Learner-Centered Education Grants

2 0 0 4 Final Report

1. Project Name and Project Director's Name. Include mailing address, phone and e-mail address.

Project Name:	A Web Based Simulation Environment for a Learner-Centered Surface Science Course
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2. Brief Description of Project:

The goal of this project was to develop an interactive web-based simulation and learning environment for the chemistry and physics that occurs at solid surfaces. Surface science occurs in many areas of everyday life, such as condensation of water on a windowpane or cooking with a nonstick skillet. There are also applications in medicine, such as tissue rejection and protein adsorption, and in the large-scale manufacture of microelectronics and chemicals. The material in the web-based learning modules is aimed at senior undergraduates and graduate students in engineering, chemistry, physics, and optical sciences to help prepare them for careers in the microelectronics, optoelectronics, and optical industries, which are some of the largest technological employers in the state of Arizona, as well as in the emerging areas of biotechnology and nanotechnology. The interdisciplinary nature of surface science is a strength since cross fertilization using concepts from a range of scientific domains yields new answers and generates new applications. The web is an optimum tool to lower the barrier to integrating ideas since access to so many resources is close at hand. The surface science web course takes advantage of this by combining a hyperlinked series of lessons including a dictionary with interactive simulations. These lessons can be run in the forward direction to build new knowledge and run in reverse to review or relearn the basic science concepts that provide the underpinning for the simulations. Students who need more of the chemistry explained and illustrated can focus on those areas, whereas students who need more of the physics can focus their attention there. This enables a student to acquire knowledge specific to his or her individual needs and accommodates different types of learners. The simulations were written in Java and are accessible using any web browser from the site: http://muscat.chee.arizona.edu/ChEE437.

3. Goals, Outcomes and Assessments

a. Goals and Primary Accomplishments:

The project goals and milestones for development of the simulations and lesson material are summarized in Table 1. The first simulation to model the adsorption or sticking of a gas molecule to a surface and its reaction on the surface was completed in May and the Java code in June 2004. Several key parameters that affect the adsorption and reaction processes on the surface can be changed via a menu driven interface by a user, and the simulation returns the results in the form of a two-dimensional map showing the filled surface sites and the resulting growth mechanism of the thin film on the surface. The code can be run from any web browser connected to the internet and executes quickly because it is written in Java code.

Table 1: Summary of Goals and Milestones for Surface Science Web Course Project

Milestone	Task Description	Status	Date of Completion
Simulation I	Develop computer algorithm based on research results to simulate adsorption and reaction on a surface	Complete	May 2004
Simulation I Java Code	Write simulation code	Complete	June 2004
Lesson material	Develop material for surface science lessons	Complete	August 2004
Simulation II	Develop computer algorithm based on research results to simulate atomic layer deposition of thin films	Complete	August 2004
Simulation II Java code	Write simulation code	Complete	March 2005
Edit lesson materials and post to web	Use LaTeX to edit material in the lessons and post text, equations, and graphics to web	In progress	January 2006

The lesson material was completed last summer, but the large number of figures and equations caused constant computer crashes when working with the documents in Microsoft Word. A switch to a text based editor and LaTeX eliminated the problems. LaTeX is a computer software tool used by mathematicians and physicists for typesetting technical documents. The lesson material was copied and pasted into a text editor. A final edit of this material consists of fixing grammar and inserting textual links to the dictionary as well as converting all of the text, equations, and graphics to LaTeX code. LaTeX also generates html code to publish the lessons on the web.

b. Outcomes and Assessment for each Goal:

A sabbatical was approved for the principle investigator after receiving the LCE grant from ABOR. The surface science course including the web component will be offered in 2006 both on the University of Arizona campus and via National Technological University (NTU). The assessment and outcomes plan drafted in the proposal will be carried out when the course is offered. This plan consists of tracking students based on scientific training to determine how the web component of the course affected their understanding and proficiency in learning surface science concepts. Also it will test the hypothesis that providing elementary concepts linked to more advanced concepts helps in learning both the elementary concepts that may be out of discipline for a particular student as well as the more advanced ideas.

4. Problems or Issues Encountered:

The major hurdle was the switch to a typesetting program capable of handling the large number of figures and equations. This was not anticipated in the original proposal. The solution to an initial setback turned out to offer a benefit for the long-term maintenance of the web page. The principle investigator used the software program Word to write all of the lesson materials. These lessons included many embedded equations and graphics that often caused Word to stop functioning, which required a computer restart. Different computers and different versions of Word were tried without the problem significant improvement. Moving all of the lesson materials to a typesetting program called LaTeX solved the problem. Although this program required an investment of time to learn, the benefits are that the program does not crash even with documents containing many equations and, in addition, the principle investigator is capable of publishing the lesson directly to html, which is the computer code of web pages. In the past, the graduate student working on the project converted the Word lesson plans to html using a commercial web page program called Dreamweaver.

5. Conclusions, Recommendations and Future Directions:

The LCE grant provided the means to develop and integrate simulations and text-based material to teach surface chemistry and physics to students from a variety of scientific fields. The course was previously taught using the web but only as a convenient storage medium for problem set solutions and other information. The simulations and linked lessons offer a means of complementing and extending the classroom presentations of the material and may lead to more in class discussion, since some of the material can be disseminated via the web. It would be interesting to extend this and go to a format where the web is used to prepare for class and classroom time is spent entirely in working on problems and in discussions of the concepts.

6. Has this project led to sustainable change in your department/college? Describe:

This project is part of several changes for educating engineers that the faculty in my department are pursuing in parallel. There are other efforts that are web-based but also non web-based alternatives as well have been instituted. For example, integrating mathematics courses with the chemical engineering curriculum instead of teaching them as two separate unrelated courses.

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7. Impact:

a. Have other faculty been affected by this project? ☒ Yes ☐ No. If so, describe:
See previous description in point 6.

b. Number of courses affected/involved.
4, but others may be affected in time.

c. Number of students affected.
150 at the sophomore through graduate student levels (ChEE 201, 202, 437/537, 455/555)

8. Significant Outcome:

What was the most significant outcome based on learner-centered principles that occurred through your project?

The development of a web based simulation to illustrate the principle of pattern formation on a surface as a result of the adsorption of molecules from a gas phase.