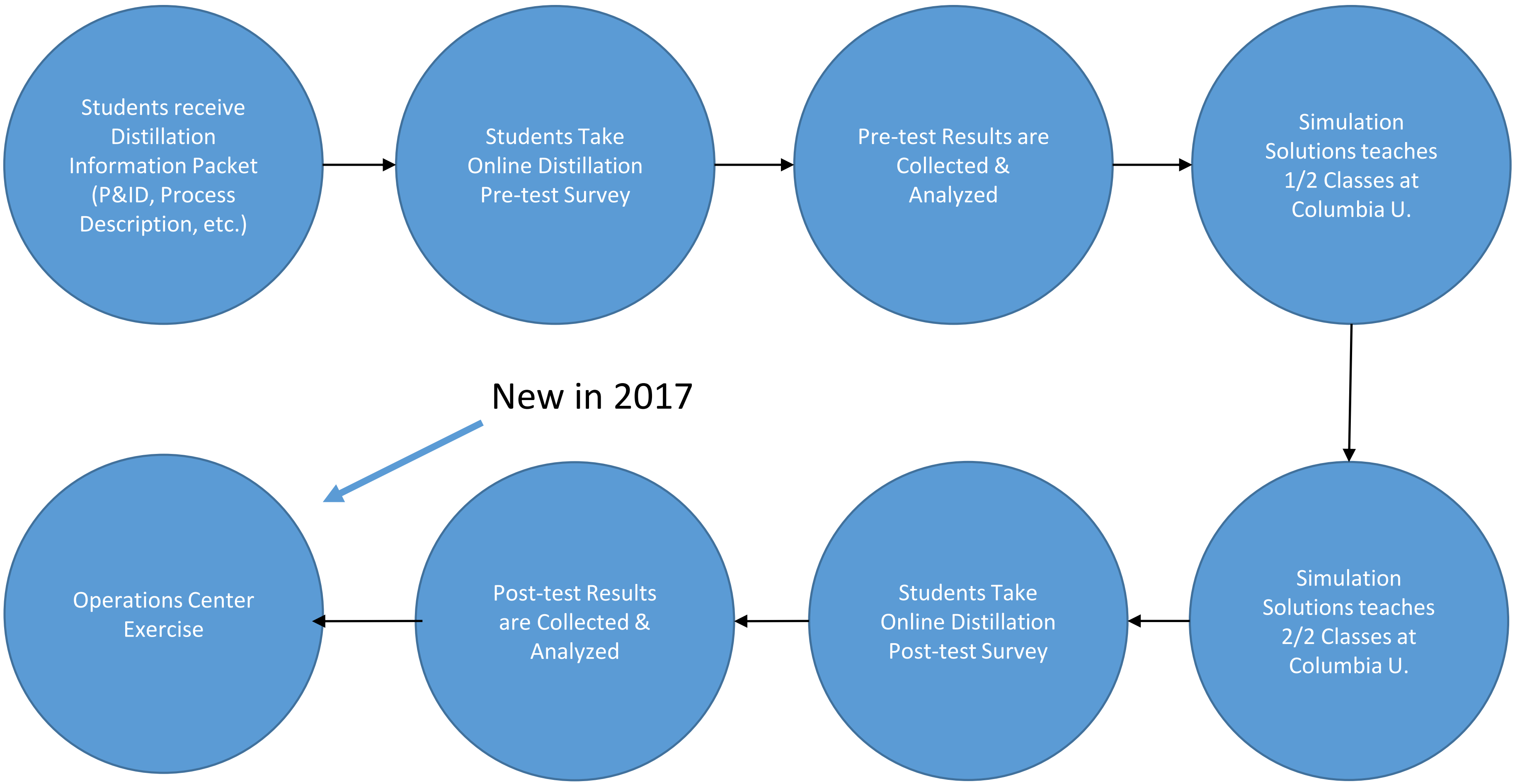


Grafting an *Operations Mindset*™ to New Operators

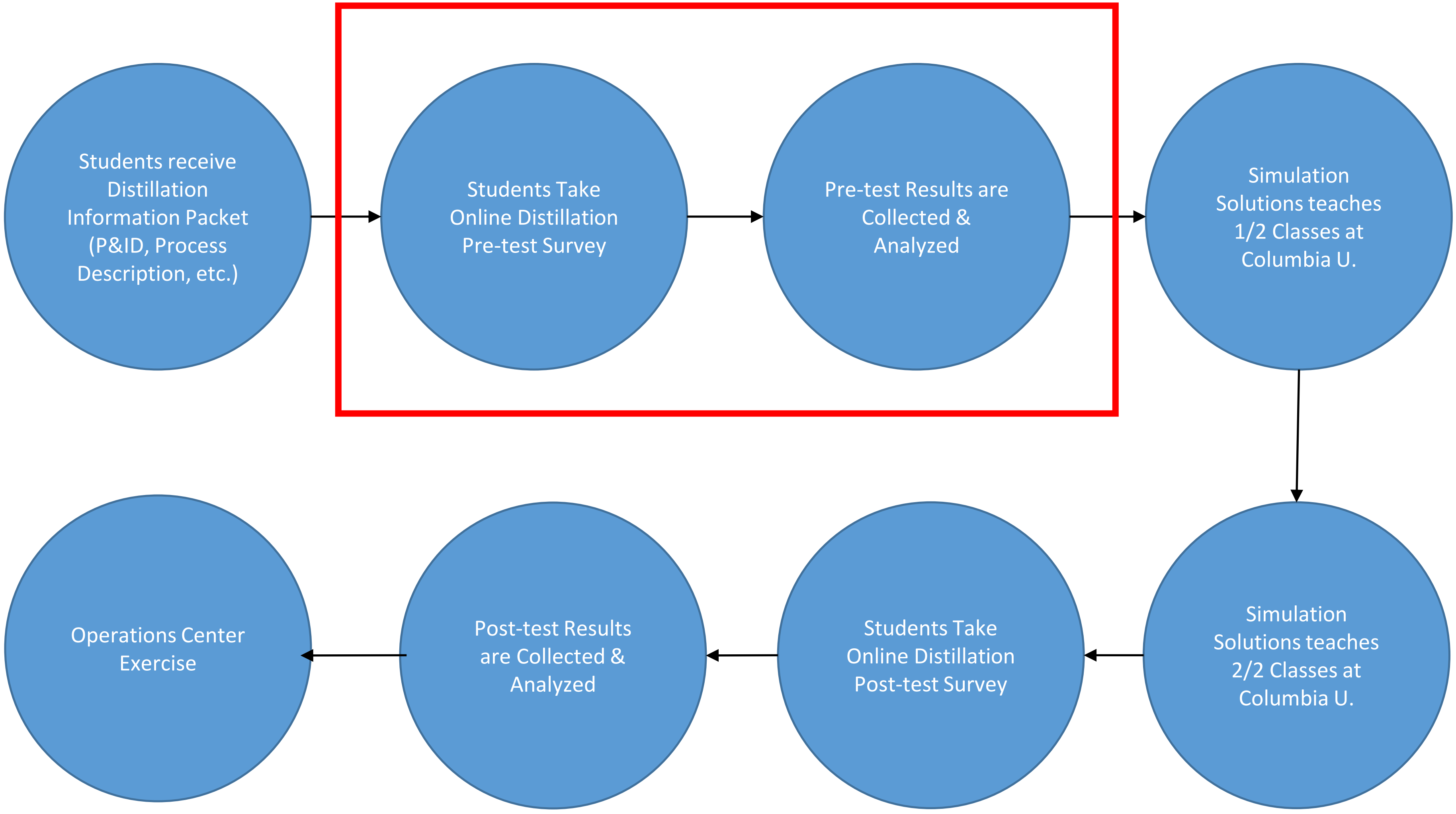
"Old School" Operator
Numerous Opportunities for Experiential Learning

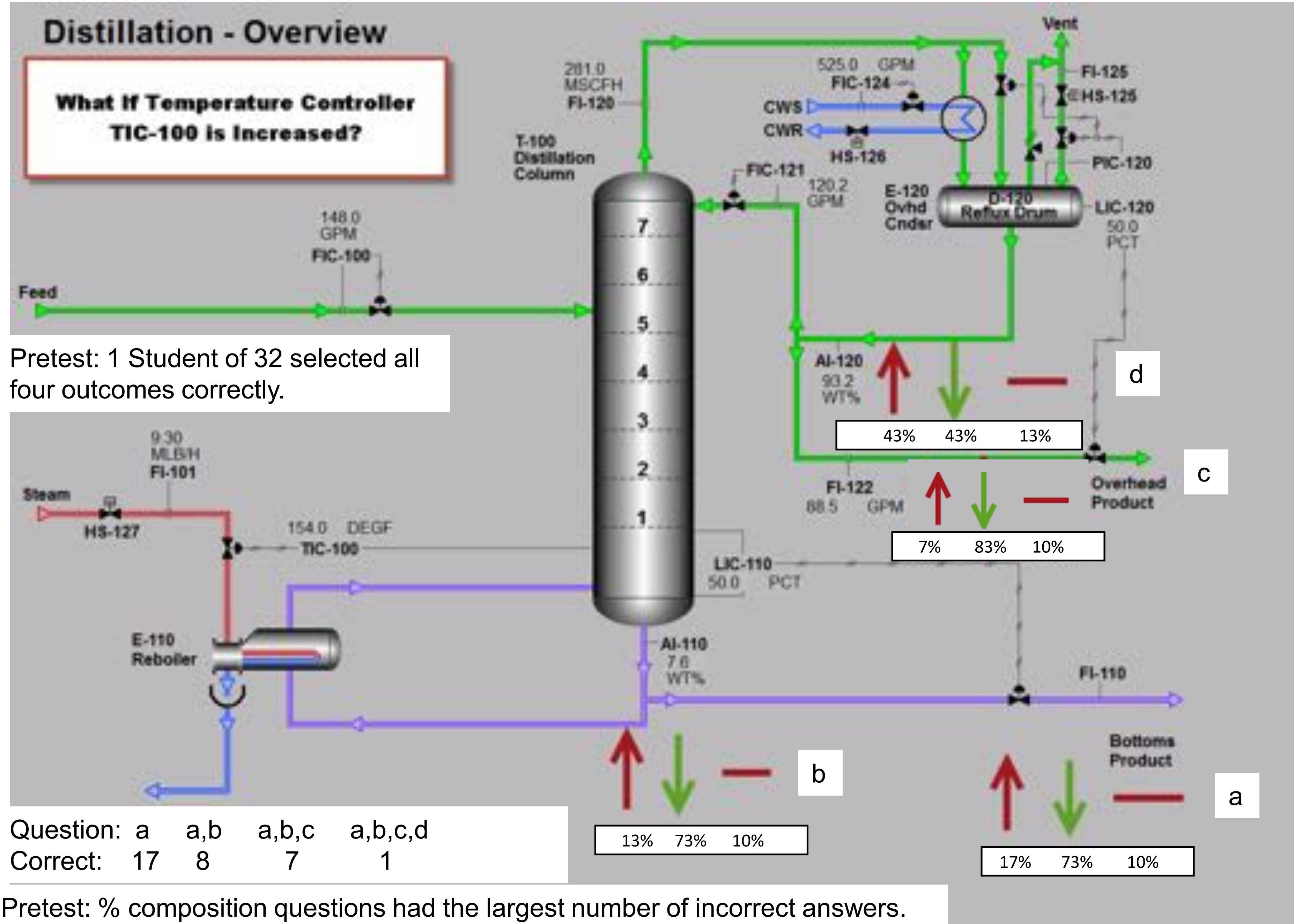
"New School" Operator
Vastly Different Circumstances

