Implementation and Usage of an Online Environment in a Chemical Engineering Curriculum

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ASEE Annual Conference

New Orleans, June 27, 2016

Department of
CHEMICAL ENGINEERING
THE UNIVERSITY OF UTAH

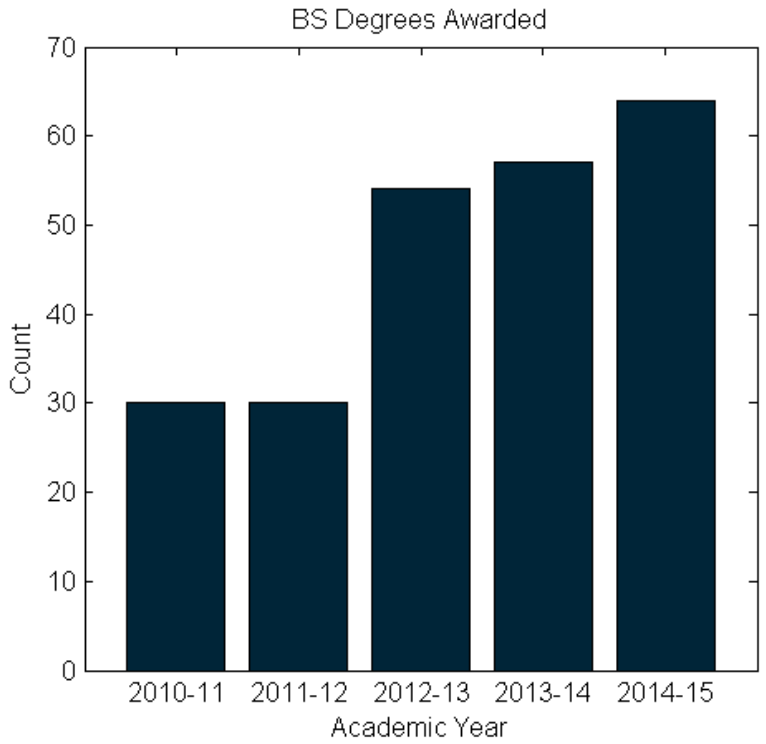
ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Our Freshman Lab Course

- Very open-ended design laboratory course
  - Students design and build equipment to assist in their production process or experimental analysis
- Students work in teams of three on projects typically lasting 2-3 weeks
- They are given individual and team-based homework assignments
- Our projects lab can accommodate a maximum of 30-40 students

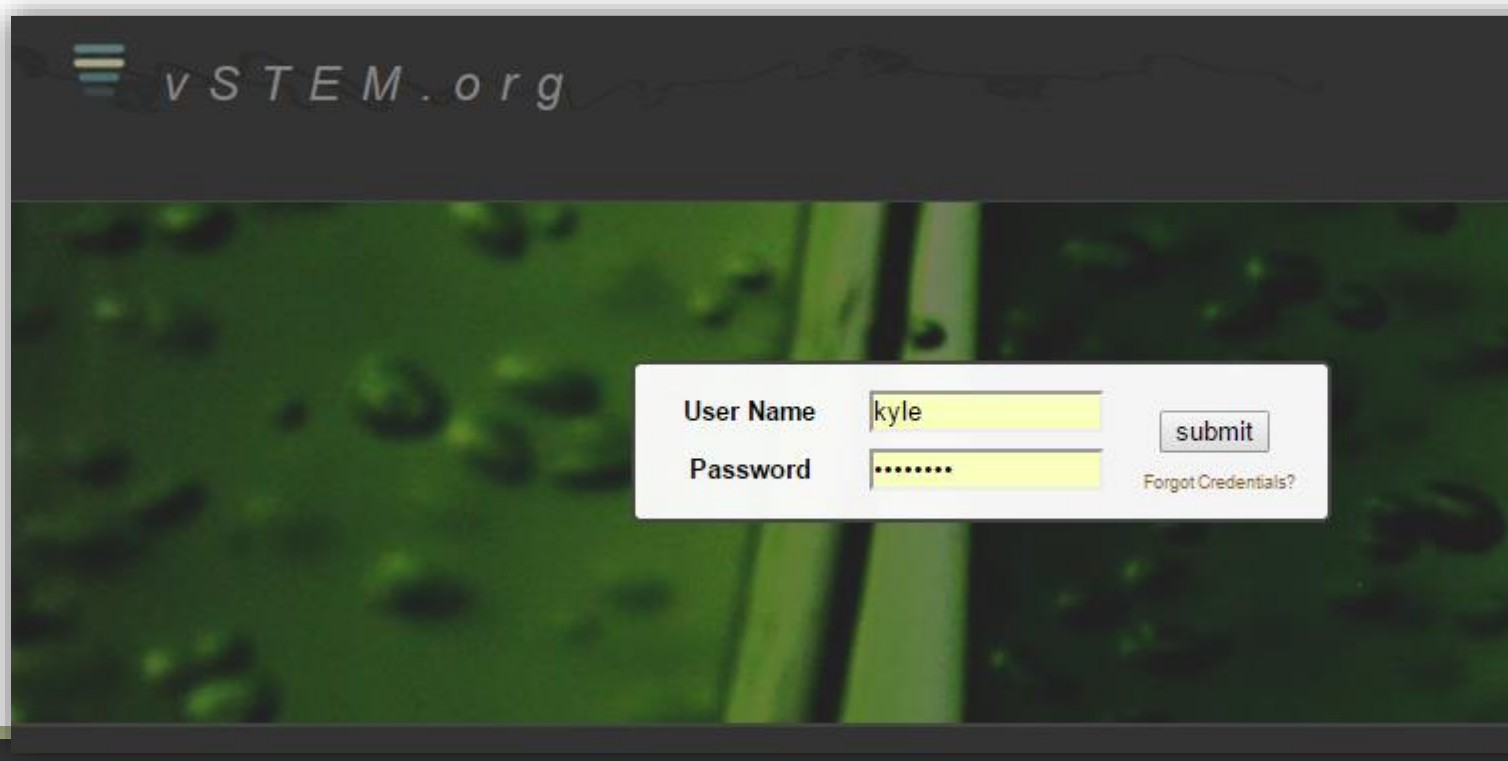
Large Class Sizes

- Our department has been growing significantly
- Over the past four years, course enrollment increased from 74 to 108 students
  - Increased to three sections, again at full capacity
- Common Difficulties:
  - Knowing each student and their name
  - Significant grading commitment
  - Answering student questions and concerns
  - Safety concerns in a lab setting
  - Need for additional instructors or TAs



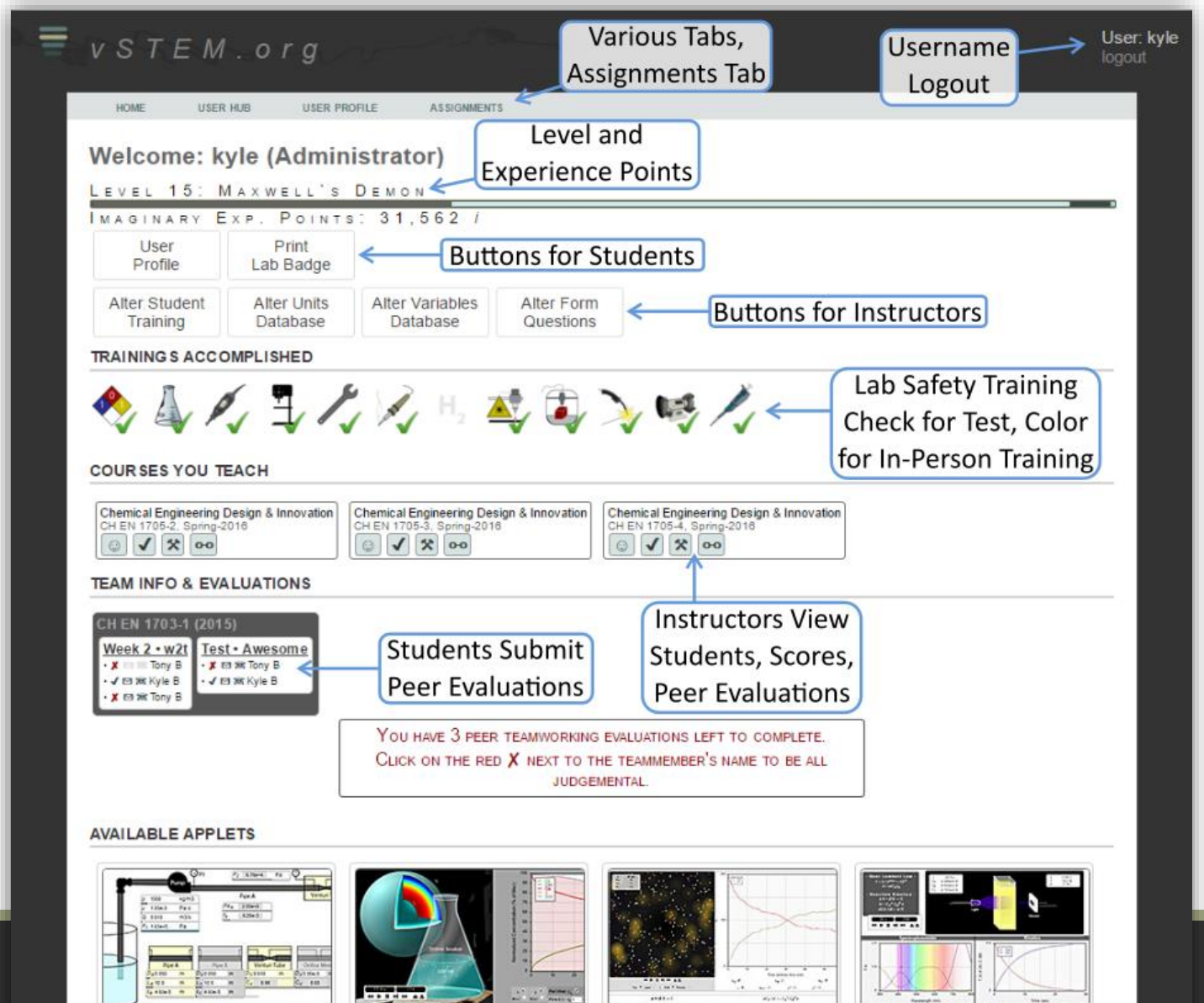
Created an Online System

- Developed an online system at vSTEM.org (virtual STEM)
  - Designed to remediate some of the difficulties of large classes
- Open-source
- Browser-based
  - Easy to access
  - Chrome, IE, Firefox, Safari
  - PC, tablet, phone
- HTML, JavaScript, PHP
  - No download necessary



