

Analysis of Student Interactions with Browser-Based Interactive Simulations

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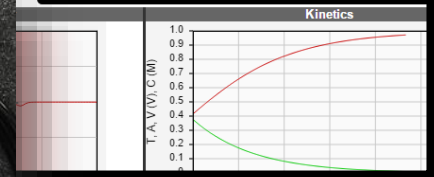
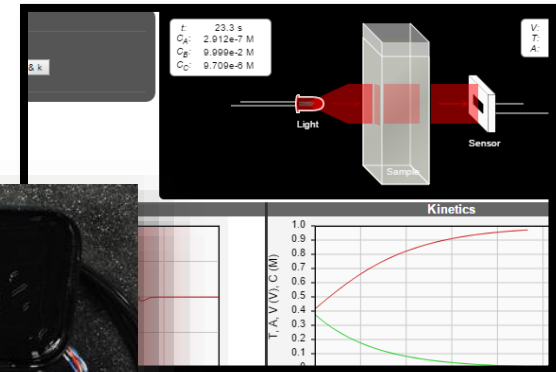
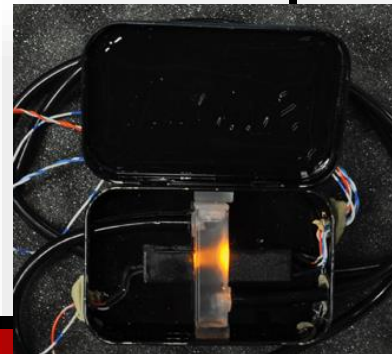
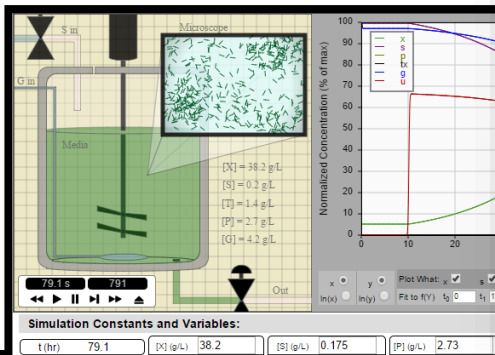
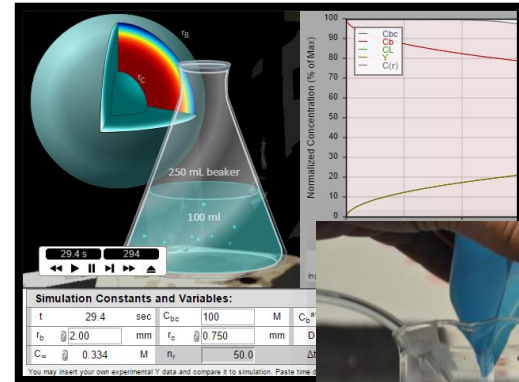


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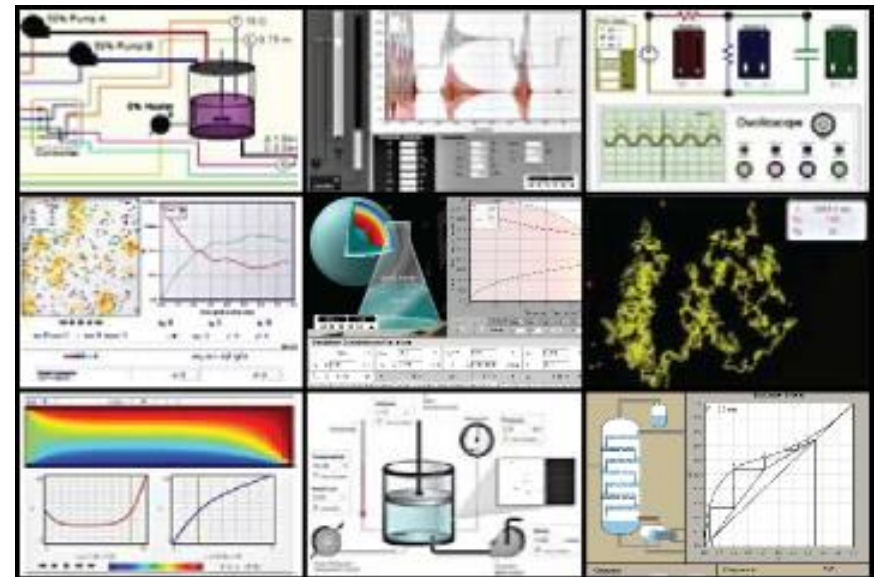
Our Simulations

- 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



Features of Our Simulations

- Cover a wide variety of chemical engineering disciplines
- Open-source
 - Freely accessible
<http://www.vSTEM.org>
- Browser-based
 - Easy to access
 - Chrome, IE, Firefox, Safari
 - PC, tablet, phone
- HTML, JavaScript, PHP
 - No download necessary



Benefits to Students

- Get a realistic sense of how adjusting parameters affect the system
- Students can move at their own pace
 - Unlimited attempts
- Instantaneous feedback
- Gaming aspect, “gain experience”, and “level up”