Coursework Flow



Coursework Flow



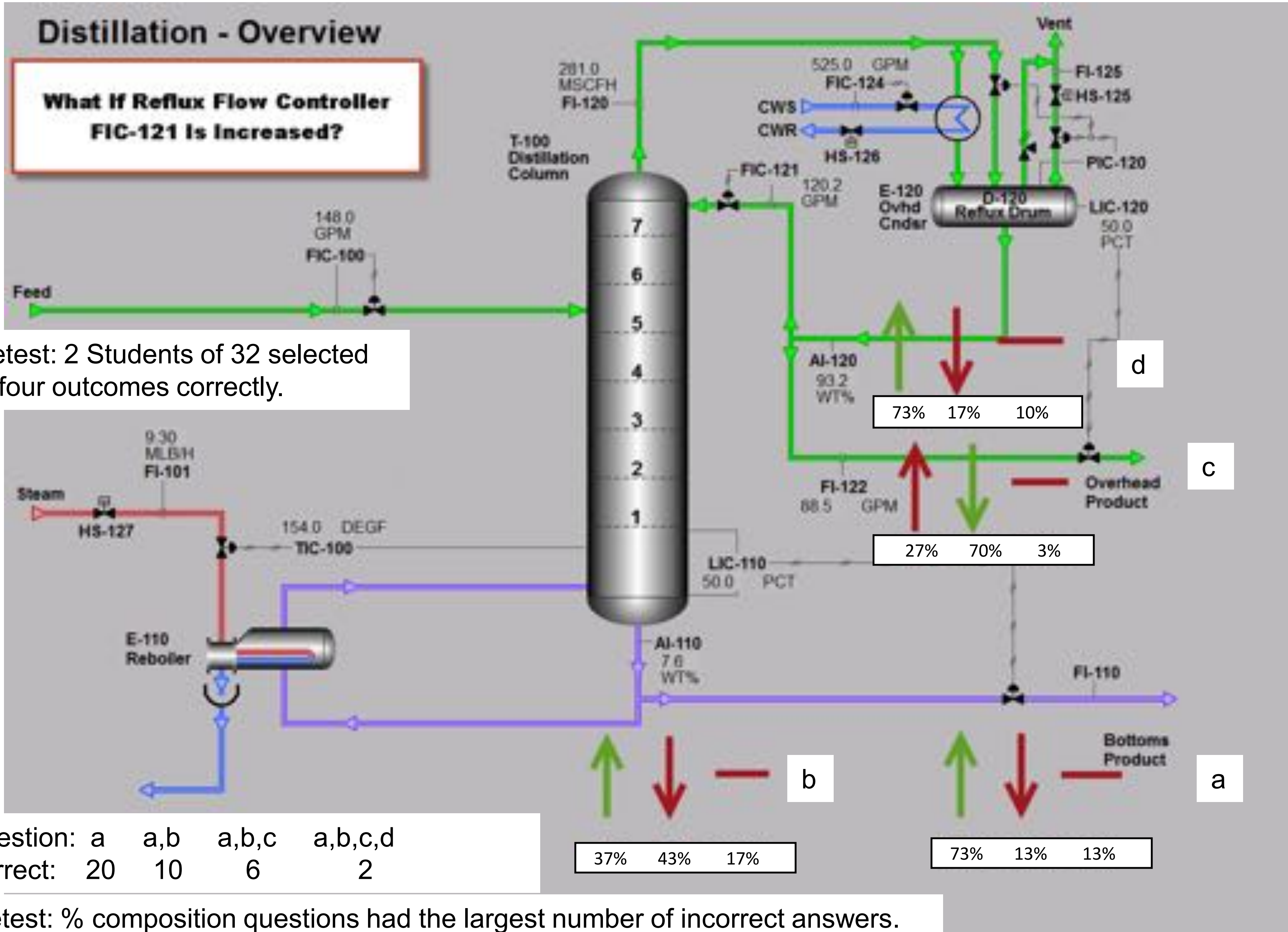


Pretest: 1 Student of 32 selected all four outcomes correctly.

Question:	a	a,b	a,b,c	a,b,c,d
Correct:	17	8	7	1

Pretest: % composition questions had the largest number of incorrect answers.

SAChE/ Course Objective/ Lesson Objective “Learn how to control and mitigate hazards to prevent accidents.”



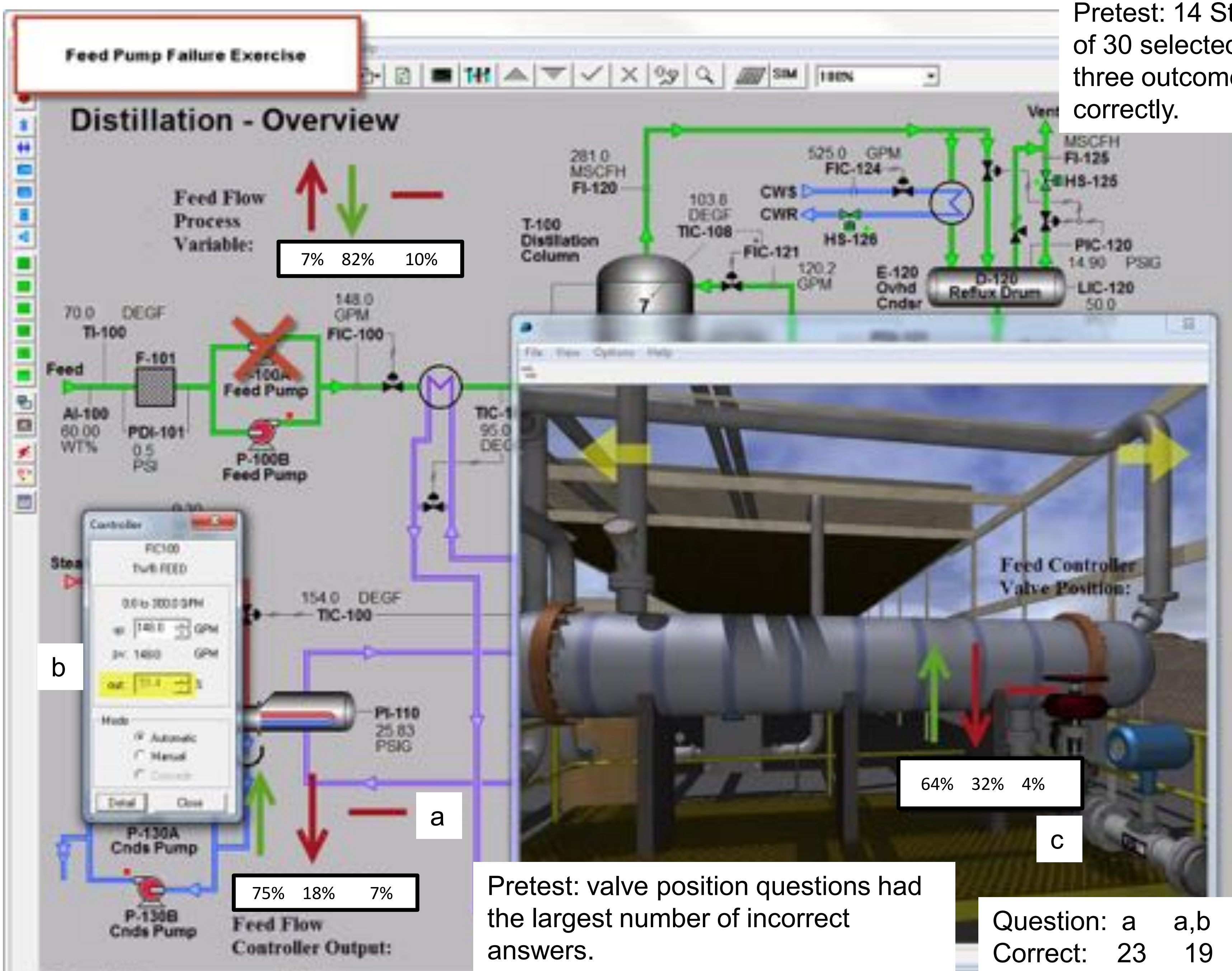
Pretest: 2 Students of 32 selected all four outcomes correctly.

Question:	a	a,b	a,b,c	a,b,c,d
Correct:	20	10	6	2

Pretest: % composition questions had the largest number of incorrect answers.

SAChE/ Course Objective/ Lesson Objective "Learn how to control and mitigate hazards to prevent accidents."

Pretest: 14 Students of 30 selected all three outcomes correctly.



Pretest: valve position questions had the largest number of incorrect answers.