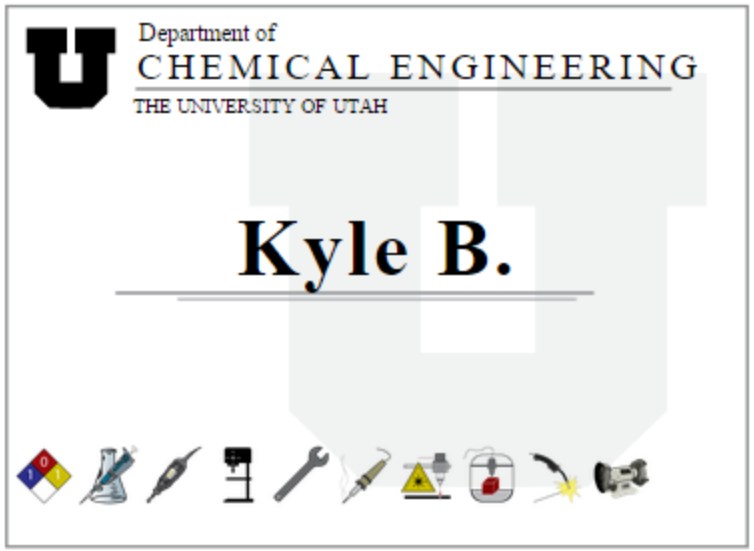
User Hub

- Designed to help navigate the site
- Some areas are only visible by instructors or admins
- Includes links to User Profile and Assignments
  - In the User Profile, students can change their user information and settings



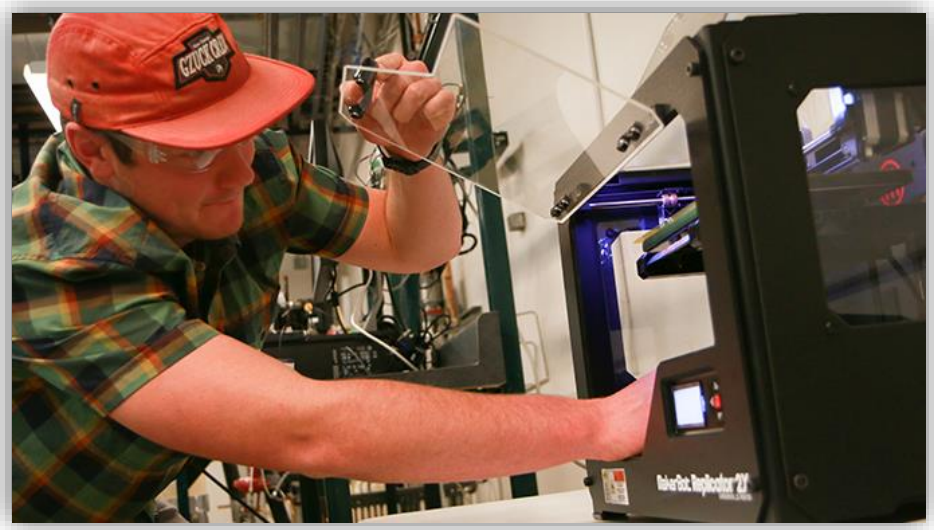
Student Name Badges

- Helps instructors, TAs, and fellow students learn names
- Badges indicate which equipment they have been trained to use
- Students are given a name badge and the ability to print them as they gain new skills
- Allows for an easy check if a student is trained to use particular equipment
  - Improves lab safety



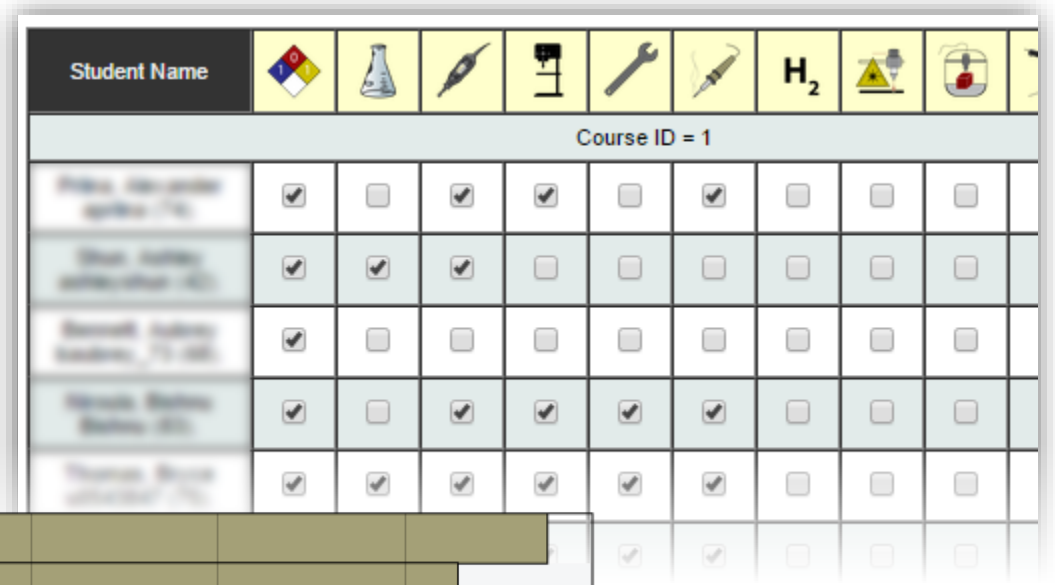
Lab Equipment Training

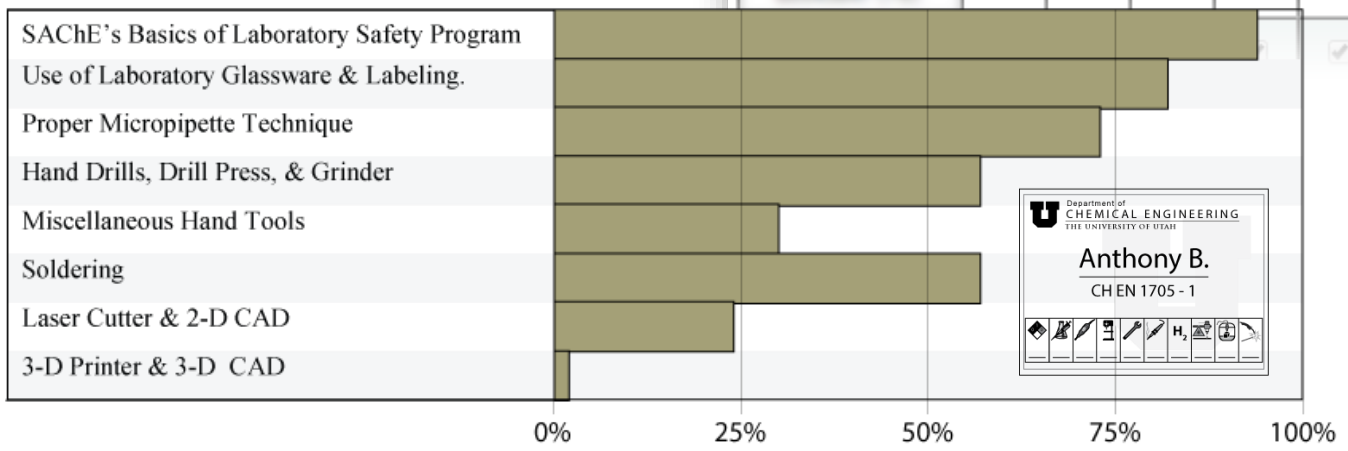
- Students using lab equipment:
  - Complete a safety and operating quiz online
    - Students are always able to go back and review their quiz
  - Trained by an instructor
- The delay helps students retain the material
- Reduces the training burden
  - Originally, they would pass an oral safety quiz