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 ^(α+β-1) /s)	=	1.50e6

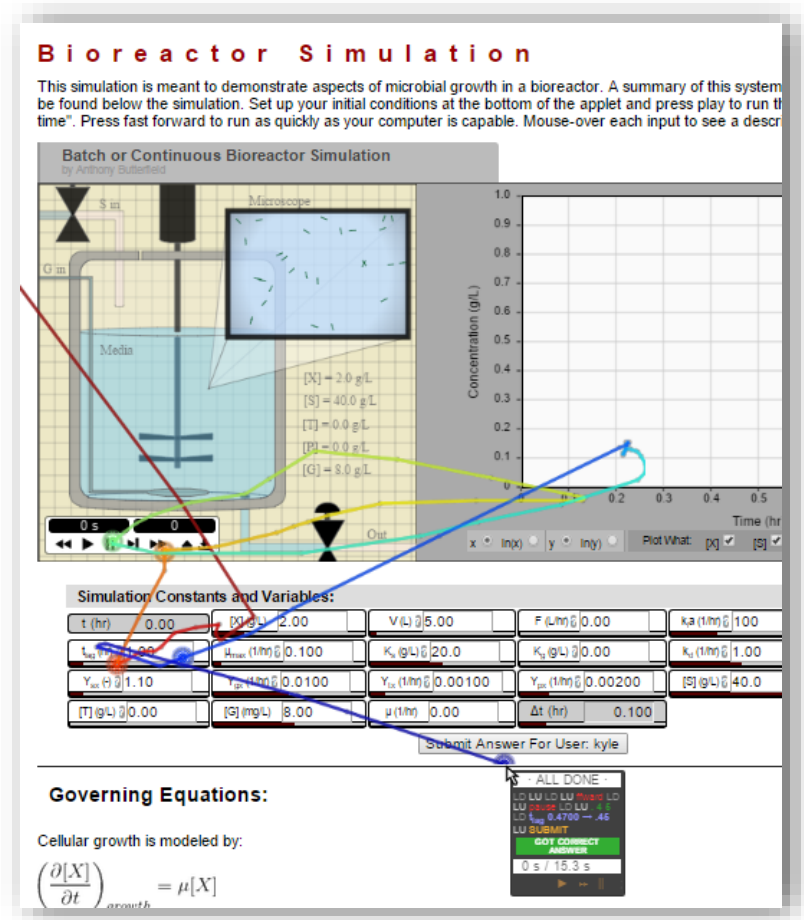
Benefits to Instructors

- Saves lab time and resources
- Automatically graded assignments
- Record all students' completed training
- Track students' usage for further optimization

Tracking Student Usage

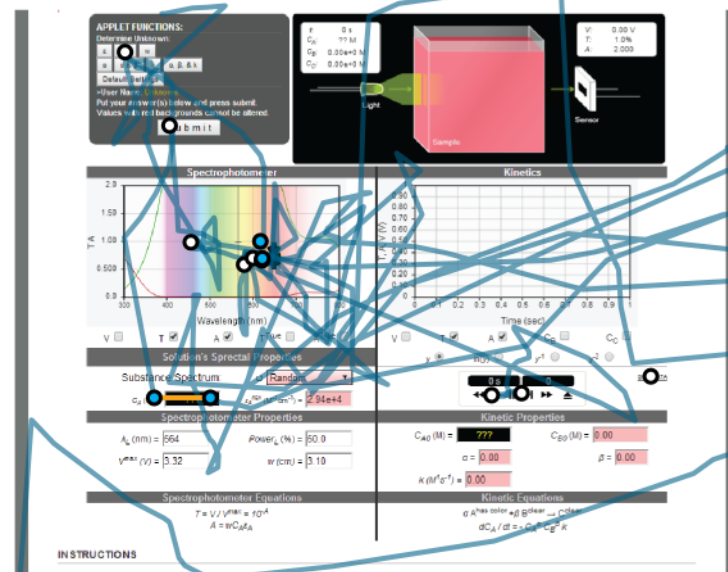
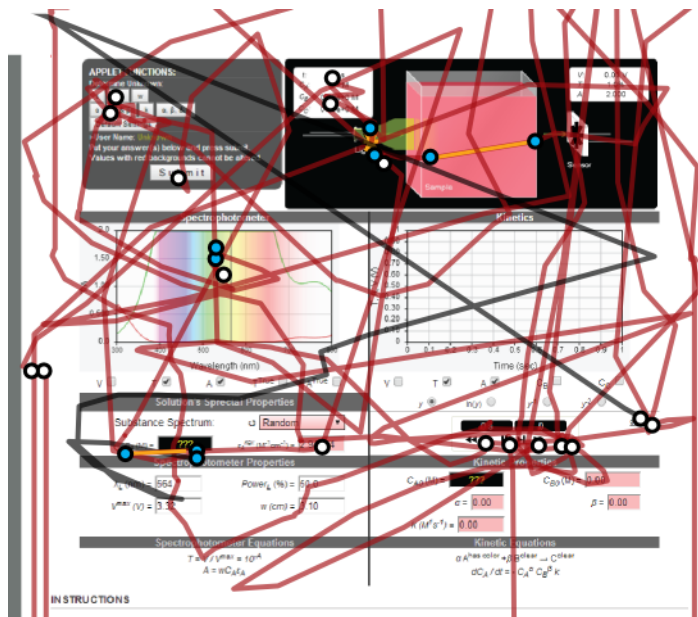
Records