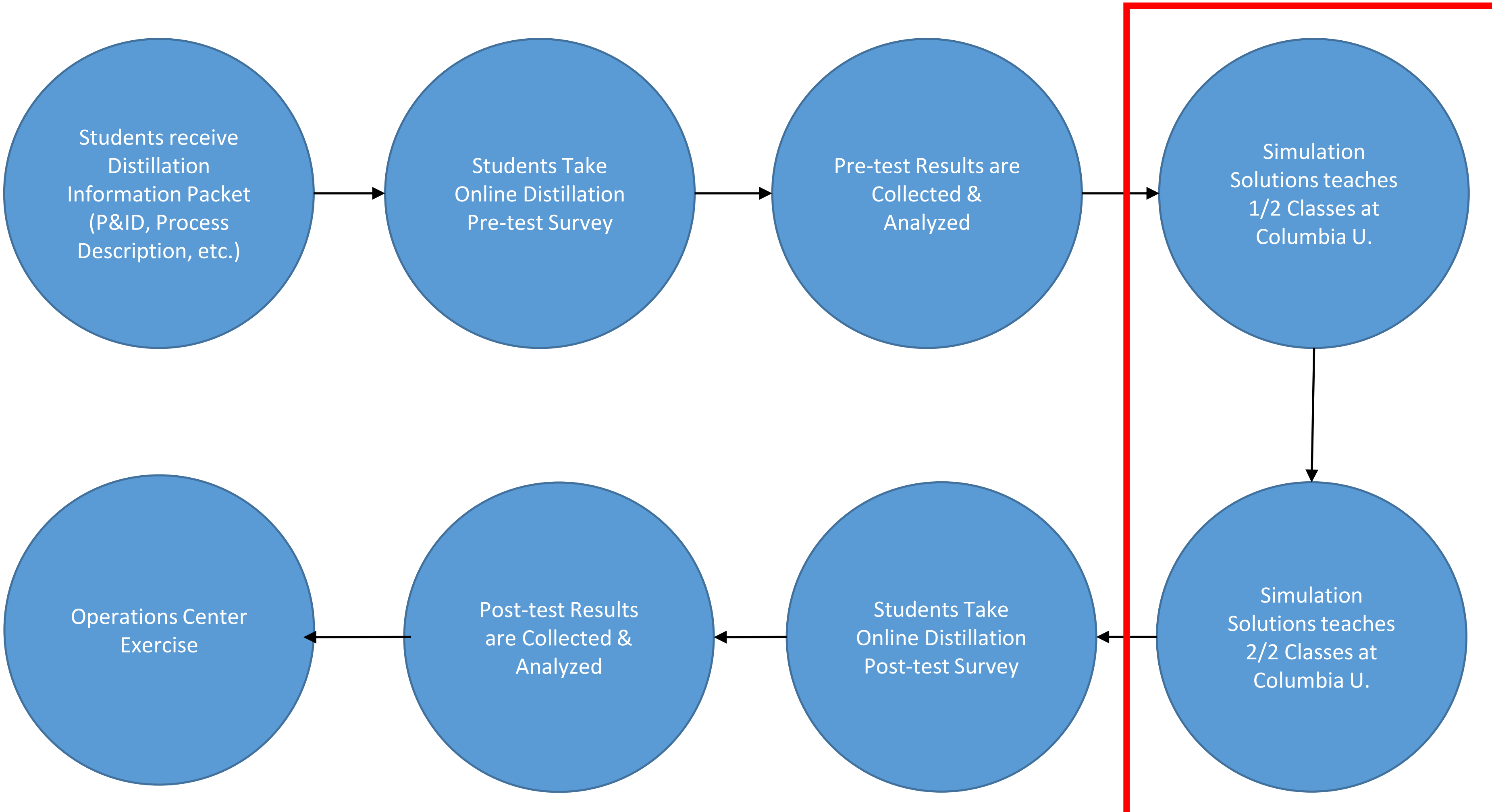
Question:	a	a,b	a,b,c
Correct:	23	19	14

SAChE/ Course Objective/ Lesson Objective “Learn how to control and mitigate hazards to prevent accidents.”

Feed Pump P-100A Failure Recovery Steps

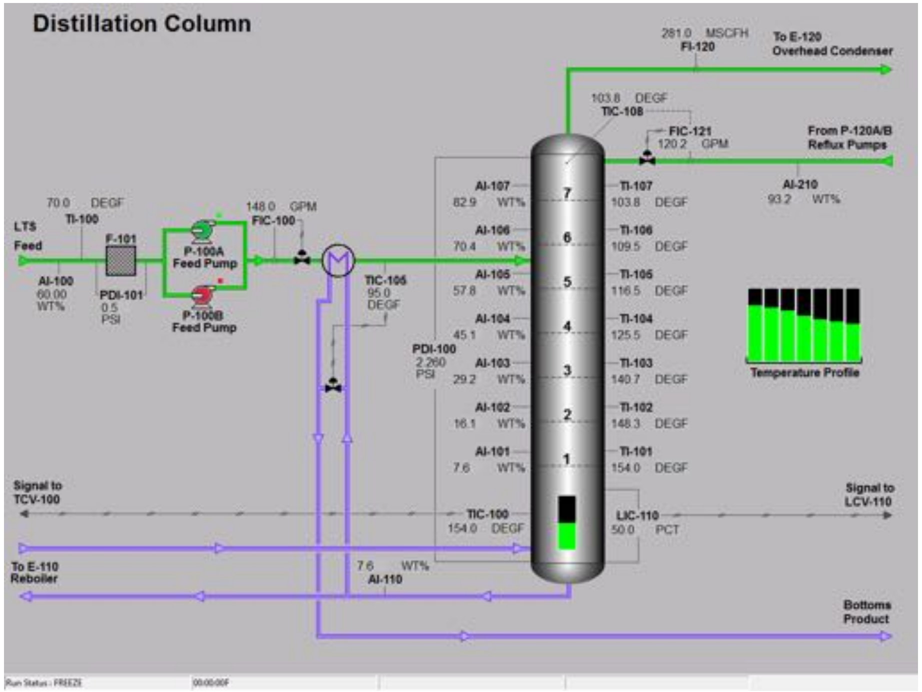
Step No.	Operator Action	Number of Students Remaining with Proper Sequence (28 Total)
1.	Place Feed Flow Controller in Manual	14
2.	Lower Feed Controller Output to 10%	9
3.	Start Spare Feed Pump, P-100B	8
4.	Increase Feed Flow Output until Process Variable is at the Design Flow Rate	7
5.	Place Feed Flow Controller into Automatic Mode	7