Measured Lab Skills

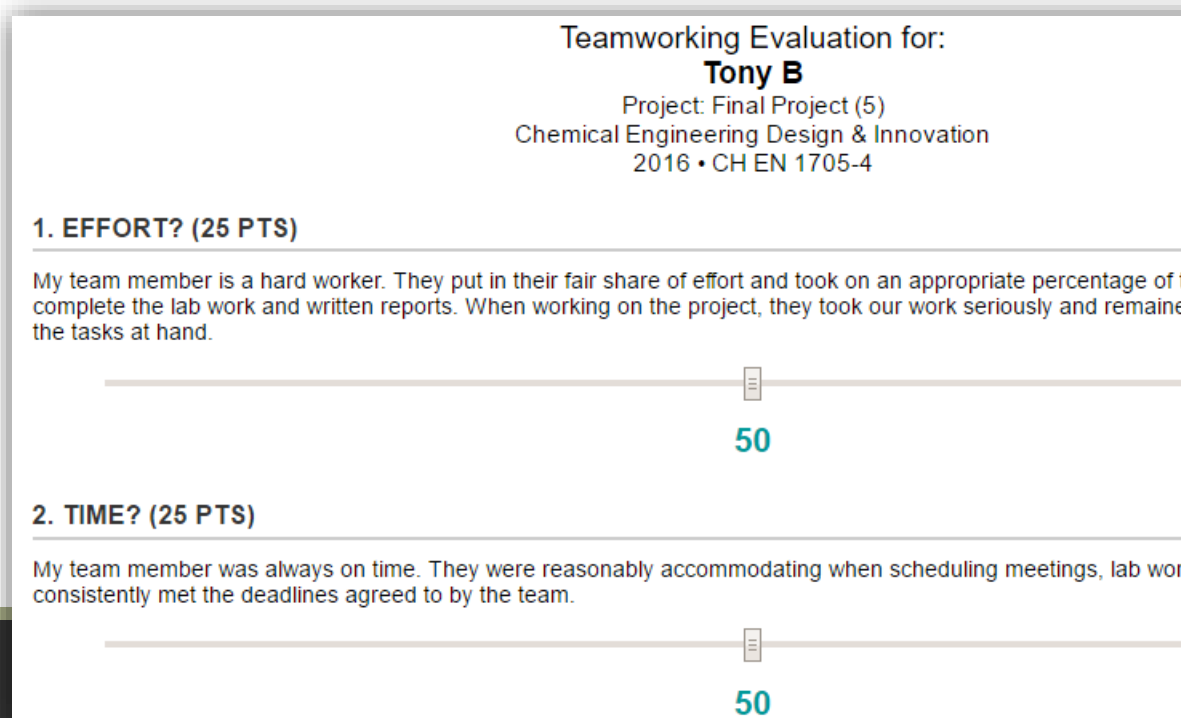
- All student training is recorded online
  - Used for educational research





Student Teams

- Students are assigned into teams of three for each lab project
  - Teams are displayed on vSTEM
- If permitted, their team members can view their phone number or email address
- Students submit team evaluations
  - Displayed to the instructor in a form easy to read
  - At the end of the semester, students receive anonymized peer feedback


Teamworking Evaluation for:
Tony B
Project: Final Project (5)
Chemical Engineering Design & Innovation
2016 • CH EN 1705-4

1. EFFORT? (25 PTS)

My team member is a hard worker. They put in their fair share of effort and took on an appropriate percentage of
complete the lab work and written reports. When working on the project, they took our work seriously and remaine
the tasks at hand.

50

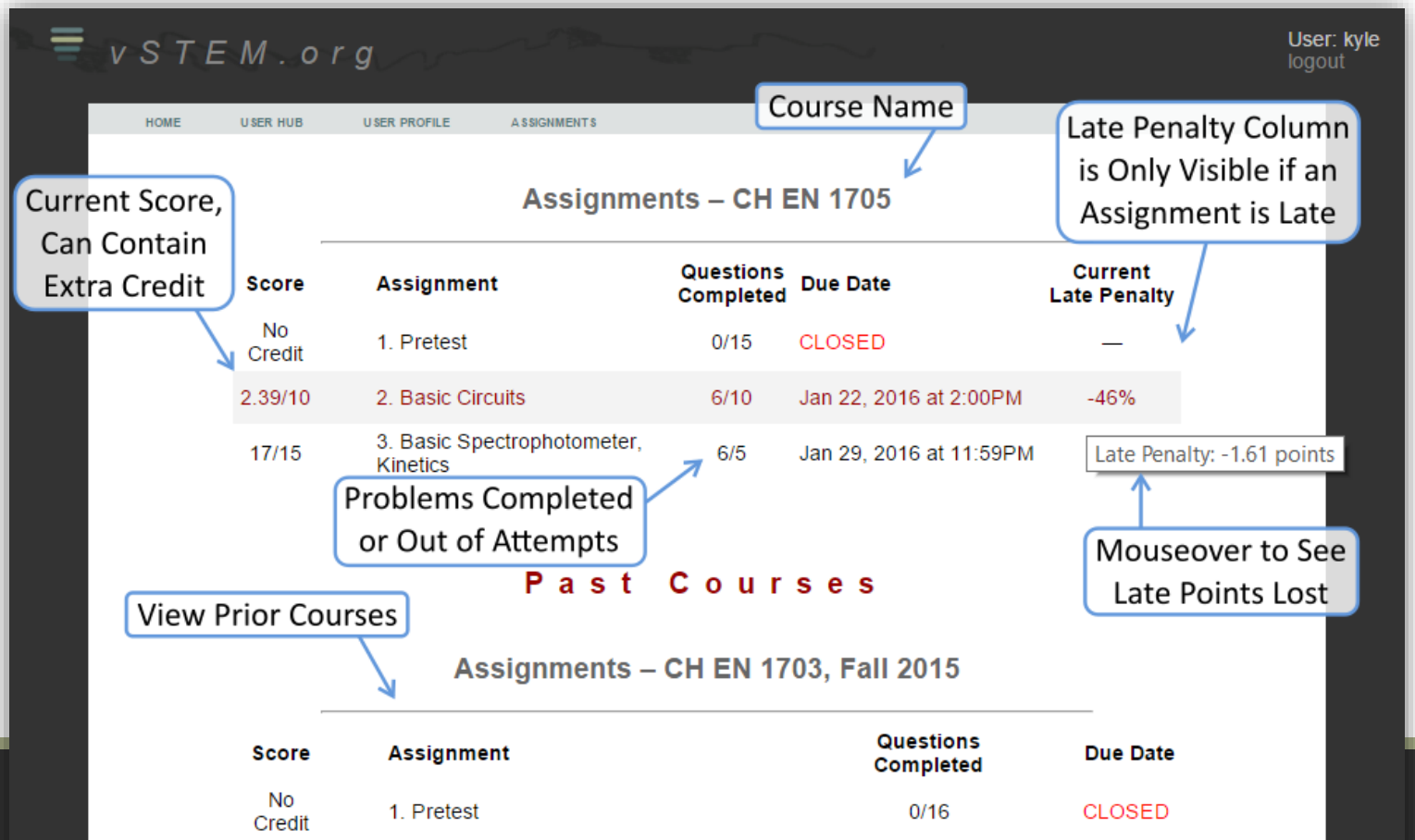
2. TIME? (25 PTS)

My team member was always on time. They were reasonably accommodating when scheduling meetings, lab wor
consistently met the deadlines agreed to by the team.

50

Online Homework System

- Developed a system to administer online homework problems
- Shows current and past courses
- Specifies:
  - Due Dates
  - Current and max score
  - Number of questions
  - Late penalty
  - Points lost for being late

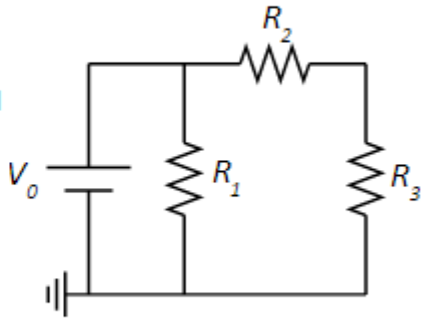


Homework Questions

- Assignments are highly customizable by the instructor
- Contains randomized values to minimize cheating
- Units can be randomized within metric, English, or both
- Which unknown variable can be selected or randomly chosen based on its difficulty

8. **(0/0.5 points. Out of attempts.)** Sorry, you have reached the maximum number of attempts for this problem.

9. **(1 point. Attempt 1 of 2.)** Refer to the circuit diagram on the right. The power supply V_0 has a voltage of 9.33 V, the resistor R_1 has a resistance of 10700 Ω, the resistor R_2 has a resistance of 901 Ω, and the resistor R_3 has a resistance of 9.9 kΩ. Therefore, the current through Resistor 2 is I_1 mA.