- 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



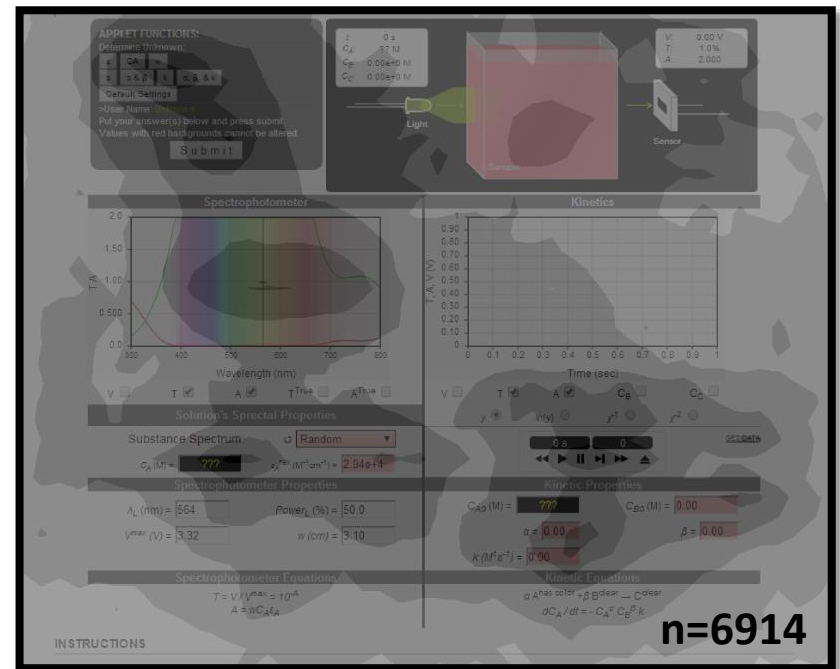
Improve Simulation Interface

- Add more intuitive functionality, based on individual attempts



Misunderstanding of Material

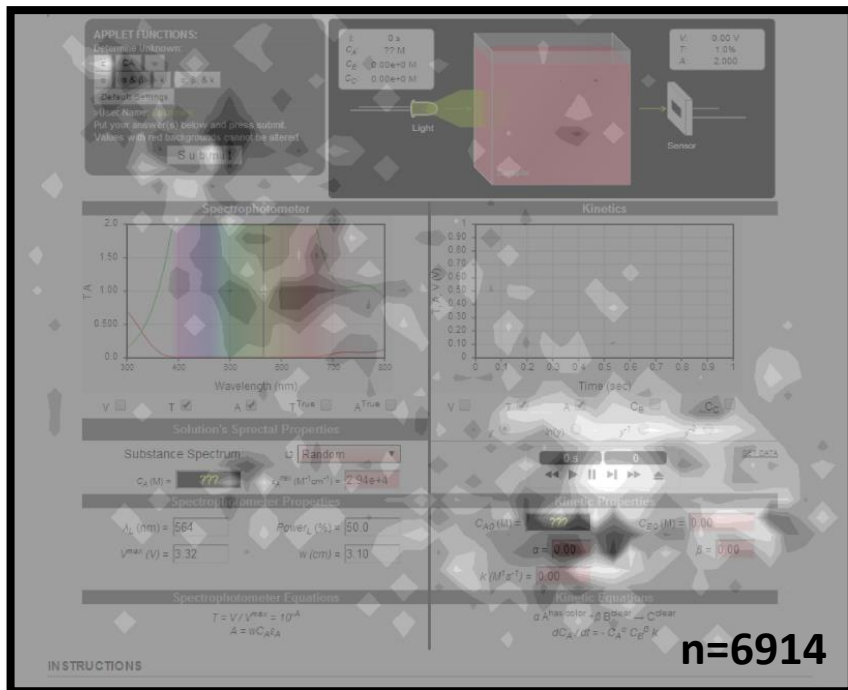
- Can we use ensemble averaged mouse location data to identify student misunderstandings?
- What if we look at differences between correct and incorrect attempts?



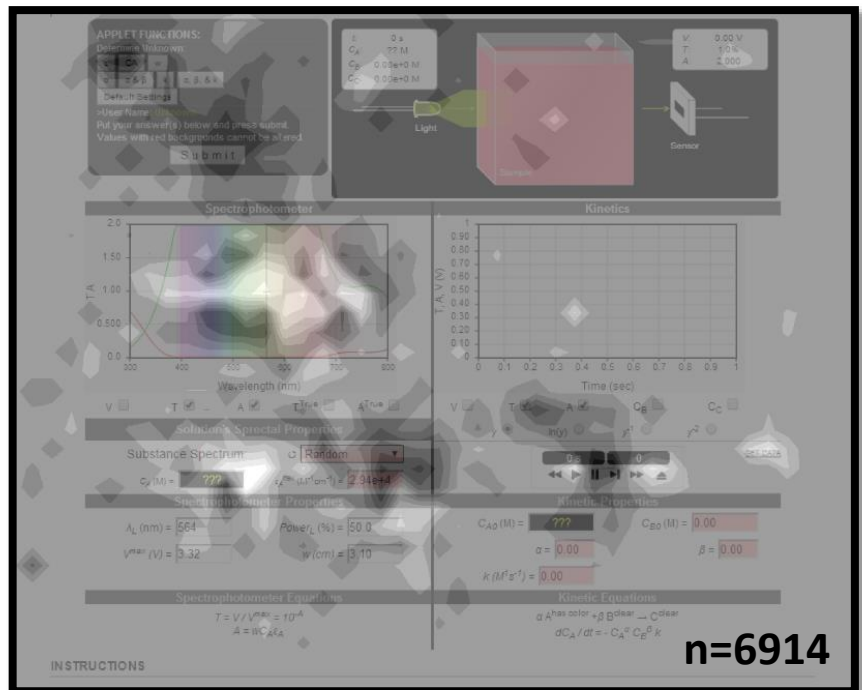
Misunderstanding of Material

- Mouse location differences for two assignments

Reaction Order



Maximum Molar Extinction Coefficient



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

We can determine

- Time of day/day of week
- Time spent
- Time between clicks
- Number of clicks
- Time early/late
- Attempts required
- On campus or not
- Order of problems