Coursework Flow



Simulator Demonstrations

Distillation



“Minds-On/Hands-On” Training™

Execute

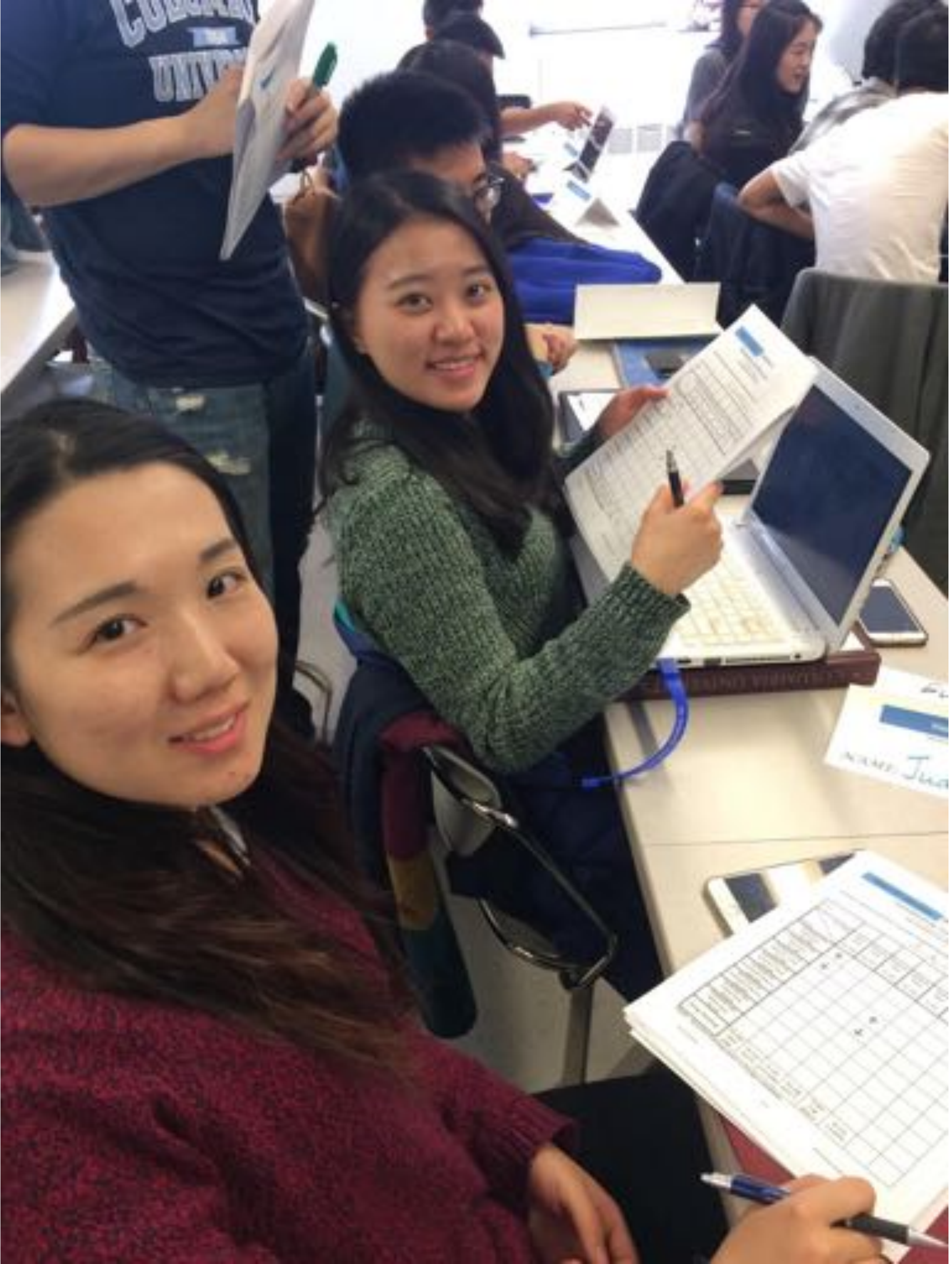
Report

Trainee-Driven Learning

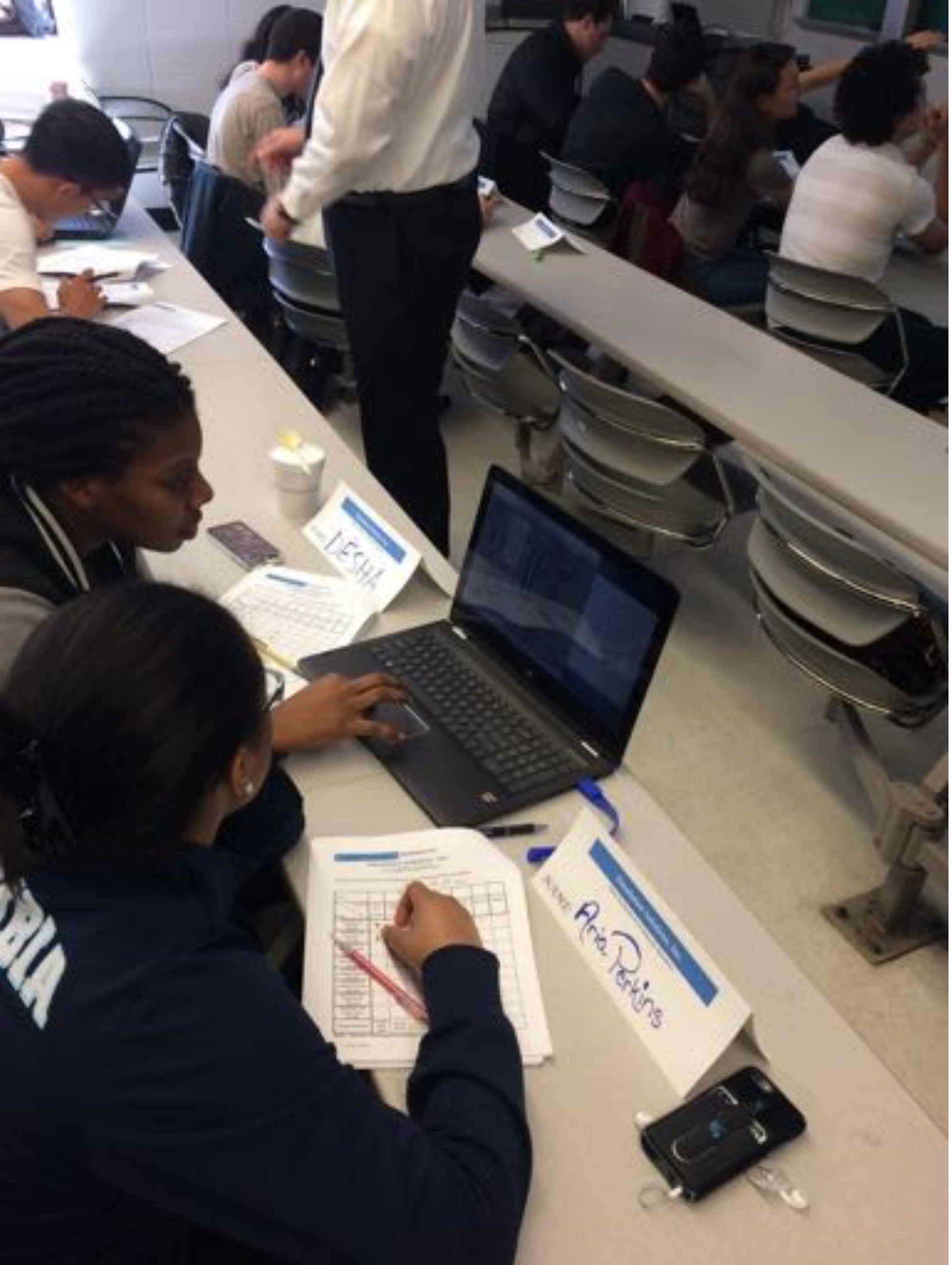
Predict

Discuss

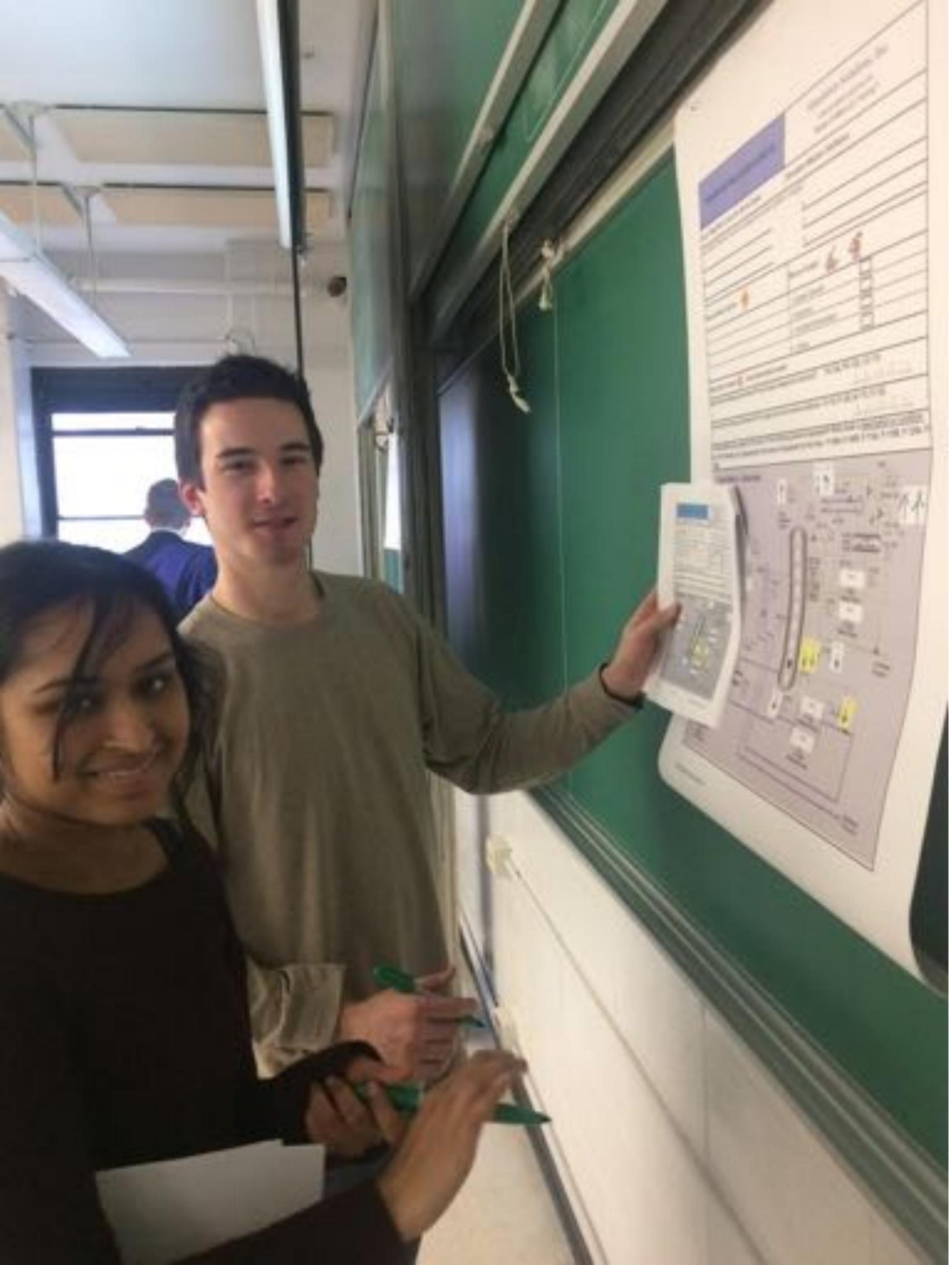
Don Glaser and Matt Garvey of Simulations Solutions Inc. instruct the CHEN E4501 Chemical Engineering Process Safety Class on aspects of operator training



Yi Ling Yang and Anqi Sun run a distillation simulation during a "What if?" exercise in class during the Simulation Solutions Inc. Guest Lecture in the CHEN E4501 Chemical Engineering Process Safety course.



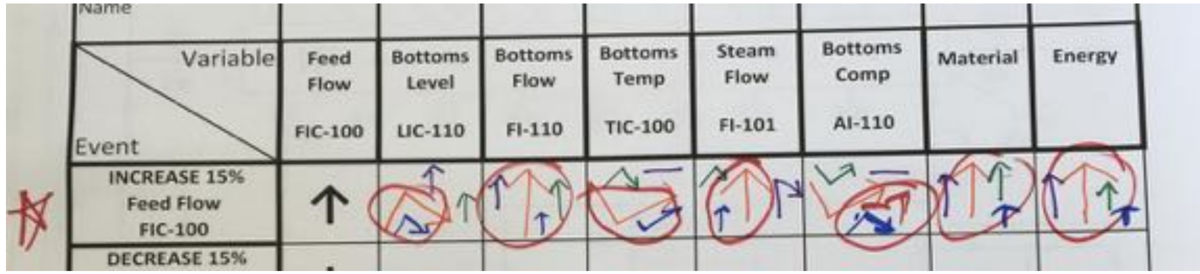
Desha Dike and Aria Perkins run a distillation simulation during a "What if?" exercise in class during the Simulation Solutions Inc. Guest Lecture in the CHEN E4501 Chemical Engineering Process Safety course.



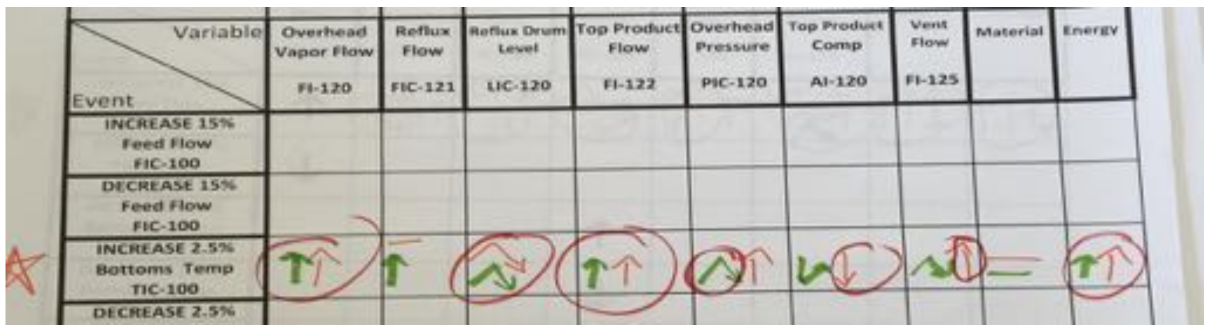
Jaren Shapiro and Farah Taufiq predict actions and then observe simulation during the Simulation Solutions Inc. Guest Lecture in the CHEN E4501 Chemical Engineering Process Safety course.