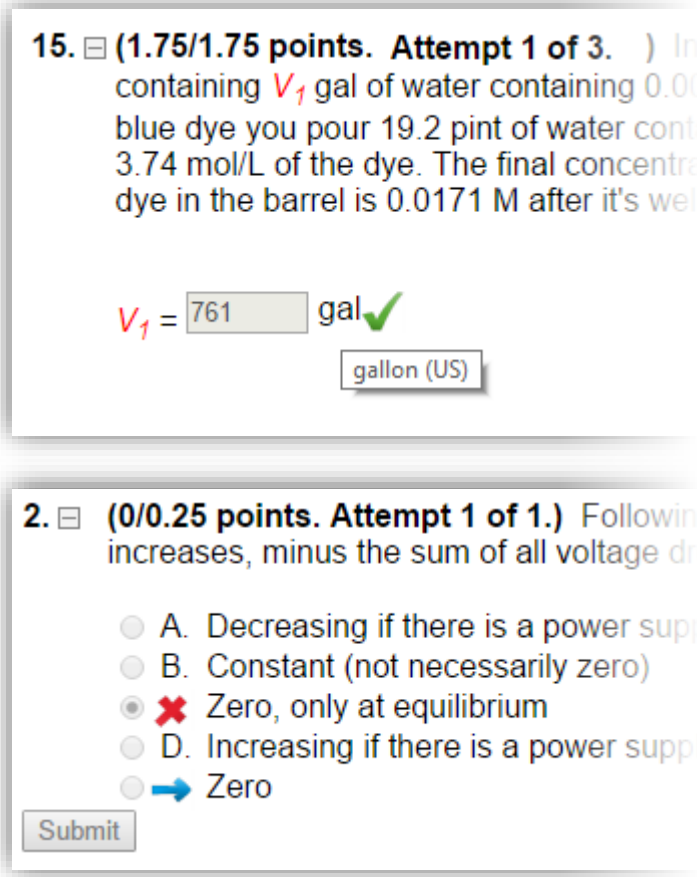


I_1 = ____ mA

Submit

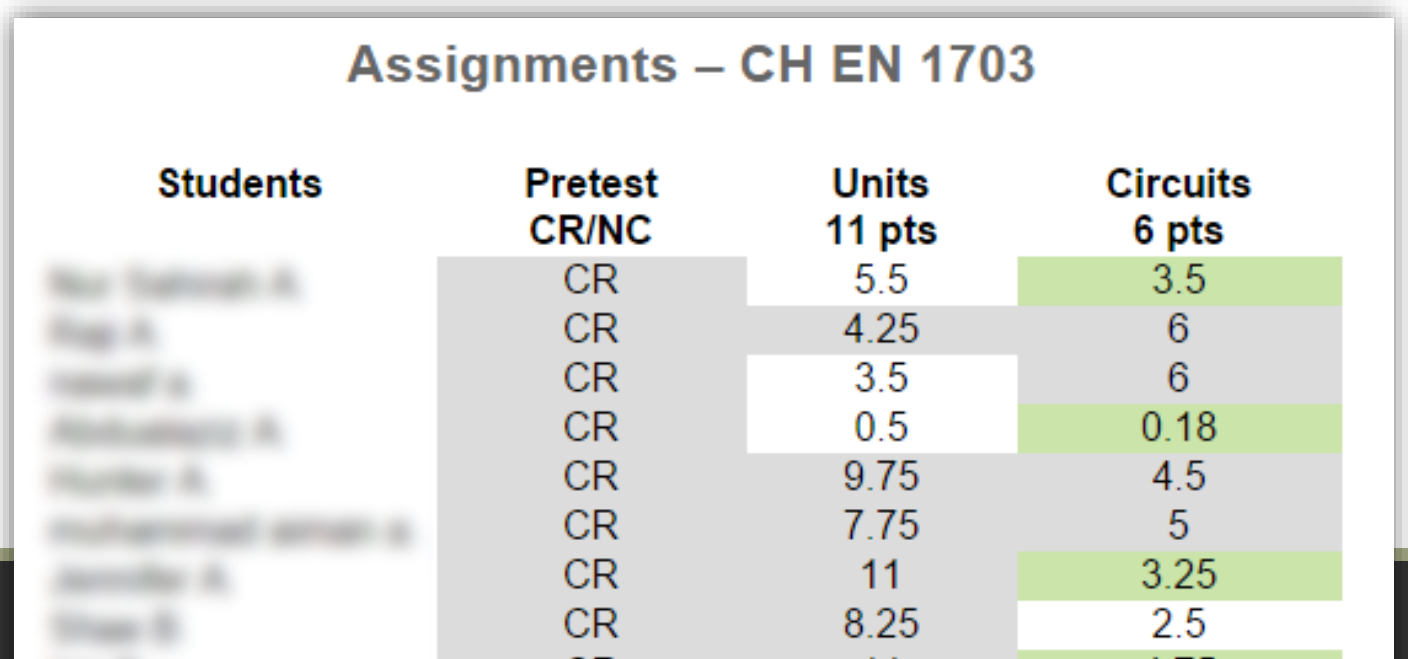
Online Homework System

- They can give students instantaneous feedback on their submissions
- TAs can spend more time helping students in the lab
- We use this to administer a variety of course materials:
  - Homework assignments
  - Pre- and post-tests
  - Student surveys
  - Safety training quizzes



Benefits to Instructors

- Automatically graded assignments
  - Student summary generated and color coded based on different criteria
- Helps instructors determine where students are struggling

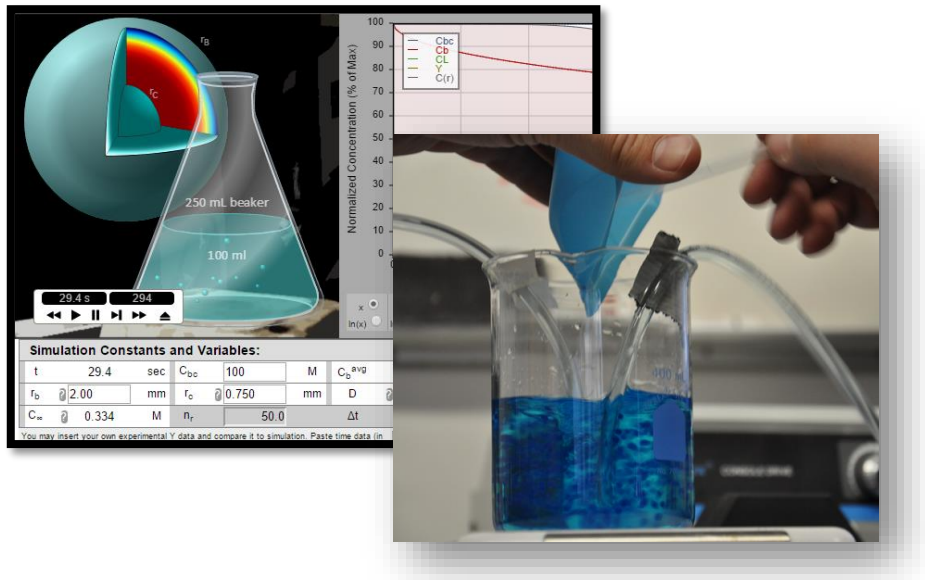


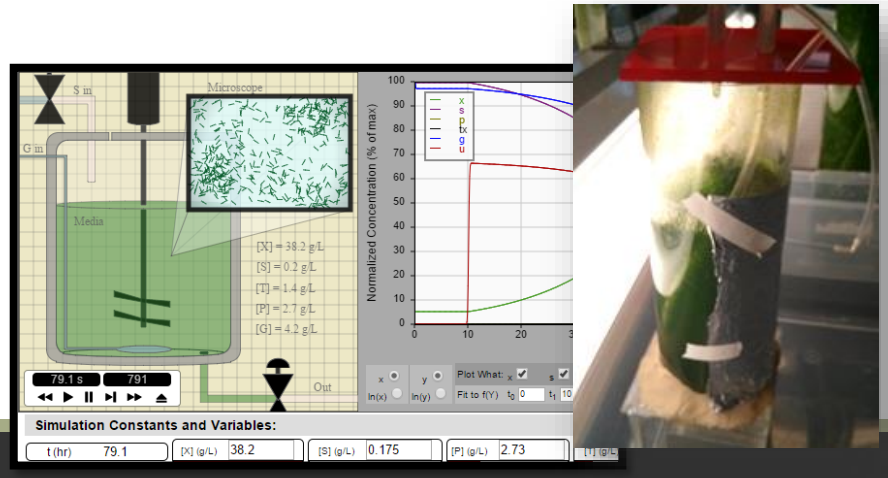
Assignments – CH EN 1703

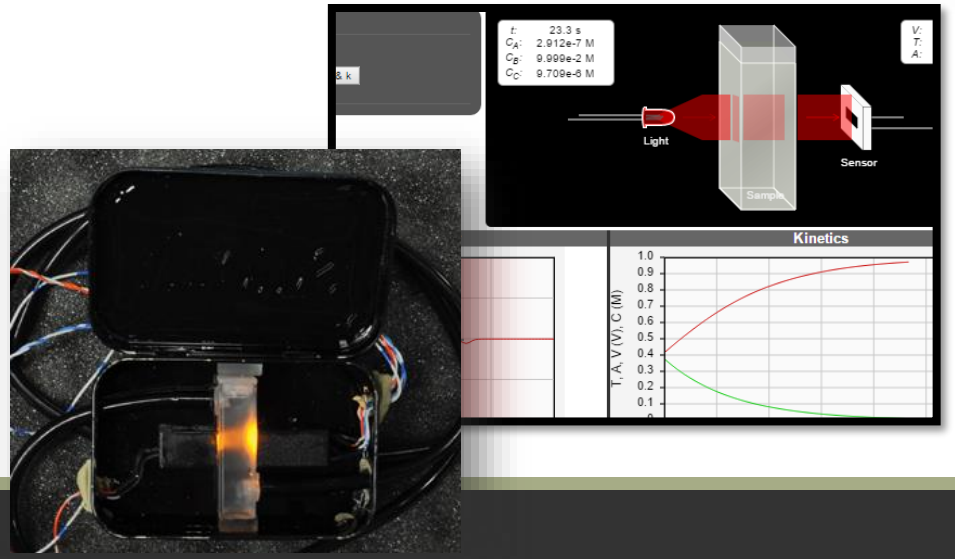
Students	Pretest CR/NC	Units 11 pts	Circuits 6 pts
[redacted]	CR	5.5	3.5
[redacted]	CR	4.25	6
[redacted]	CR	3.5	6
[redacted]	CR	0.5	0.18
[redacted]	CR	9.75	4.5
[redacted]	CR	7.75	5
[redacted]	CR	11	3.25
[redacted]	CR	8.25	2.5

Interactive Simulations

- Simulate lab experimentation
  - Coupled with hands-on projects
- Used in our freshman and senior laboratory courses
  - Soon to be implemented in our mid-curriculum courses