Preliminary Analysis: Pairwise Relationships

	Attempts Required	Attempt Sequence	Time Early/Late	Number of Clicks	Time Between Clicks	Time Spent	Time of Day	Day of Week	Order	Percentile	On Campus	Logged In
Correct												
Logged In												
On Campus												
Percentile												
Order												
Day of Week												
Time of Day												
Time Spent												
Time Between Clicks												
Number of Clicks												
Time Early/Late												
Attempt Sequence												

- - Key - -

Not Analyzed

Not Enough Data

Unsure How to Analyze

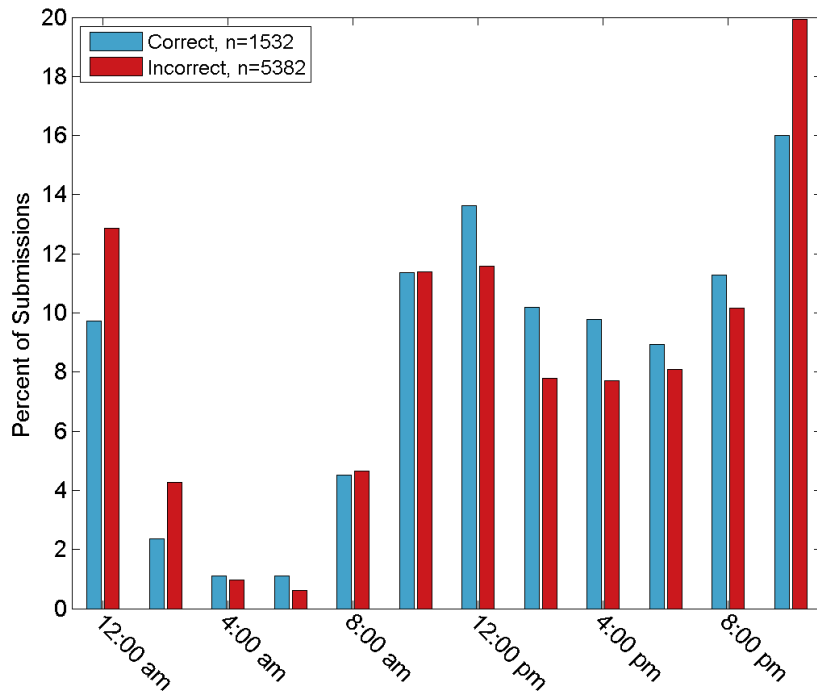
Unlikely Significant

Possibly Significant

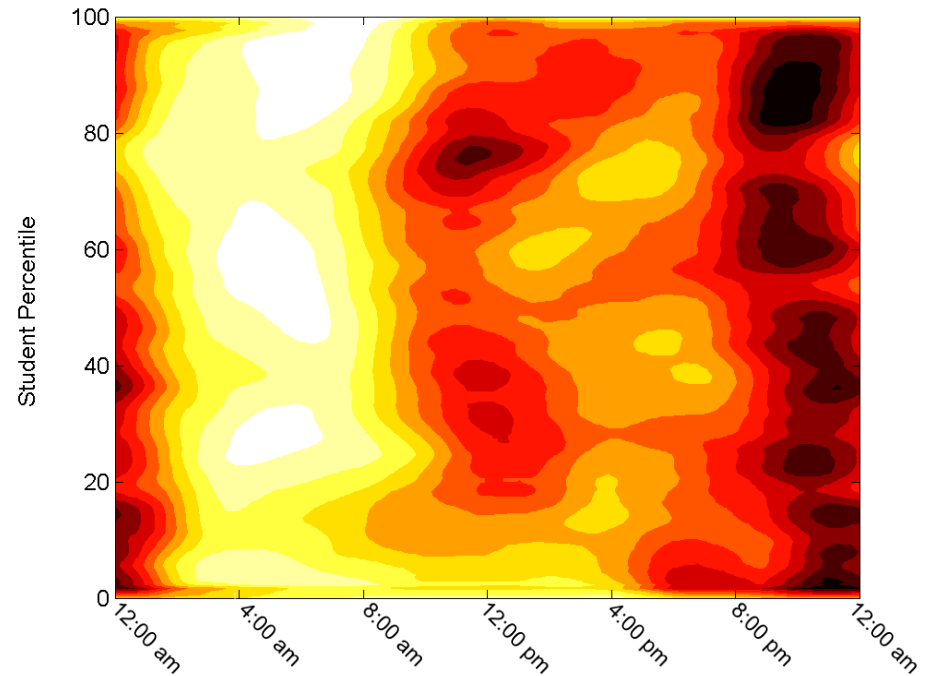
Likely Significant

Determine Successful Behavior

Students have lower success rates late at night

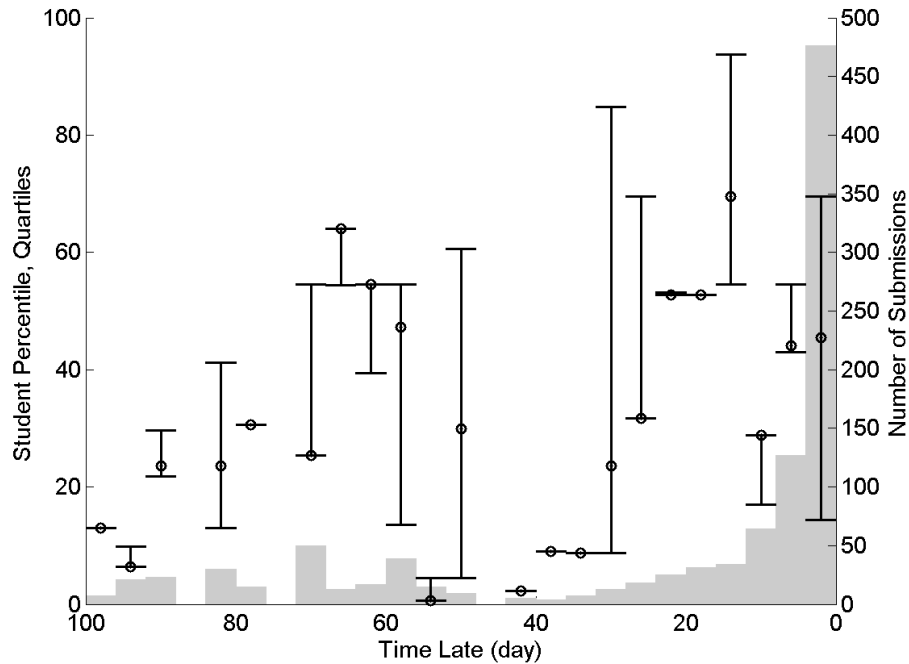


High percentile students do homework earlier in the day

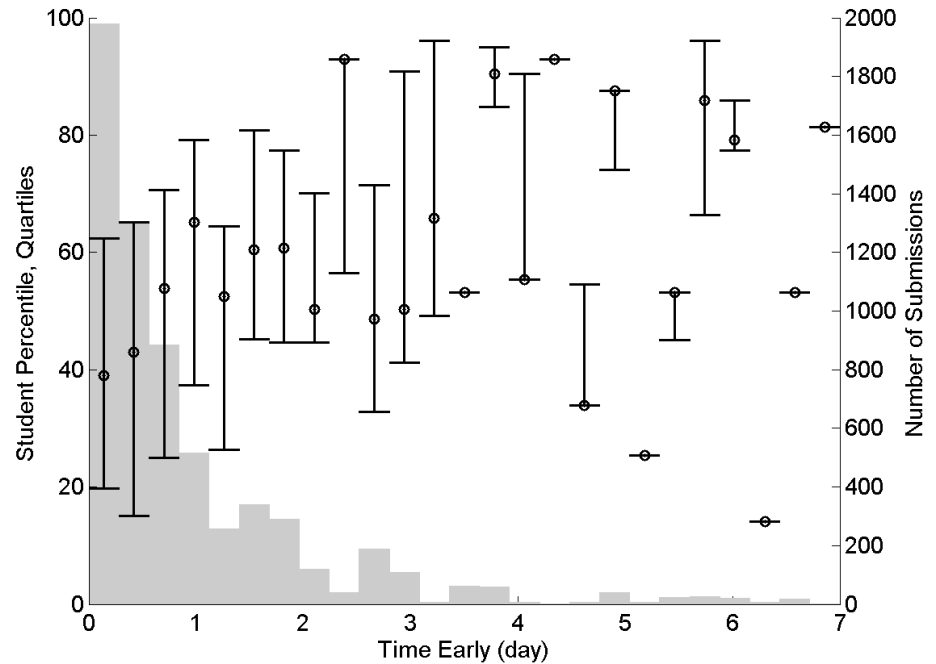


Determine Successful Behavior

Later submissions tend to be low percentile students

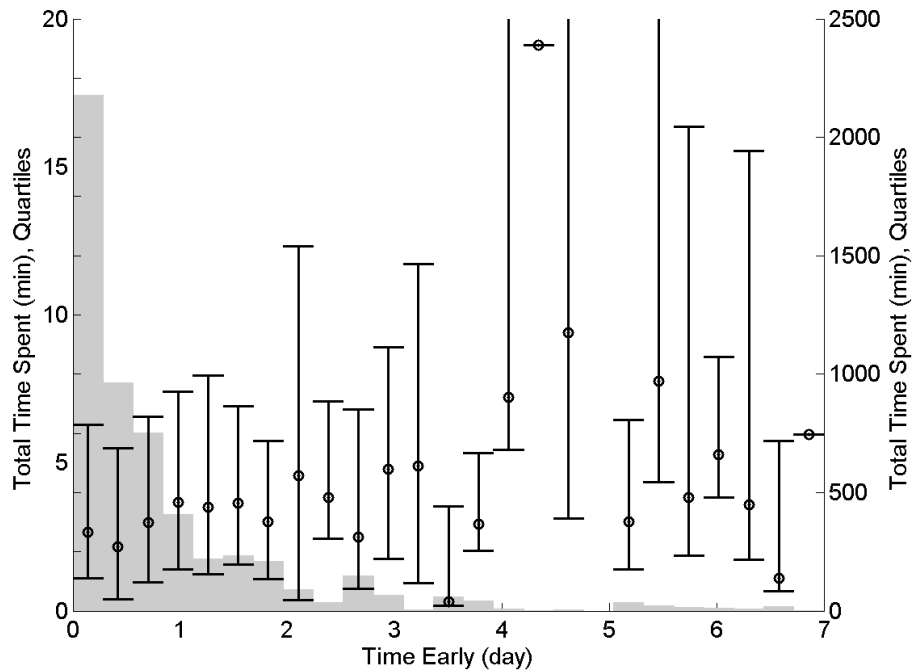


Earlier submissions tend to be high percentile students