Distillation
"What-If" Flip Charts

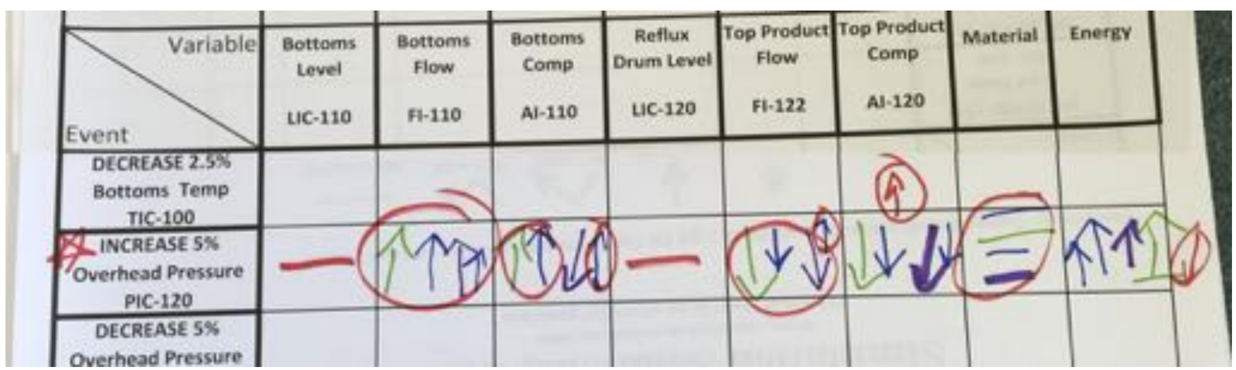
How will the Bottom of the Tower react if Feed Flow is increased?



How will the Top of the Tower react if Reboiler Steam is Increased?



How will Product Flows & Compositions react if Overhead Pressure Increases?



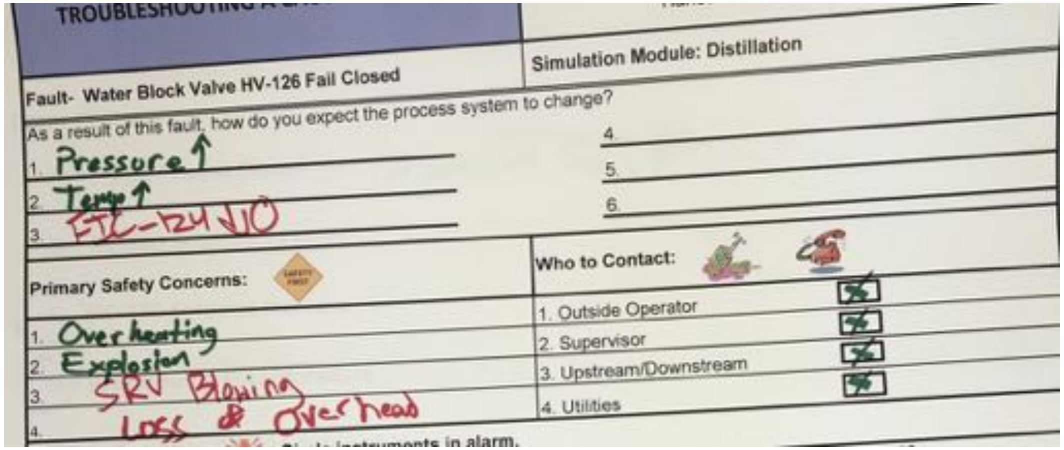
Distillation "What-If" Discussion

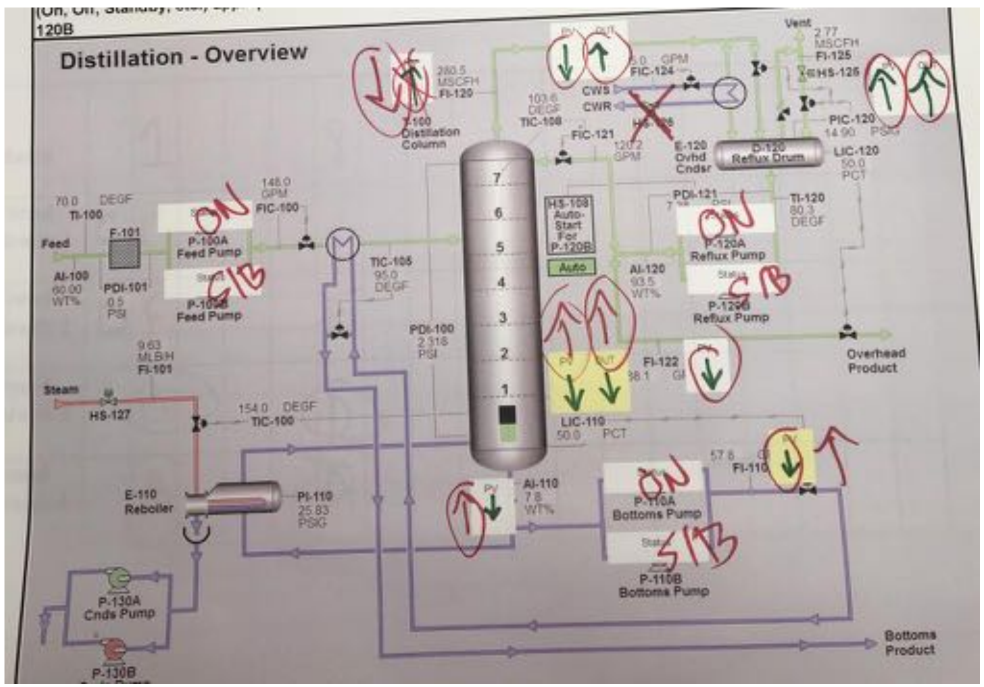
- Students were asked to predict how Controllers and Indicators would respond to a Setpoint change in a Distillation Simulator. (i.e. Increasing Feed Flow Rate, Tower Temperature, Reflux Flow Rate, Overhead Pressure).

- Students did not always correctly predict controller responses. For example: When more Feed is put down a Distillation Column the bottoms level will rise, but eventually come back to set point given the controller in this system. This is achieved by the Bottoms Flow increasing. Some students only predicted that this level would rise, and not return to setpoint.

- Another area of trouble was predicting Product Stream purities. For example when the Overhead Pressure was increased in the system, many students predicted that the Top Product would have less "lights" in the stream. An increase in Pressure will actually sweeten the Top Product Stream.

Troubleshooting Exercise Results – Loss of Cooling Water to the Tower





Troubleshooting Exercise Discussion

- Students were asked to predict Controller and Indicator Responses if Cooling Water to the Tower went to zero, due to a closed block valve.

- A focus was put on the “big picture” safety concerns of this fault, a few safety concerns students listed were:

  - Over Pressurization of Tower
  - Safety Relief Valve Blowing
  - Loss of Overhead Product (Distillate) Flow

- An emphasis was placed on considering downstream and upstream effects of a fault within your unit.

Student Survey Results 2017 (Graded on Scale 1-5)

	For each statement below, rank from 1-5, where 5 indicates strong agreement and 1 indicates strong disagreement.	CHEN E4501 Lessons 18 and 19	Standard Deviation
1	As a result of lessons 18 and 19 my ability to understand the importance of process safety and the resources and commitment required has improved. (course objective 1)	4.59	0.57
2	As a result of lessons 18 and 19 my ability to understand how to control and mitigate hazards to prevent accidents has improved. (course objective 4)	4.44	0.64
3	As a result of lessons 18 and 19 my understanding of operator training through the use of simulators has improved..	4.63	0.56
4	As a result of lessons 18 and 19 my understanding of process control and chemical engineering design concepts has improved.	4.48	0.58

31of 31 students responded.

Student Survey Results 2017 (1 of 2)

General Comments about Simulation Solutions Safety Course Spring at Columbia University

CHEN E4501 Chemical Engineering Lessons 19 and 20

- Worthwhile program. Hopefully, in the future it'll be great if we can have the class in a computer lab since Mac's can't run the software.
- Really helpful because it was interactive. Feel more confident in understanding of safe procedures and hazard mitigation.
- It is interesting to use the simulators to understand preventing hazards in engineering design.
- Fun class and learned a lot.
- Fun, but I felt a bit rushed.
- Software was very helpful for visualizing real time effects of process variable manipulator. Exercises were well developed.
- Great presentation. The workbook is an effective tool.
- The lesson was useful in illuminating the hazards of process control but perhaps more links to the concepts from class would be useful.
- I appreciate the operator training since we usually don't get hands-on experience with engineering concepts. The guest lecturers were nice and thorough.
- You help me learn a lot.
- Very Helpful.
- Great lessons.