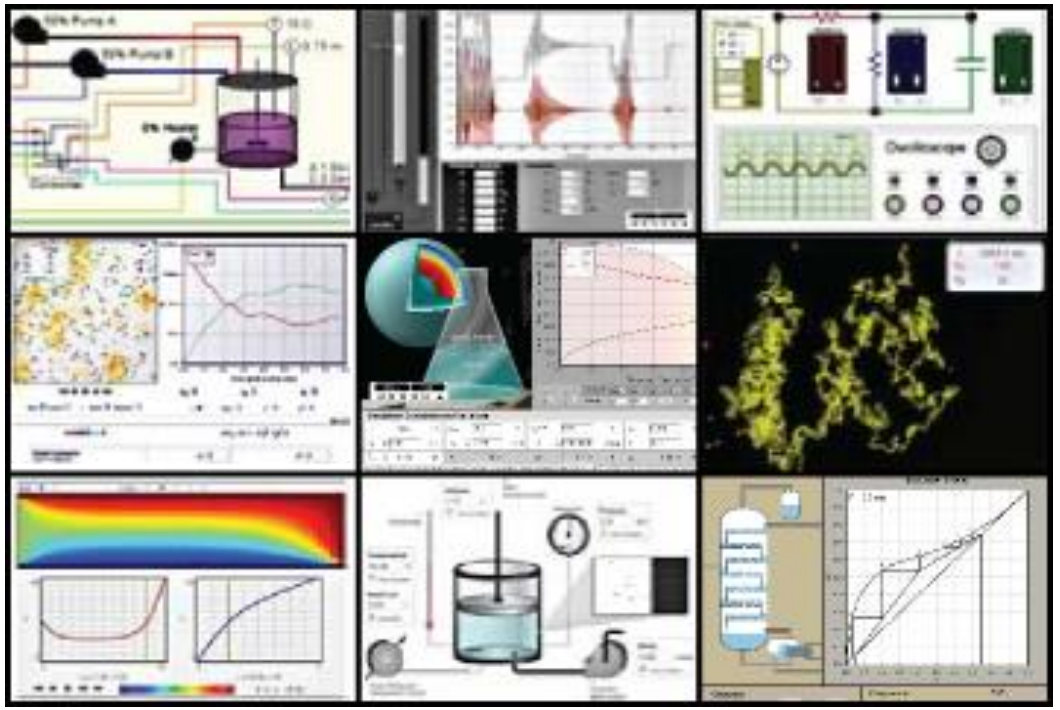






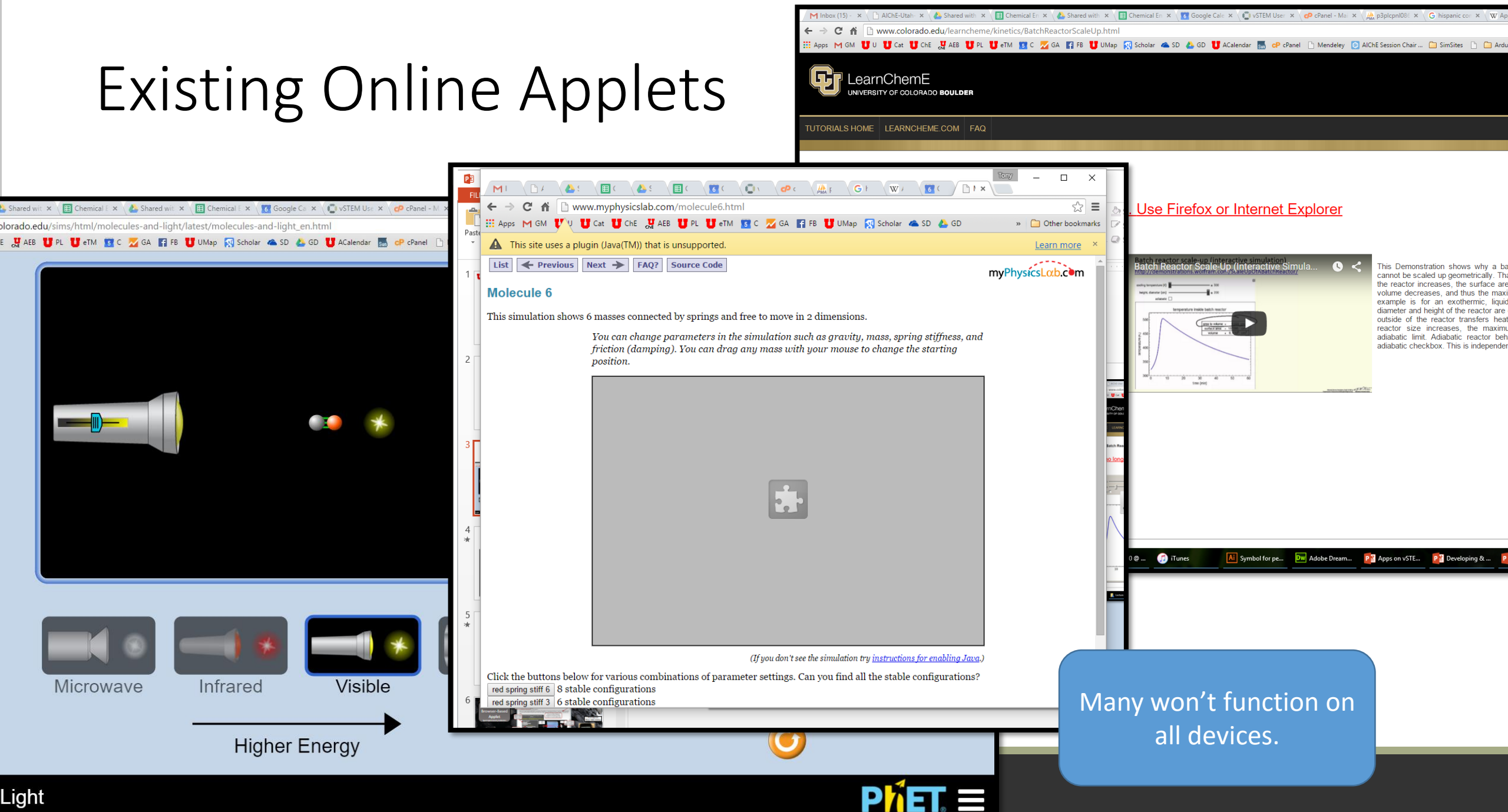
Our Simulations

- Cover a wide variety of chemical engineering disciplines
  - Chemical kinetics
  - Biochemical engineering
  - Thermodynamics
  - Reactor design
  - Process control
  - Heat and mass transfer
  - Fluid mechanics



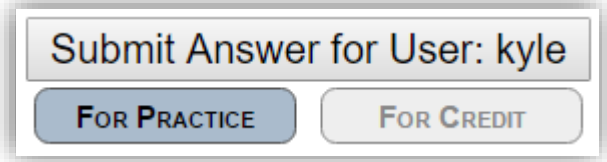
- Includes written instructions and screencast tutorials