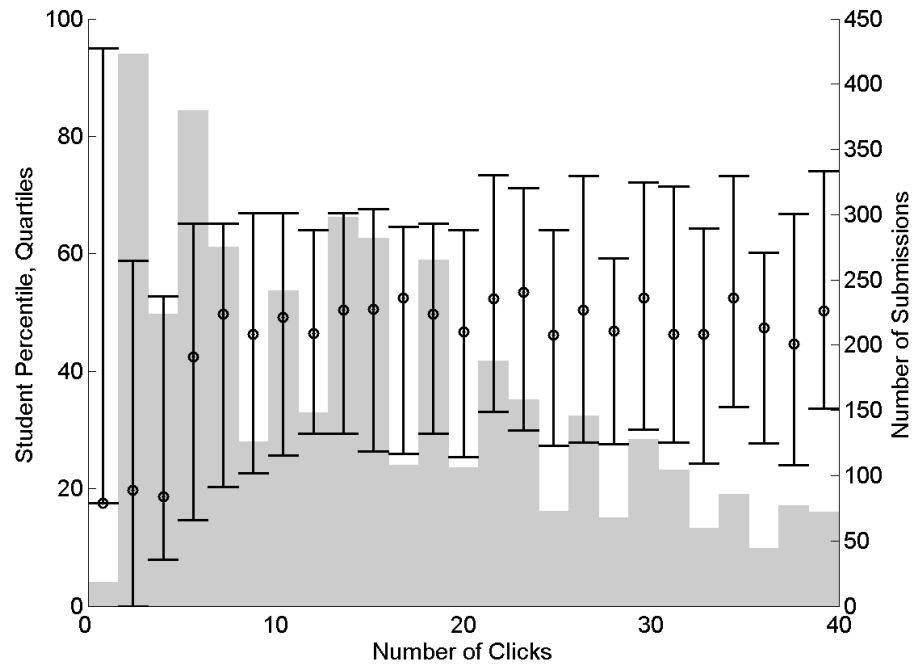


Determine Successful Behavior

Earlier submissions spend more time exploring the simulations



Low number of clicks correlates with lower percentile students (guessing?)

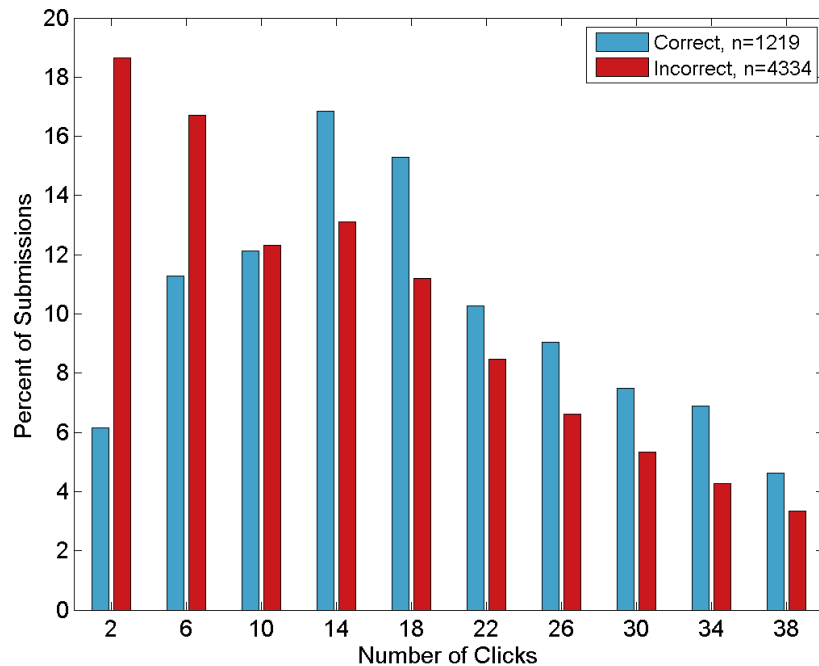


Eliminate Student Guessing

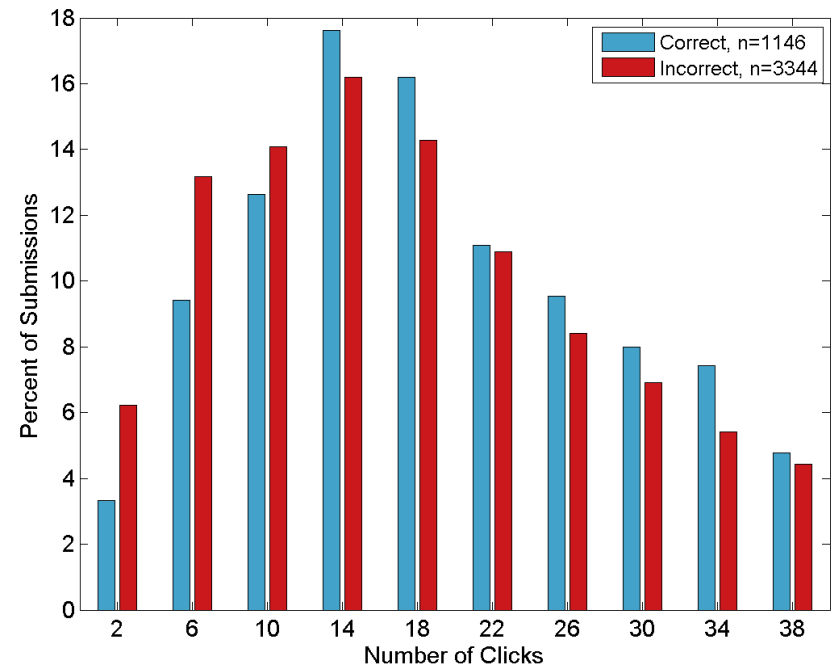
- Typical criteria of student guessing:
 - Less than 20 sec
 - Less than 6 clicks
 - More than 5 attempts
 - Guessing the same answer, or the previous correct answer
 - Guessed before
- Using a combination of these, we can detect student guessing