Student Survey Results 2017 (2 of 2)

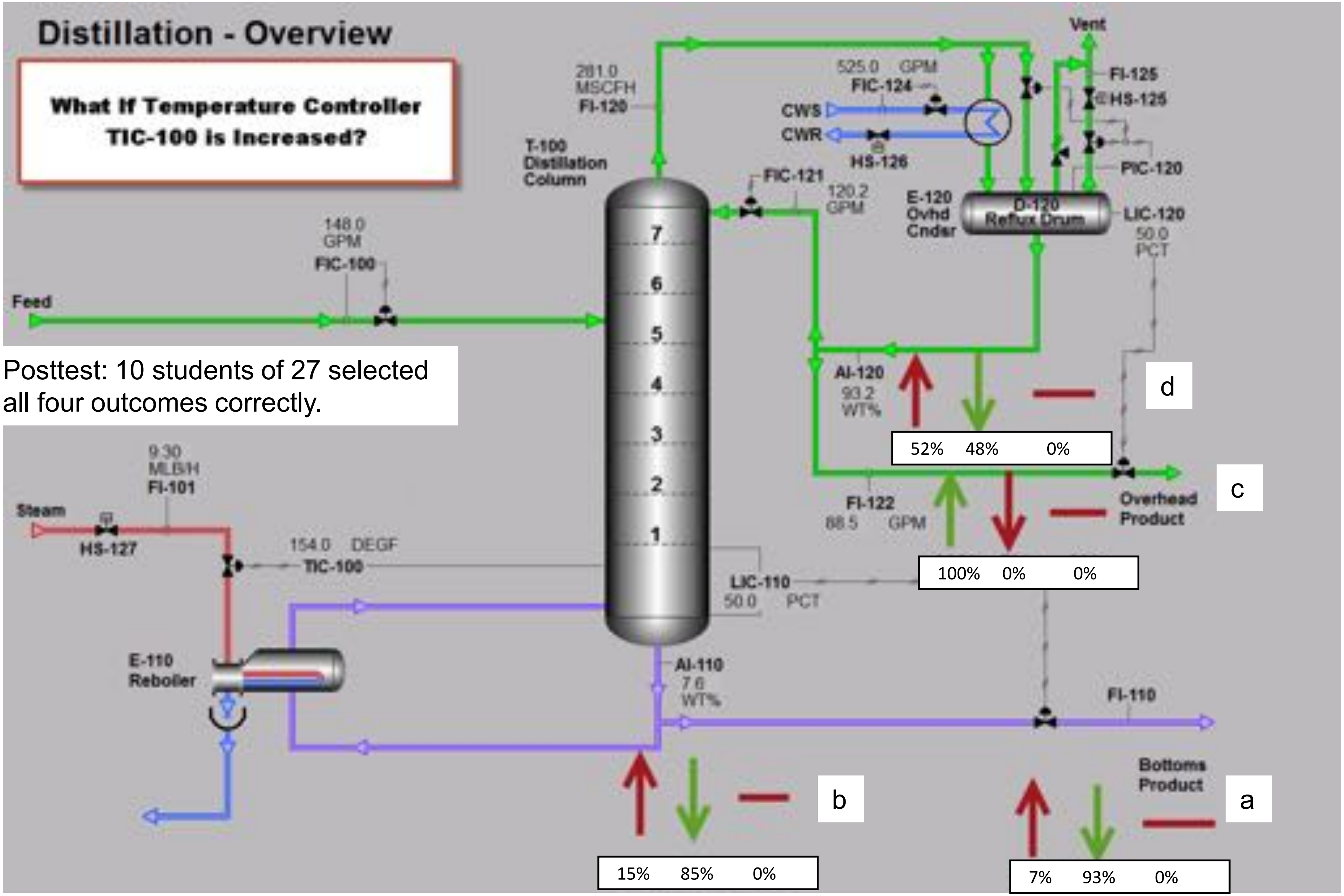
General Comments about Simulation Solutions Safety Course Spring at Columbia University

CHEN E4501 Chemical Engineering Lessons 19 and 20

- Class time is short. What we need to learn is much. I truly did not understand some content.
- Slightly rushed towards the end of lecture, but otherwise informative and helpful.
- Great experience to use software on simulation.
- I really like the addition of simulator training.
- Simulation Soln representatives were very helpful.
- Useful course
- These two lessons are really meaningful.
- It’s fun. I feel closer to the real world.:-)
- Great lesson! Works great seeing simulation!
- Having a visual and industry view of controls has helped me understand where the controls course we took was mostly theoretical.

Coursework Flow

Posttest: 10 students of 27 selected all four outcomes correctly.

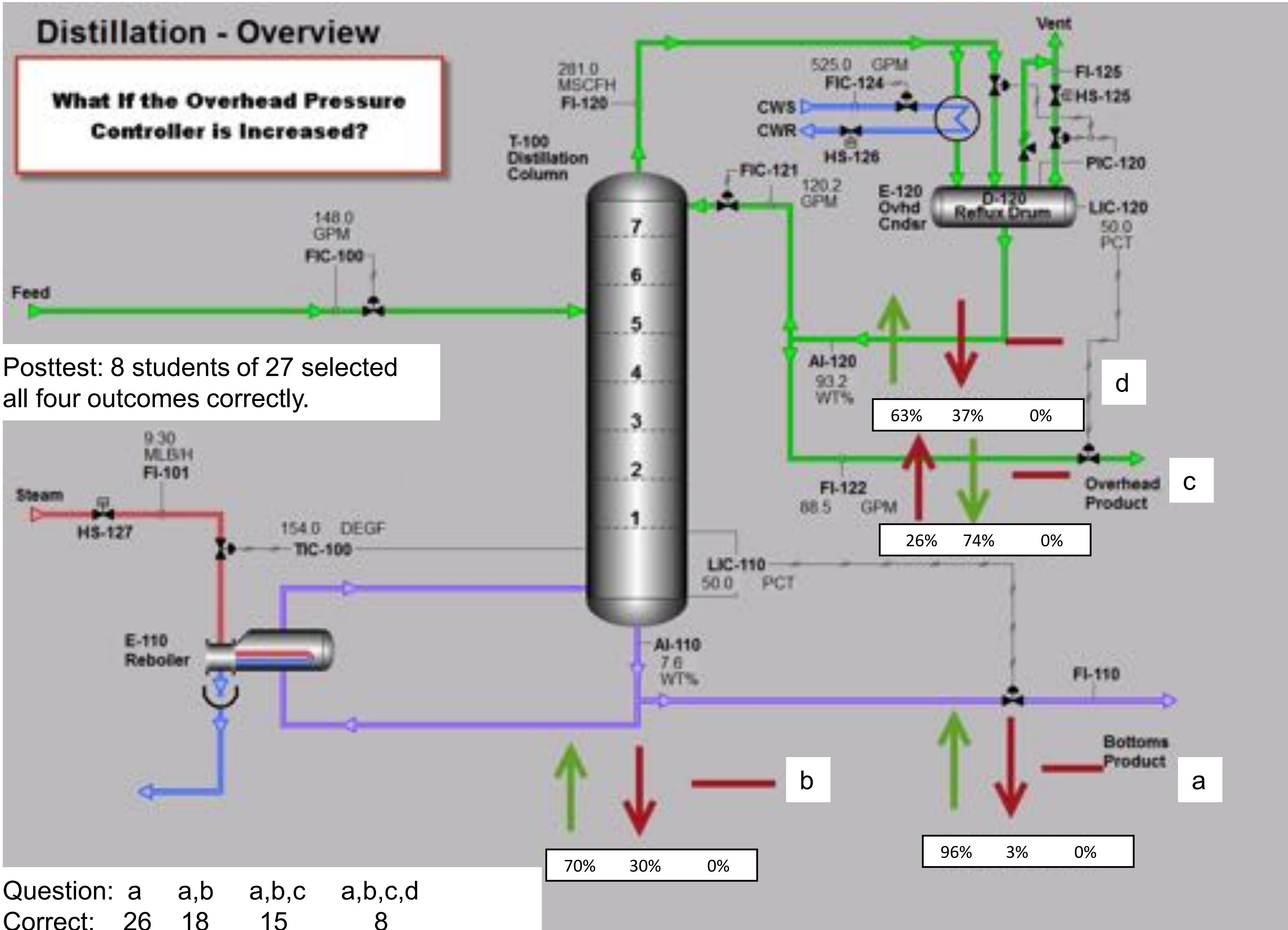


Question: a a,b a,b,c a,b,c,d

Correct: 25 22 22 10

Post-test: % composition questions had the largest number of incorrect answers.

SAChE/ Course Objective/ Lesson Objective “Learn how to control and mitigate hazards to prevent accidents.”



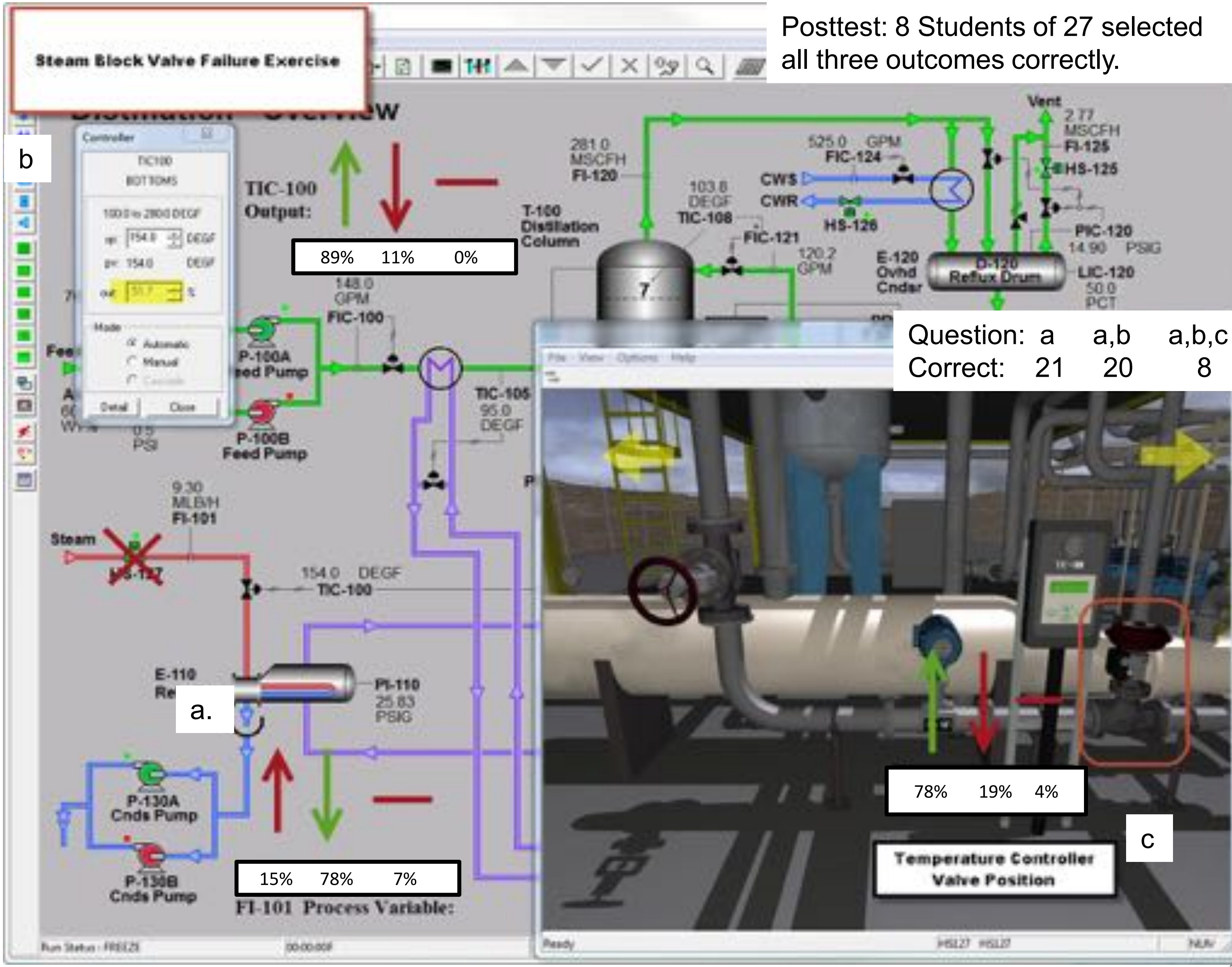
Posttest: 8 students of 27 selected all four outcomes correctly.