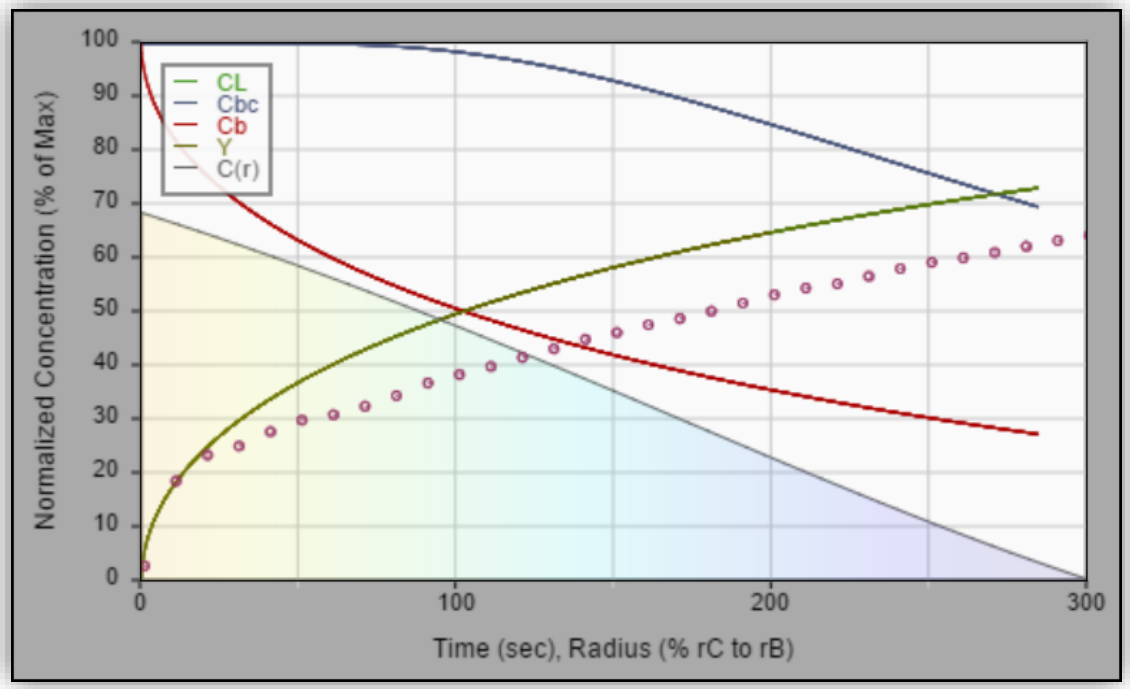
Existing Online Applets



Using the Simulations

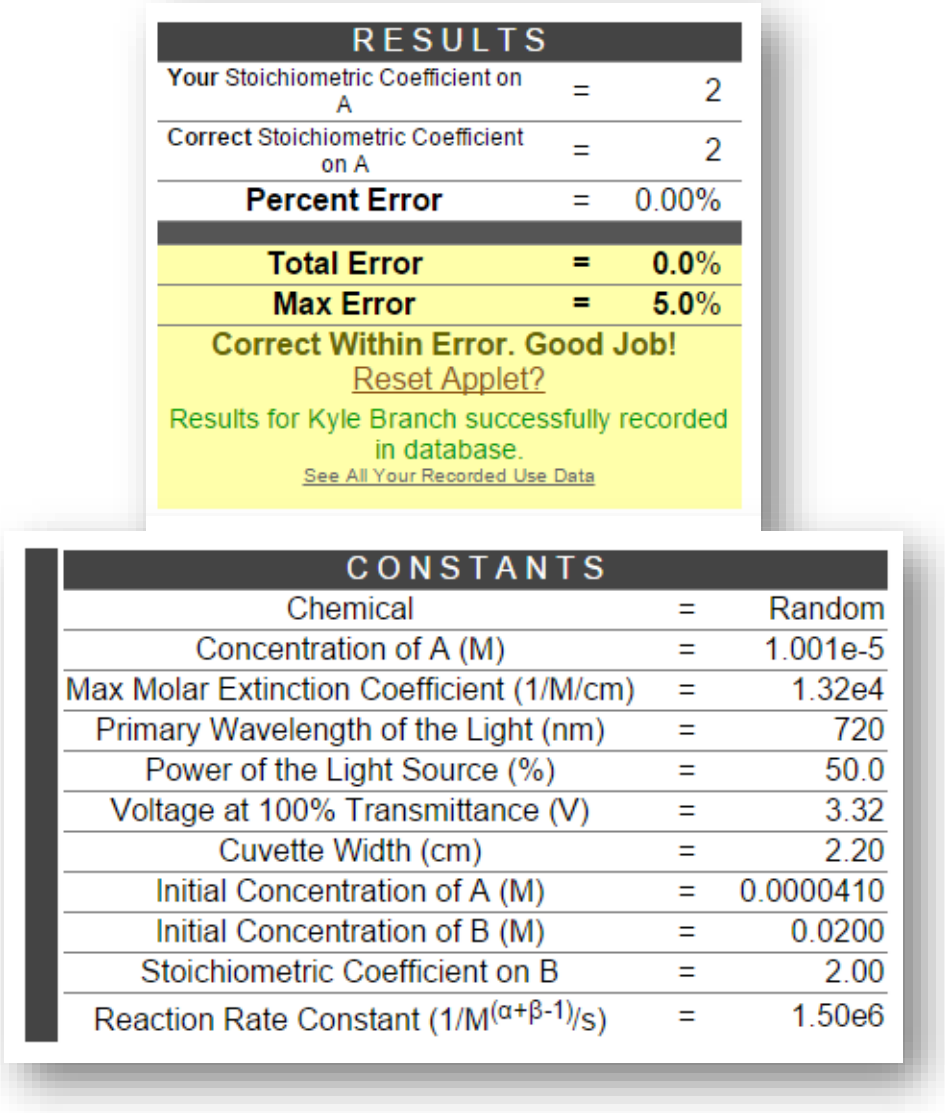
- Students select if their submission is for “practice” or “credit”
  - Students have unlimited practice attempts
- Students can input their experimental data and compare it to theory
- The interactive simulation assignments can be linked to the textbook-style homework interface





Benefits to Students

- Get a realistic sense of how adjusting parameters affects the system
- Prepares them for their upcoming lab project
  - Saves lab resources and students' time
- Students can move at their own pace
  - Unlimited practice attempts
- Instantaneous feedback



RESULTS		
Your Stoichiometric Coefficient on A	=	2
Correct Stoichiometric Coefficient on A	=	2
Percent Error	=	0.00%
Total Error	=	**0.0%**
Max Error	=	**5.0%**

Correct Within Error. Good Job!

Reset Applet?

Results for Kyle Branch successfully recorded in database.

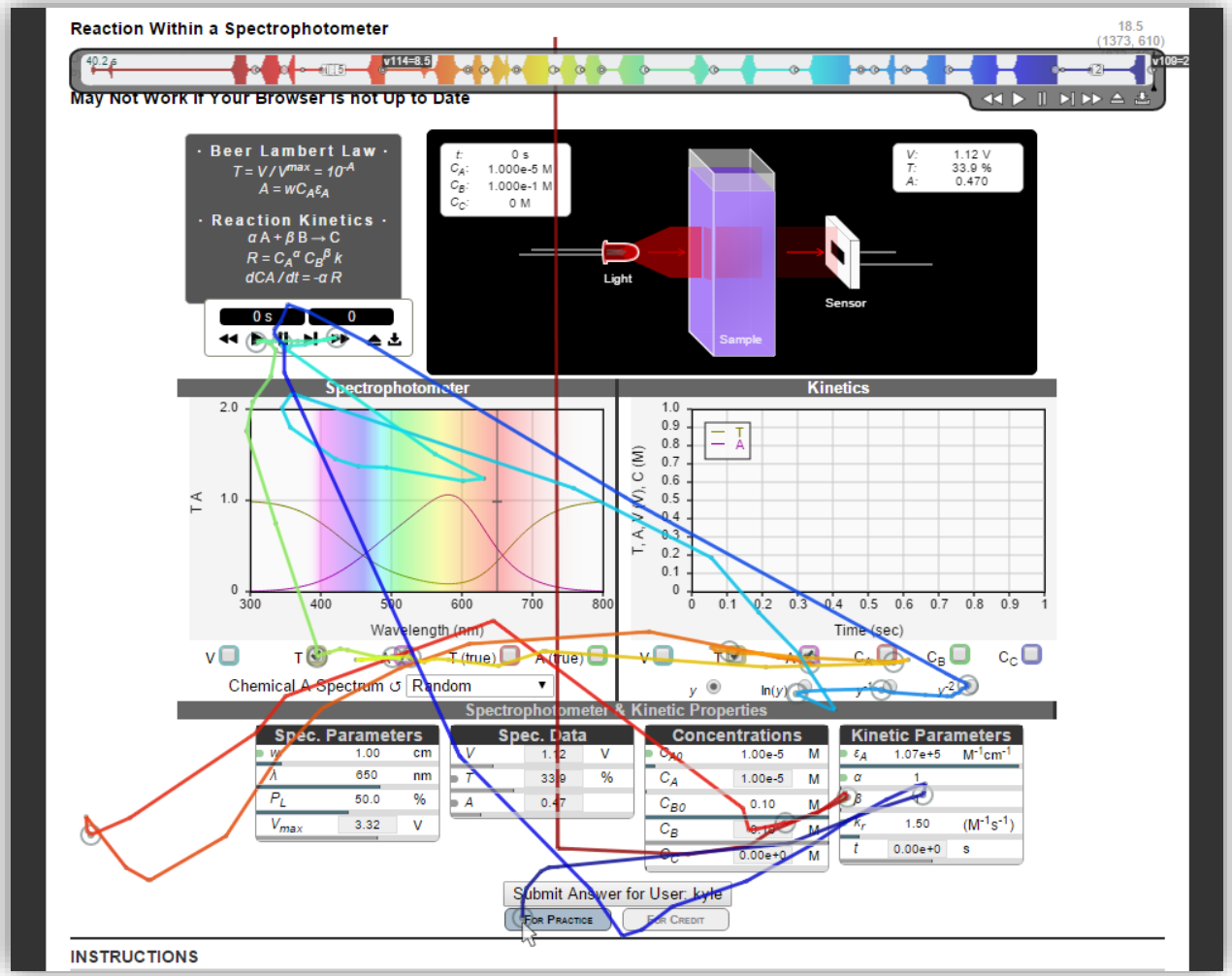
See All Your Recorded Use Data

CONSTANTS		
Chemical	=	Random
Concentration of A (M)	=	1.001e-5
Max Molar Extinction Coefficient (1/M/cm)	=	1.32e4
Primary Wavelength of the Light (nm)	=	720
Power of the Light Source (%)	=	50.0
Voltage at 100% Transmittance (V)	=	3.32
Cuvette Width (cm)	=	2.20
Initial Concentration of A (M)	=	0.0000410
Initial Concentration of B (M)	=	0.0200
Stoichiometric Coefficient on B	=	2.00
Reaction Rate Constant ($1/M^{(\alpha+\beta-1)}/s$)	=	1.50e6

