

Development and Usage of an Online Homework System in a Chemical Engineering Curriculum

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Kyle Branch is a fourth-year graduate student at the University of Utah Department of Chemical Engineering. He has helped develop and teach a freshman laboratory course, and an introduction to chemical engineering course which both use the online homework system described. His main research interest is in engineering education, focusing on the creation and analysis of interactive simulations for undergraduate chemical engineering courses.

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Anthony Butterfield is an Assistant Professor (Lecturing) in the Chemical Engineering Department of the University of Utah. He received his B. S. and Ph. D. from the University of Utah and a M. S. from the University of California, San Diego. His teaching responsibilities include the senior unit operations laboratory and freshman design laboratory. His research interests focus on undergraduate education, targeted drug delivery, photobioreactor design, and instrumentation.

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We have developed an online, open-source system to administer a variety of course materials to students, including homework assignments, lab safety training quizzes, course surveys, and simulated laboratory experiments. The homework assignments have been designed to randomly generate many parameters in each homework problem in order to give each student a unique problem and minimize cheating. The assignments are all automatically graded and allow students multiple attempts in order to reduce the grading commitment on instructors and allow students the ability to correct misunderstandings as early as possible.

We have added real-time educational data mining functionality to provide both instructors and students with student usage statistics. Before attempting a homework assignment, students are able to see how students in the past have performed and how much time it has taken them to complete each problem. Instructors are able to see when each student submits their assignments and how well they are performing in the course. In addition, we have analyzed which student characteristics and behaviors on the interactive simulations correlate with a higher grade in the course, using a variety of regression models.

We have also included awards which students are able to obtain through doing exceptionally well on homework assignments, through training on laboratory equipment, and from collecting high-quality data on laboratory experiments. In previous research, gamification has been found to increase student engagement in a course. Through obtaining these awards, students can obtain “experience” and “level up” on the website.

Preliminary results have shown that students enjoy the awards and are being motivated to achieve at least 100% on homework assignments in order to obtain them. Some students are also solving unassigned homework problems in order to gain as much “experience” as possible.

Uses of vSTEM

- Features
 - Cover a wide variety of chemical engineering disciplines
 - Open-source
 - Freely accessible
 - Browser-based
 - Easy to access
 - Works across browsers and devices
 - HTML, JavaScript, PHP
 - No download necessary
- Assignments
 - Automatically graded
 - Students can receive instantaneous feedback
 - Reduces the required time for grading
 - Good for increased course sizes
 - Randomly Generated constants, unknown and units
 - Minimize cheating
 - Interactive laboratory style problems
 - Train students before coming to the lab
 - Save lab resources and time
 - Students can progress at their own pace
 - Students develop ideas of how to complete their project before completing it in the lab
 - Get a realistic sense of how adjusting a parameter affects the system
 - Tracking student usage
 - Understand how students use the simulations and how they learn
 - Understand common misconceptions
- Trainings
 - We are able to know what lab equipment students are trained on
 - Increases lab safety
 - Students are required to complete and pass an online quiz beforehand to ensure they know safety precautions before being trained and certified to use lab equipment
 - Saves instructor time
 - Students are able to review their quiz to refresh the safety precautions
- Gain experience and level up
 - Seen that some students have used this and done problems that weren't assigned
- Lab Badge
 - Students can print out their name badge which includes a list of all of the equipment they have been certified to use
 - Instructors can quickly check if students have been trained to use equipment
 - Instructors can see the student's name and lab section
 - Particularly useful for large class sizes
- Future work ...