Question:	a	a,b	a,b,c	a,b,c,d
Correct:	26	18	15	8

SAChE/ Course Objective/ Lesson Objective “Learn how to control and mitigate hazards to prevent accidents.”

Posttest: 8 Students of 27 selected all three outcomes correctly.

Question:	a	a,b	a,b,c
Correct:	21	20	8



SAChE/ Course Objective/ Lesson Objective “Learn how to control and mitigate hazards to prevent accidents.”

Condensate Pump Failure Recovery Steps

Step No.	Operator Action	Number of Students Remaining with Proper Sequence (27 Total)
1.	Place Temperature Controller in Manual	22
2.	Lower Temperature Controller Output from 100% to the Design Rate of 50%	17
3.	Start Spare Condensate Pump, P-130B	13
4.	Adjust Temperature Controller Output until the Design Temperature of 154 degF is achieved.	13
5.	Place Temperature Controller in Automatic Mode	13

Comparing Pre-test and Post-test Data

- Students showed substantial improvement in recovering from a plant upset in a safe manner in order to mitigate and control a hazard.

- Students showed improvement in predicting how both product flow rates and product purities would respond to disturbances in a distillation column.

Lessons Learned Simulator Exercise

Lessons learned

By scheduling 2 Project Progress Reviews Prior to the case study and design assignment, students were encouraged to go in a direction that required them to do the case study work prior to the Progress Review. This seemed to help decrease procrastination.

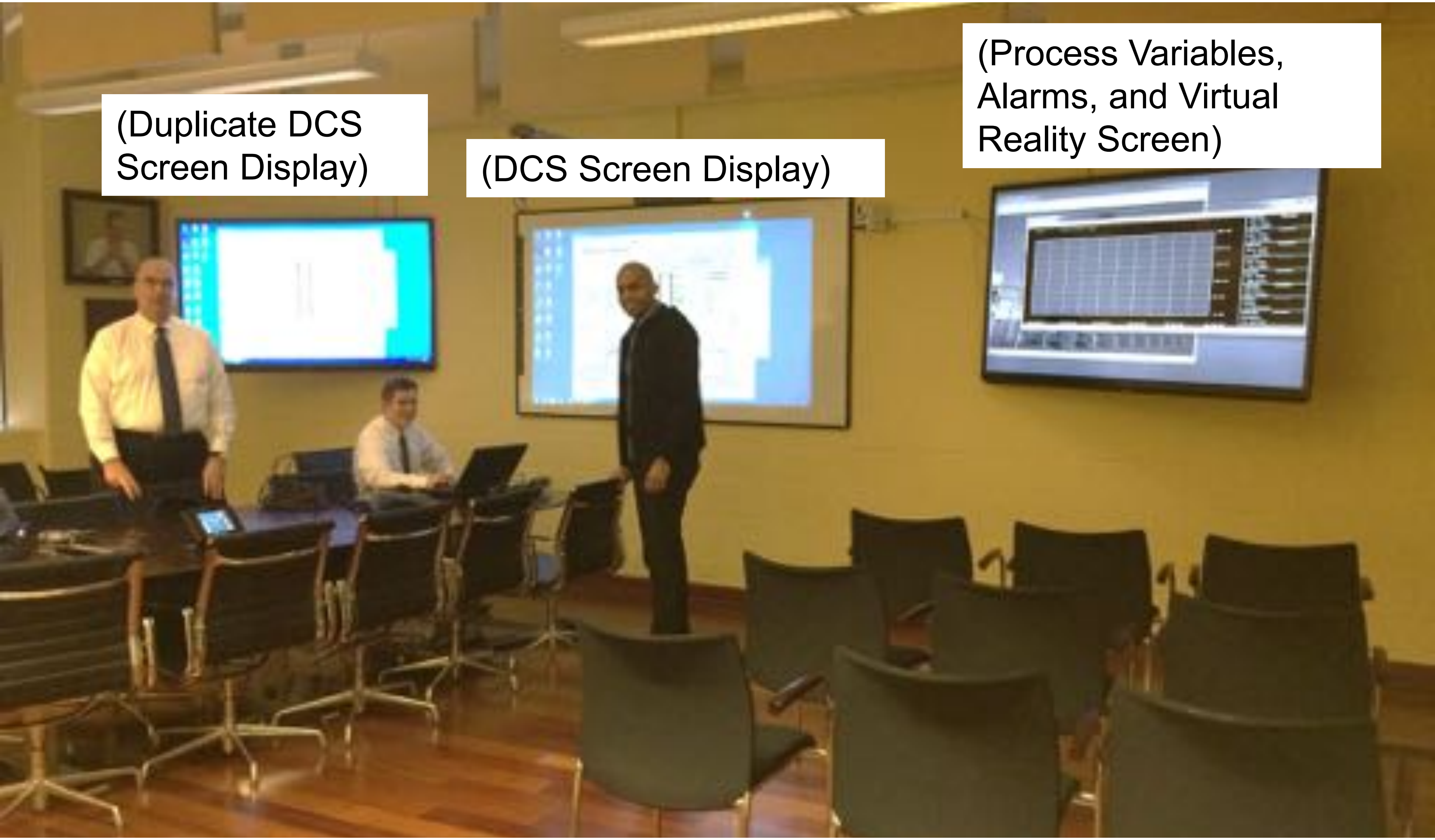
Students were inspired and enjoyed opportunities to use computer software that simulated process equipment.

Student performance on the pretest and post test showed a marked improvement. With only two 75 min classes, and a small amount of individual “stick time” on the simulator, student ability to predict outcomes improved considerably.

Having a pre-test and post-test seemed to increase interest in the event as well as provide the major means by which performance was evaluated.

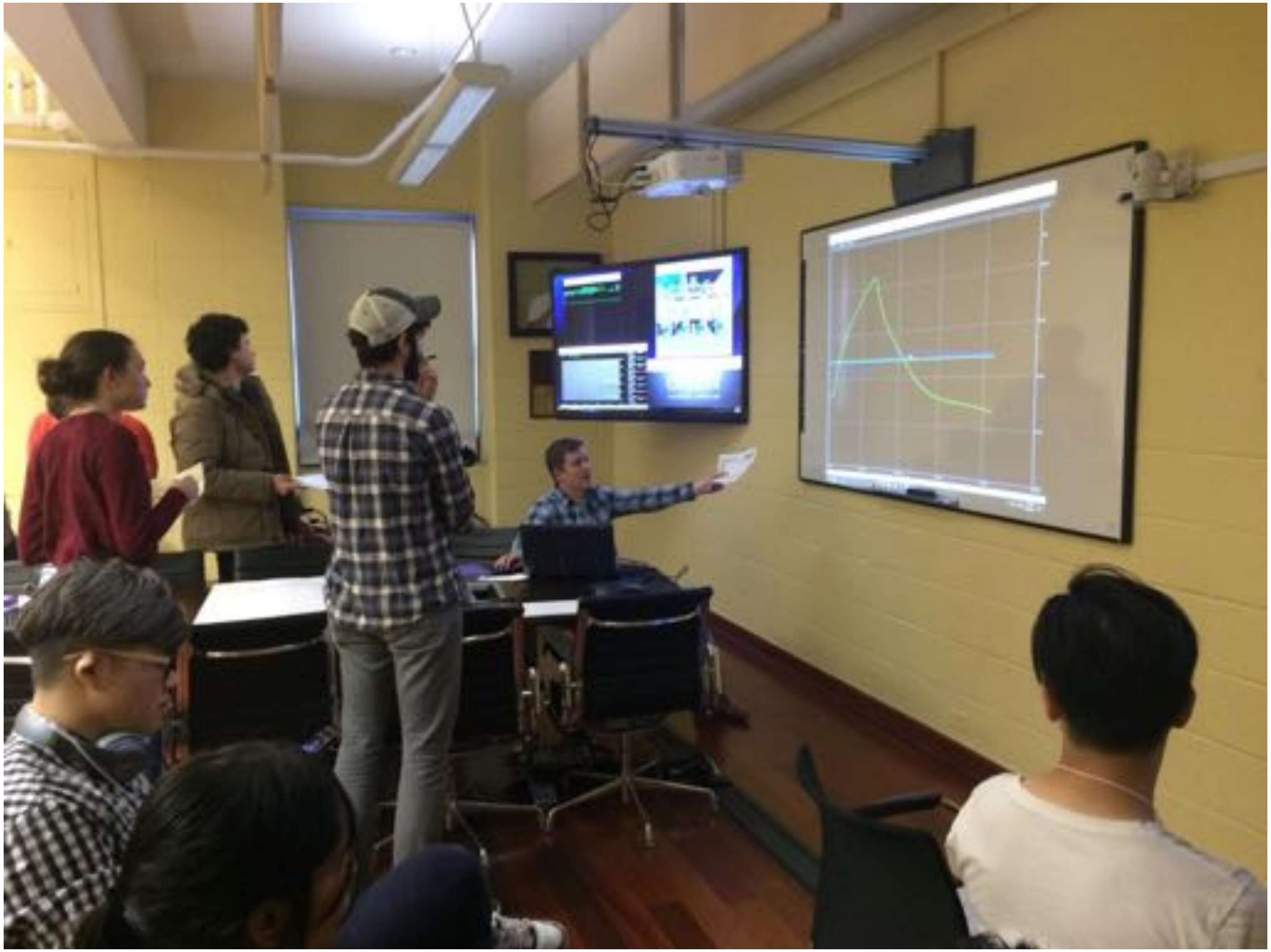
Ability to understand overall design goal including product rates and separation needs improvement.