Tracking Student Usage

Records

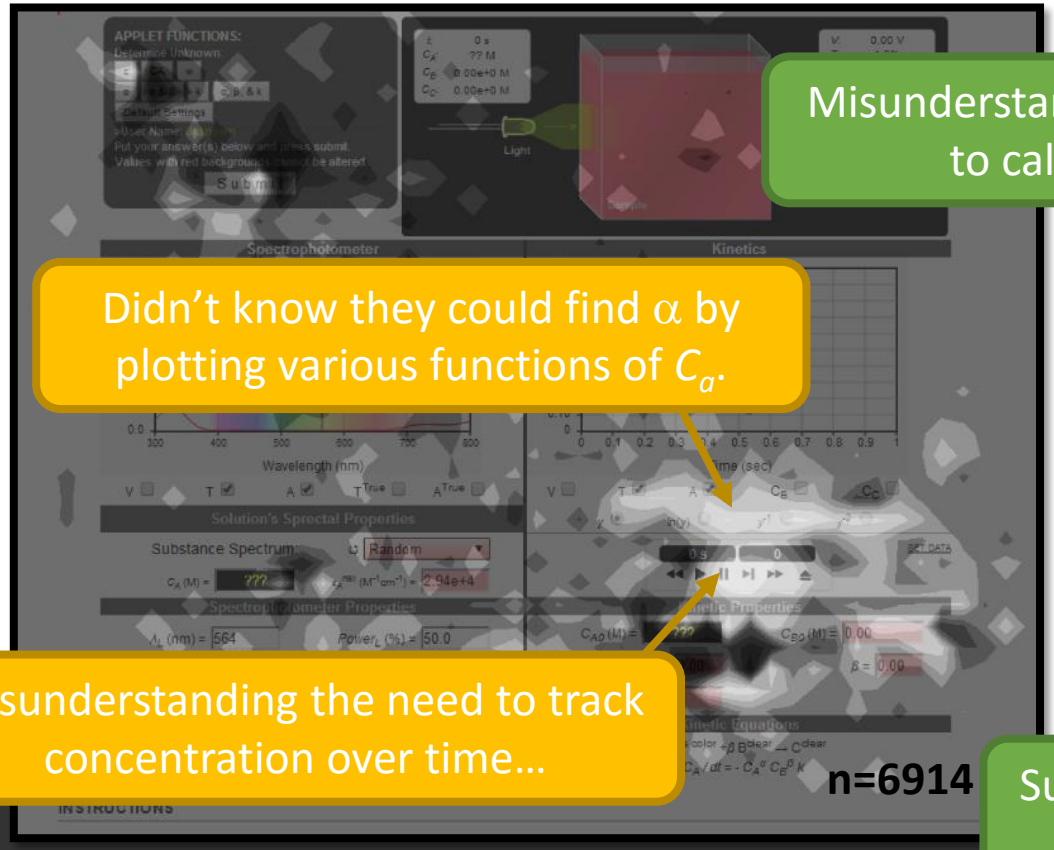
- Which student
- Correct or incorrect
- Submission time
- Time and location of each event
  - Mouse movements, clicks, typing
- All simulation constants
- Browser, IP address, and Operating System



What Can We Learn from Averaged Scribbles?

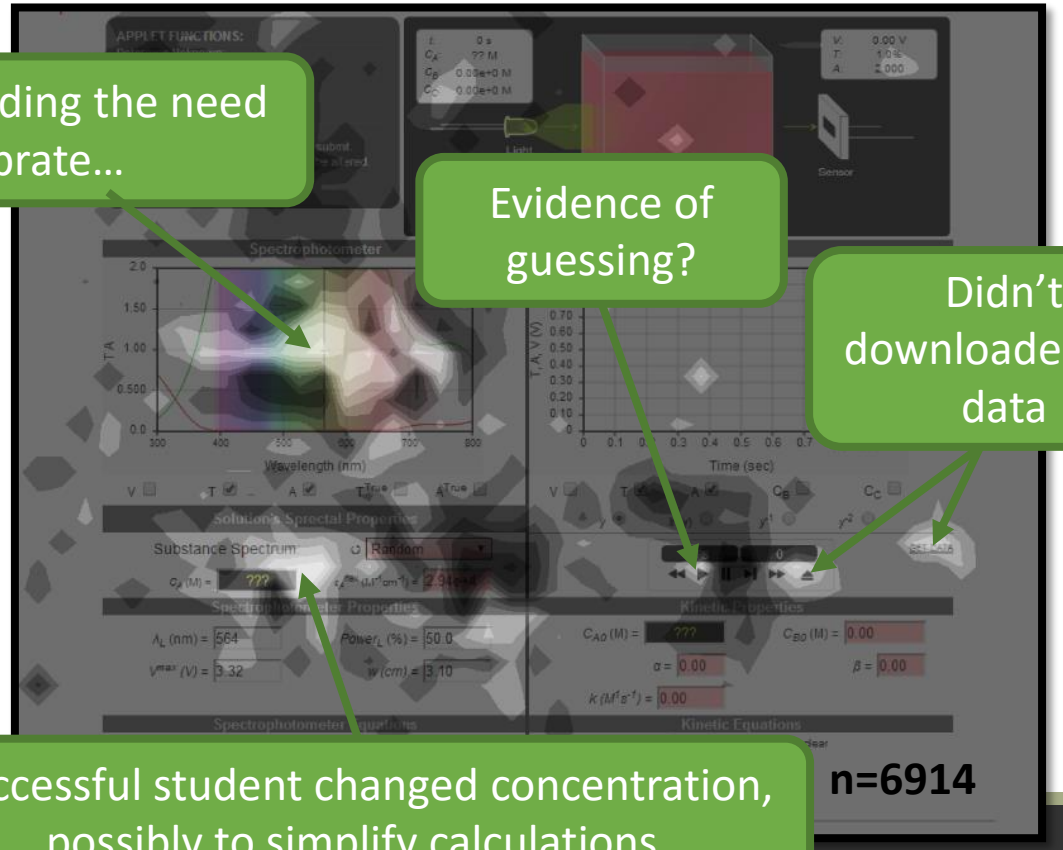
Stoichiometric Coefficient

α



Maximum Molar Extinction Coefficient

ε_{max}



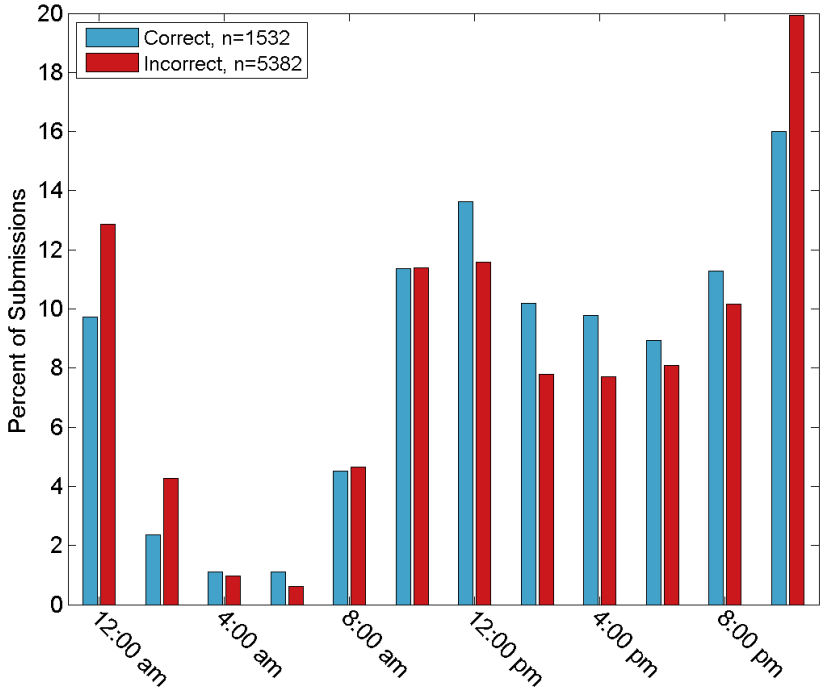
Determine Successful Behavior

Earlier submissions tend to be high percentile students

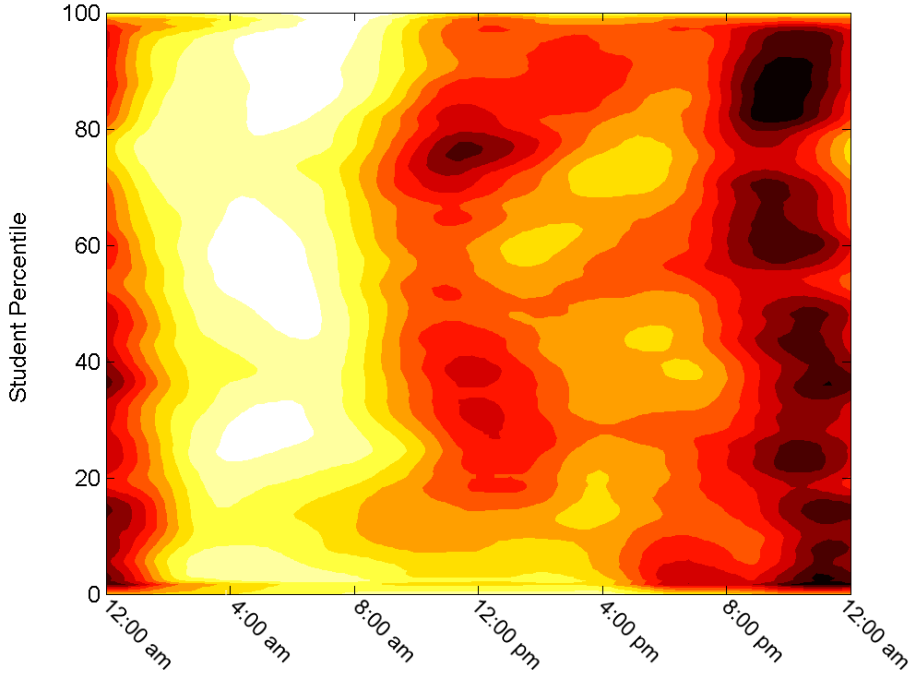
Later submissions tend to be low percentile students