Eliminate Student Guessing

Original data

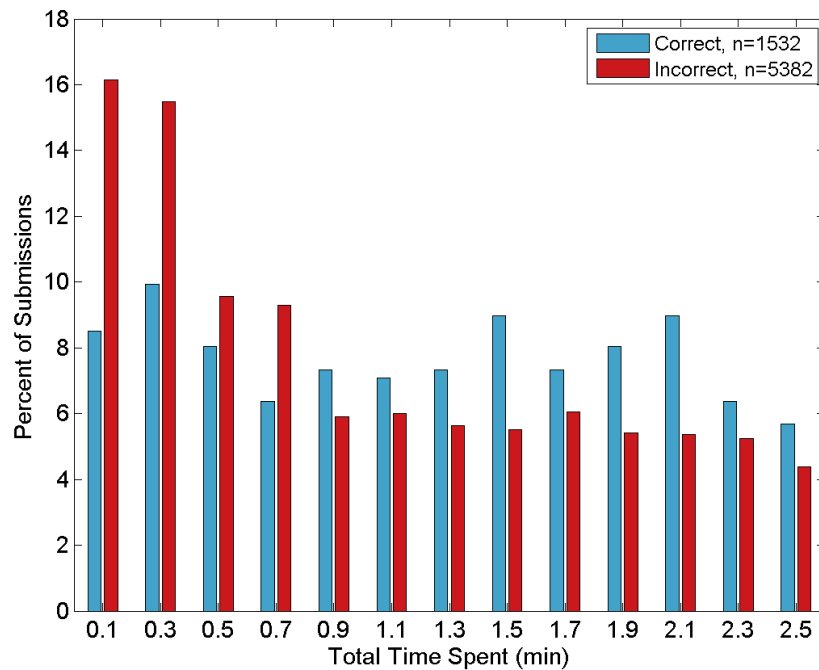


Filtered data

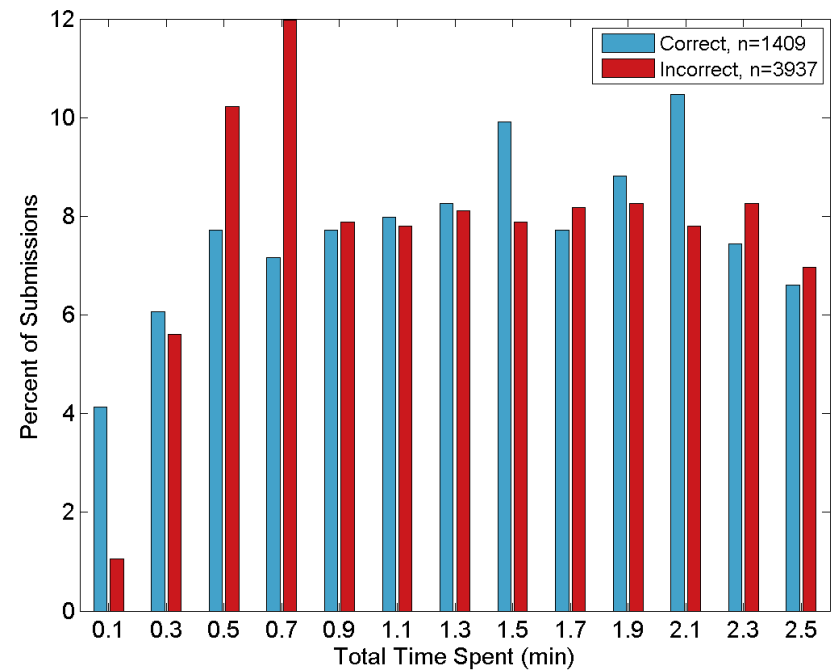


Eliminate Student Guessing

Original data



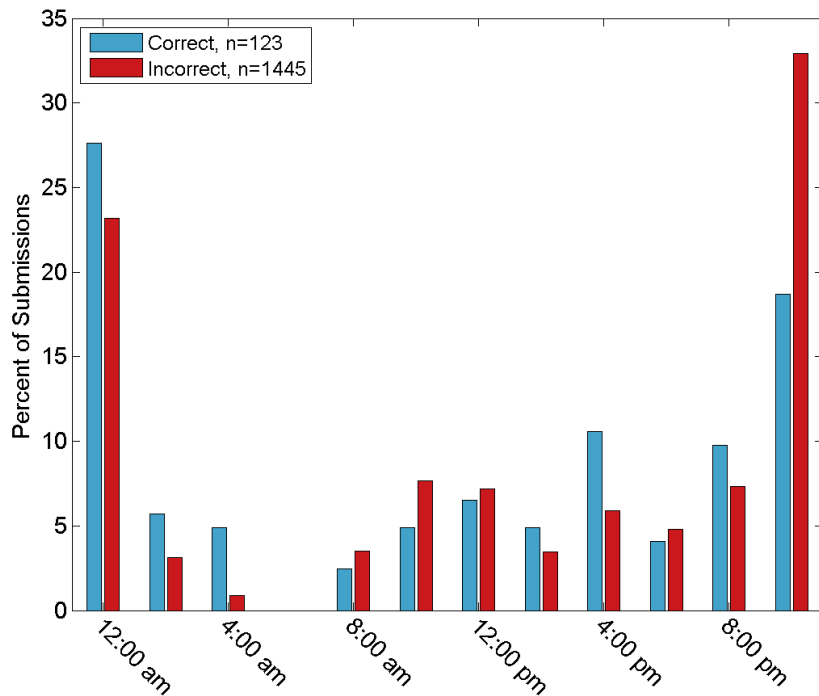
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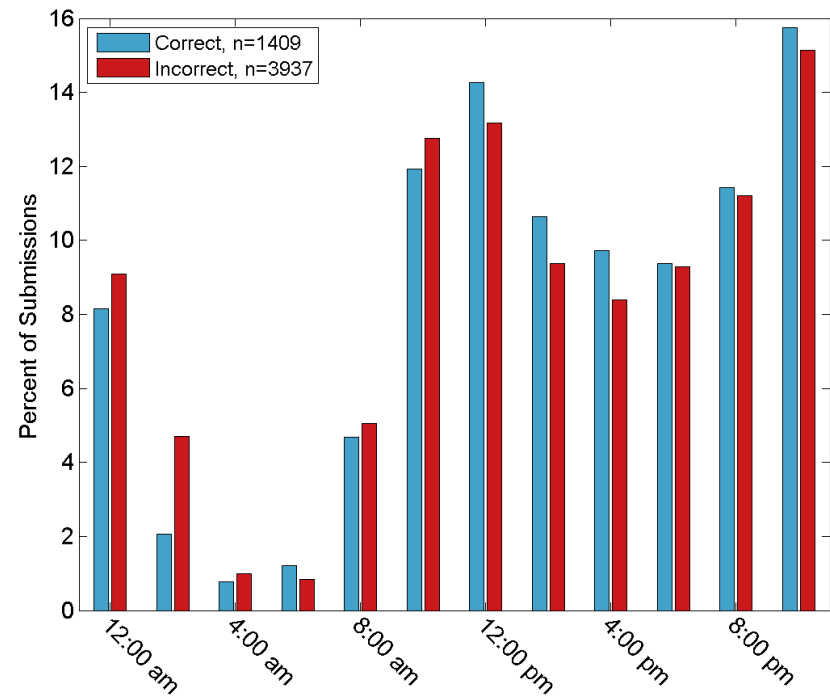
Eliminate Student Guessing

- Students are much more likely to guess late at night

Guessing data

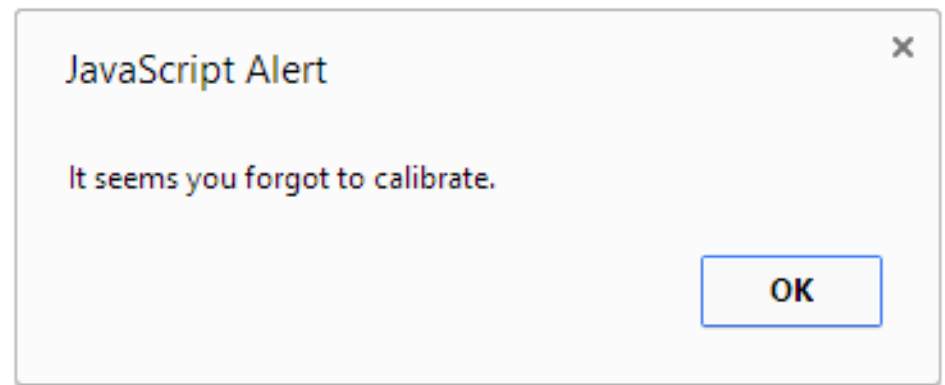


Filtered data



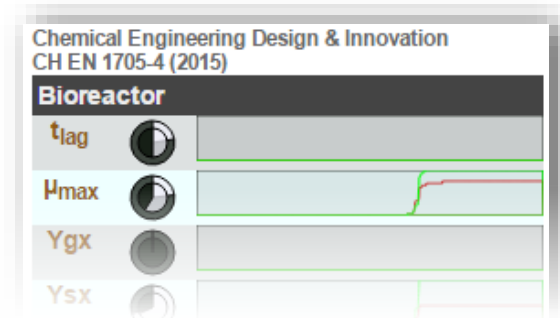
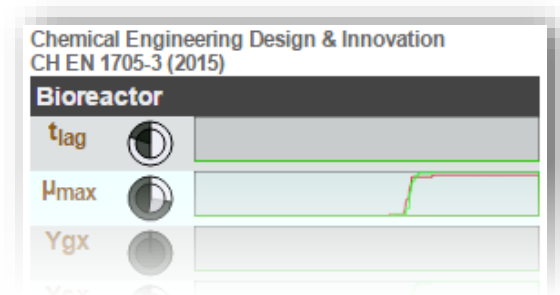
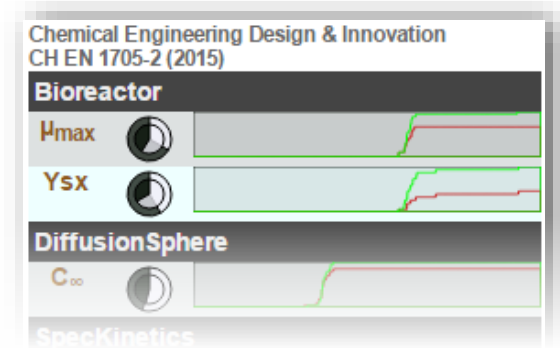
Add Automated Interventions

- “It seems you forgot to calibrate.”
 - “You should double check your units.”
 - “You seem to be clicking more than necessary.”
 - “You’re not logged in, are you sure you want to submit your answer?”
-
- Worked examples
 - Screencasts
 - Peer modeling



Future Work

- Real time educational data-mining
 - For students to see when their peers do their homework, if they are struggling with similar problems, etc.
- Develop simulations with textbook and conceptual questions for comparison
 - Can randomize unknown, value, and units



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