Operation Center Exercise



826 Mudd Building, Omar A. Davidson Multi-Media Room (L to R) Don Glaser, Matt Garvey, and Ariel Sanchez, test connection with screens set up for the Operations Center Exercise

Operation Center Exercise



Group 1, Process Engineers, talk to the operator about what is appearing on the display screen while some students observe the action in 826 Mudd Building, Omar A. Davidson Multi-Media Room, Thursday 30 March 2017

Operation Center Experience

Screen 1

Screen 2

Screen 3

Operator

Computer attached to projection system

Piping and Instrumentation Diagram (P&ID) On conference table

Observers and Some role players

Observers and Some role players

Door

Supervisor

Observers

2. Review Time Line and sequence of events

	1:10 PM	1:15 PM	1:20 PM	1:25 PM	1:30 PM	1:35 PM	1:40 PM	1:45 PM	1:50 PM	1:55 PM	2:00 PM	2:05 PM	2:10 PM	2:15 PM	2:20 PM	2:25 P
Group 1time (min)	0	5	10	15	20	25										
Group 2 time (min)						0	5	10	15	20	25					
Group 3 time (min)											0	5	10	15	20	25
Distillation Column Critcal Event		**Utilities - CW Block Valve HS-126 Fail close Outside operator /utilites**		**Equipment - Bottoms Pump, P-110A Failure. Motor Failure, Light Goes Red**			**People- Vent Block Valve, HV-125 Fails Closed**		**Equipment - Condensate Pump P-130A Motor Failure, Light Goes Red**			**People- Block valve fail close- HS127**		**Equipment - TCV-100 Steam Leak**		
Process Engineer Unit	**Shift change**				**Shift change**	**Shift change**					**Shift change**	**Shift change**			**Shift change**	
Utilites		**Cooling Water Fail**														
1st Responder			**1st Responders**													
Contractor/Repairman													**Contractor/Repairman**			
Press Release								**Press Release**								

Spring 2017 CHEN E4501 Chemical Engineering Process Safety
Operation Center Exercise
After Action Review

Agenda

1. Define After Action Review

2. Review Time Line and sequence of events

3. Each group briefly presents their Issue, Discussion, and Recommendation with class follow up on each topic.

Spring 2017 CHEN E4501 Chemical Engineering Process Safety
Operation Center Exercise
After Action Review

1. Define After Action Review-

•"An after-action review (AAR) is a professional discussion of an event, focused on performance standards, that enables soldiers to discover for themselves what happened, why it happened, and how to sustain strengths and improve on weaknesses. It is a tool leaders and units can use to get maximum benefit from every mission or task. It provides--

•Candid insights into specific soldier, leader, and unit strengths and weaknesses from various perspectives.

•Feedback and insight critical to battle-focused training.

•Details often lacking in evaluation reports alone."
(http://www.au.af.mil/au/awc/awcgate/army/tc_25-20/chap1.htm accessed 31 Mar 2017)

Other References:
Forbes: (https://www.forbes.com/sites/jeffboss/2016/12/01/dont-skimp-on-the-after-action-review-6-reasons-why/#17902202ba3d

Harvard Business Review: https://hbr.org/product/hbr-tools-after-action-reviews/TLAAR1-ZIP-ENG)

"What do I think is the problem?"

"What are the indicators?

"How certain am I of the indicators?"

"What is available to me to solve the problem?"

www.simulation-solutions.com

Do "METT-T" Analysis

Course of Action Development (restrictions/constraints)

"What if? Analysis"

Take Action

How do I know the solution is working? (Process variables as indicators of successful/unsuccessful action)

Review ways to prevent problems in the future.

Update Standard Operating Procedures

2. Review Time Line and sequence of events

Day 3 – Thursday, 30 March 2017 Operations Center Exercise Day (826 Mudd:)

Three process engineer teams will rotate through plant operations operating the distillation column with a role player and simulator scenario activities. Three groups will be selected at the beginning of the semester as process engineer teams. Other groups will be selected as observer/recorder groups. Some groups will be selected as role player groups. Each group will be required to research the roles of the group assignment in the chemical process industry regarding regulations/best practices/and actions taken to ensure process safety. The observer/recorder groups will research all player roles and be ready to observe and record the actions of the Operations Center Exercise Day. On the second day of this exercise, the observer team will report observations of the actions taken by the process engineer teams and role players over the designated time segments.

Process Engineer Teams: Group 1, Group 4, Group 8

Role Player Teams:

- 1st Responder(Fire and Paramedic): Group 2
- Hot Work Contract Repair: Group 5
- Press Agents: Group 7

Observer/Controller Teams: Group 3, Group 6

The operations center exercise will start with a shift change from the chemical engineers from Simulation solutions to the first student group. From that point forward the student groups will do shift changes according to the schedule below. The teams need to be prepared for events during the exercise such as but not limited to: Shift Change, 1st Responder Coordination, Mass Media/Press, Hot Work Contractors, Pump Failure, Valve Failure, Instrument Failure, and Inclement Weather.

Process Engineer Team Shifts will cycle as follows:

1:10 PM Shift Change from Simulations Solutions to Group 1

1:35 PM Shift Change from Group 1 to Group 4

2:00 PM Shift Change from Group 4 to Group 8.

Spring 2017 CHEN E4501 Chemical Engineering Process Safety
Operation Center Exercise
After Action Review

Lessons Learned

- **Recognizing Root Cause vs Symptoms**
- **Alarm Rationalization**
- **Inter-Agency Coordination**
- **Time Rate of Change of Deviations or Corrections**

Acknowledgements

Thanks to the Columbia Students of CHEN E4501!
Big Thanks to Don Glaser and Matthew Garvey and Ariel Sanchez!
Go Lions!

Simulation Solutions, Inc.

Minds-On/Hands-On Training for Operators™

Conclusion and Future Work

Continued success with initial integration of SaChE Recommendations into curriculum.

Continue a "Back to Basics" approach with Process Flow and Process Control Diagrams

Continue the approach related to operator training and evaluation of process safety education and examining ways to incorporate more predictive style exercises with the use of simulators.

Refinement of process simulation in the classroom with CHEN E4500 Principles of Process Design Course

Future work: on standards for process simulation and Operations Center Role Playing Scenarios in the classroom with CHEN E4501 Chemical Engineering Process Safety Class

Add a design component using ASPEN to the distillation problem to renew emphasis on key design variables.

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Back Up Slides Start Here

Student Survey Results 2016 (1 of 2)

General Comments about Simulation Solutions Safety Course Spring 2016 at Columbia University

CHEN E4501 Chemical Engineering Lessons 19 and 20

- good as expected
- I'm still confused about the some basic concepts regarding controllers. The speech may have went too quickly
- I hope that we have more reading material on this since the lecture is a bit fast and overwhelming
- Good
- I thought it was engaging and fun! I don't feel like an expert now but it was a good introduction to operator controls and applied concepts. I feel with further training this would really prepare someone to work as an operator
- very interesting and informative
- This experience has greatly improved from last year. Through expanding the lesson to two classes it was much easier to absorb the material and it does not feel as rushed. Additionally, it is very interesting to experience a practical application of chemical engineering rather than theoretical. (most likely the grader who took the course in 2015)
- Personally, the first lesson felt hard to follow but the second lesson I caught on and felt I had gained and improved my knowledge of process control
- These 75 minutes felt like 15 mins. Very interesting. But I think if this can be 2 weeks, it would help understand controls even better. Thanks Dr. Bozic
- Zero complaints. Great presenters, practical applicability was very helpful, only suggestion would be to have the exercises be a little more guided to hear more of the proper mindset in finding solutions and allowing us to do more exercises.
- Really likes working with simulator. Was a lot of fun, wish we were able to do more, but it covered a good amount given the time. Definitely Recommend!
- Really enjoyed and learned much from them!
- It was better than last time. Do it again.
- It was really fun to have an interactive class. These lessons were a great way to see the inner though process of a future engineer.

Student Survey Results 2016 (2 of 2)

General Comments about Simulation Solutions Safety Course Spring 2016 at Columbia University

CHEN E4501 Chemical Engineering Lessons 19 and 20

- Helpful for basic understanding of chemical engineering simulating. I can't thoroughly understand details but it's overall good.
- The contents on What-if problem was great. Hope to learn more on hazard control topics.
- It was great to learn the operating process by using simulation software, which helped a lot to improve my understanding in terms of various situations.
- was really informative, interactive and fun.
- it helped me have a global view of control system and the entire chemical reactor process.
- It's really interesting to learn about the engineering design and simulators. Definitely should keep the lessons in the future!
- useful information would prefer all answers to worksheet so I can review on my own & a copy of the simulation program
- These lessons were useful but it would be better if we can run the software on macbook too for everyone to get the experience for using the simulator
- I wasn't sure about the presentations/simulations at first but ended up having a great time learning about process control/design concepts. My understanding has definitely improved, even though I don't quite understand everything yet. Before the lessons I had no idea how to read the provided diagram but now I feel like I have a better understanding.
- very helpful to learn the process control
- Process was very cool. It may be worthwhile to mention that the software for the demo isn't very demanding- i.e. I was initially concerned that the software being loaded would be a huge file size, something like Chem CAD or ASPEN, that it wouldn't be able to run on my (deleted word) computer. It worked fine though.

2015 to 2017 Comparison

For each statement below, rank from 1-5, where 5 indicates strong agreement and 1 indicates strong disagreement.	2017 CHEN E4501 Lesson 18 and 19	2017 Standard Deviation	2016 CHEN E4501 Lessons 19 and 20	2016 Standard Deviation	2015 CHEN E4501 Lesson 21 and 22	2015 Standard Deviation
As a result of CHEN E4501 lessons 18 and 19 my ability to understand the importance of process safety and the resources and commitment required has improved. (course objective 1)	4.58	0.56	4.67	0.62	4.80	0.50
As a result of CHEN E4501 lessons 18 and 19 my ability to understand how to control and mitigate hazards to prevent accidents has improved. (course objective 4)	4.45	0.62	4.33	0.73	4.40	0.58
As a result of lessons 18 and 19 my understanding of operator training through the use of simulators has improved.	4.68	0.54	4.63	0.63	4.56	0.65
As a result of CHEN E4501 lessons 18 and 19 my understanding of process control and chemical engineering design concepts has improved.	4.48	0.57	4.48	0.89	4.64	0.57