Earlier submissions spend more time exploring the simulations

Students have lower success rates late at night

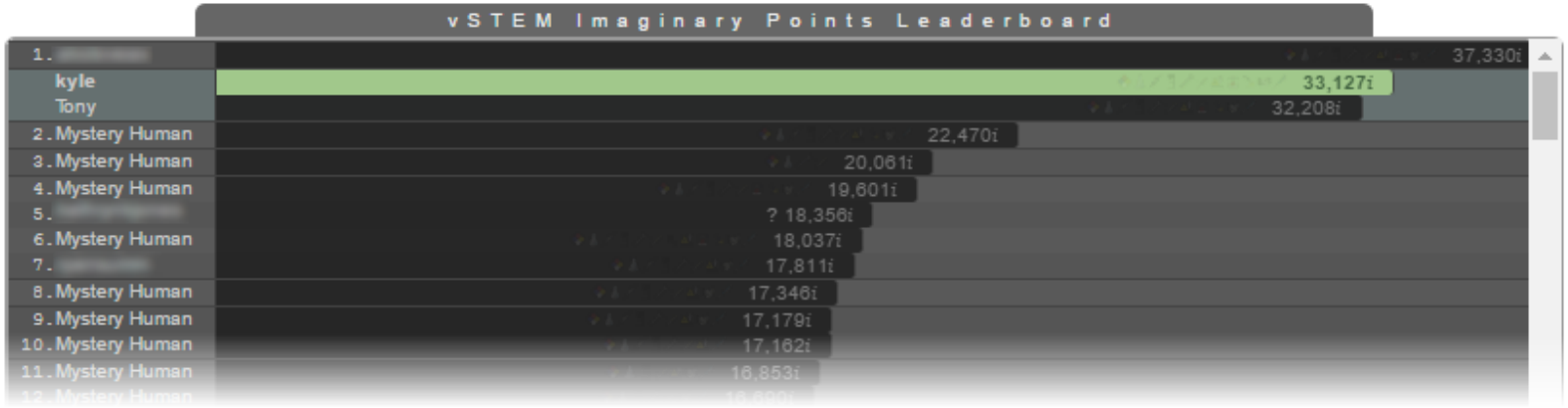


High percentile students do homework earlier in the day



“Imaginary” Experience

- Gamification has shown to improve student engagement
- Gain experience for solving simulation variables, equipment training…
  - Some students solved unassigned variables to gain more experience
- A course leaderboard shows who has the most “experience”*
  - For those who have enabled it in their privacy settings

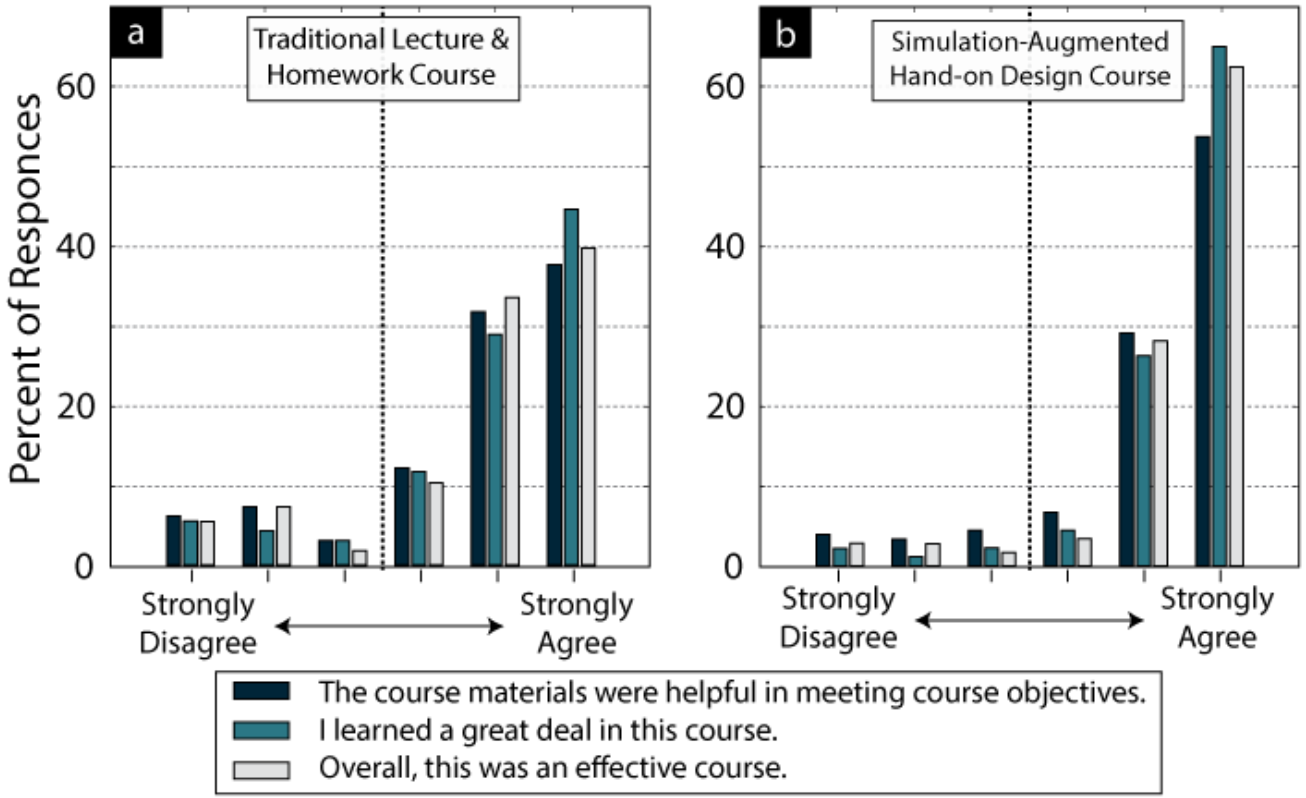


LEVEL 15: MAXWELL`S DEMON

IMAGINARY EXP. POINTS: 31,974 *i*

Same Freshmen, Same Year

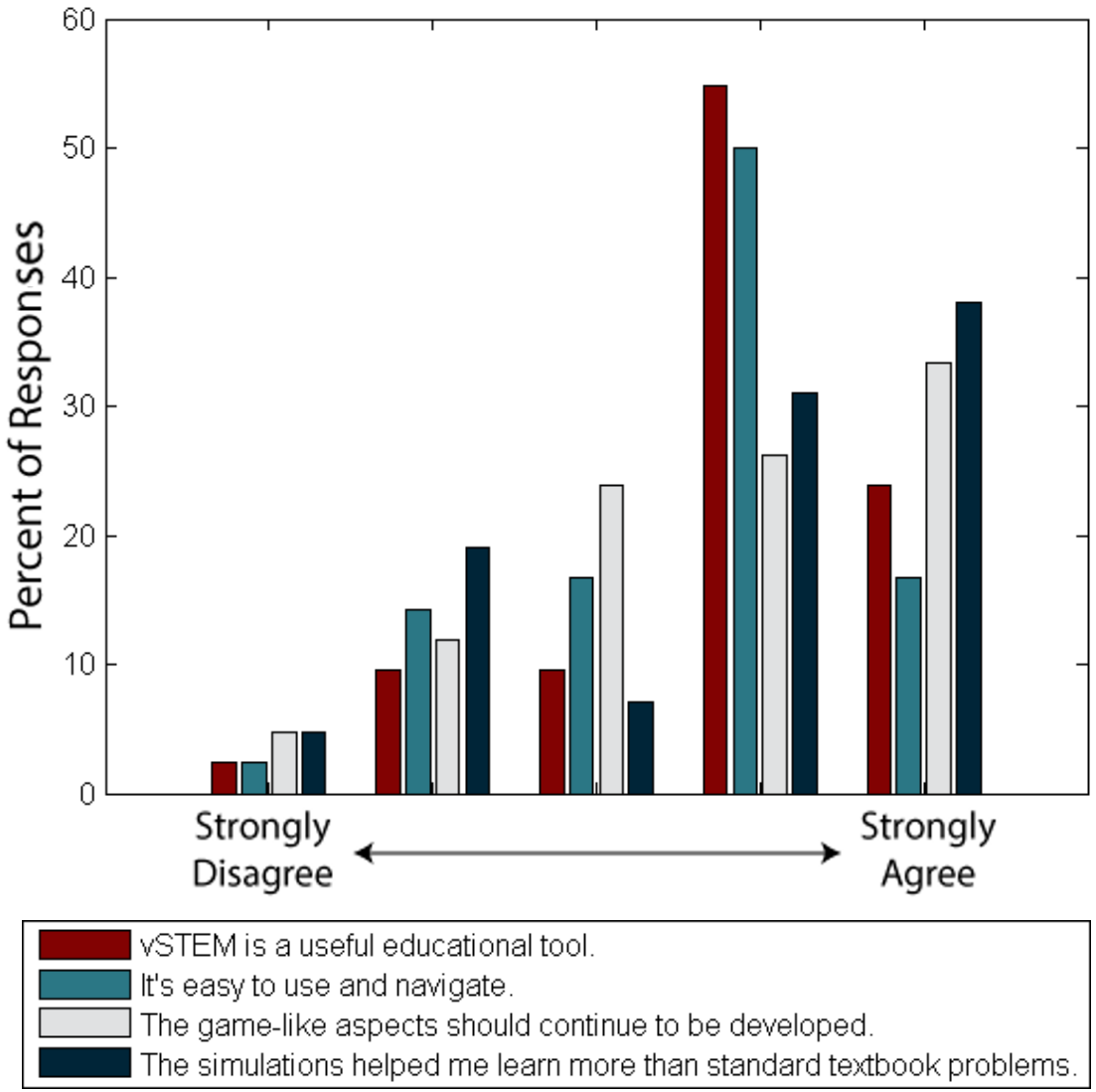
Traditional vs. New Course Model



Students prefer this course to a traditional textbook and lecture style course covering the same material

Student Response

- Students found using vSTEM to be a fairly positive experience
- Some additions for Phase II:
  - Make adjustments to improve navigation
  - Add a tutorial
  - Add awards and achievements that students can unlock
  - Add automated interventions to simulations
  - Easier to adopt the system



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