Collaborative Research: Integration of Conceptual Learning throughout the Core Chemical Engineering Curriculum – Year 2

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Dr. Milo Koretsky is a professor of Chemical Engineering at Oregon State University. He currently has research activity in areas related to thin film materials processing and engineering education. He is interested in integrating technology into effective educational practices and in promoting the use of higher level cognitive skills in engineering problem solving. Dr. Koretsky is a six-time Intel faculty fellow and has won awards for his work in engineering education at the university and national levels.

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Debra Gilbuena is a Ph.D. candidate in the School of Chemical, Biological, and Environmental Engineering at Oregon State University. She currently has research focused on student learning in virtual laboratories. Debra has an M.BA, an M.S., and four years of industrial experience including a position in sensor development, an area in which she holds a patent. Her dissertation is focused on the characterization and analysis of feedback in engineering education. She also has interests in the diffusion of effective educational interventions and practices.

Mr. Bill Jay Brooks, Oregon State University

Bill Brooks is a Ph.D. candidate in the School of Chemical, Biological, and Environmental Engineering at Oregon State University. As an undergraduate, he studied hardware engineering, software engineering, and chemical engineering. Brooks has been involved in the development of several educational software tools including the Virtual BioReactor, the Web-based Interactive Science and Engineering (WISE) Learning Tool, and the AIChE Concept Warehouse. His dissertation is focused on technology-mediated, active learning techniques and the mechanisms through which they impact student performance.

Ms. Christina Smith, Oregon State University

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Overview and Objectives

We report on the progress of the second year of a CCLI Type 2 project. The goal of this project is to create a community of learning within the discipline of chemical engineering (ChE) focused on concept-based instruction. The project plan is to develop and promote the use of a cyber-enabled infrastructure for conceptual questions, *the AIChE Concept Warehouse*, which ultimately could be used throughout the core ChE curriculum (Material and Energy Balances, Thermodynamics, Transport Phenomena, Kinetics and Reactor Design, and Materials Science). Conceptual questions, both as Concept Inventories and ConcepTests, will be available through an interactive website maintained through the Education Division of the American Institute of Chemical Engineers (AIChE), the discipline's major professional society. The overall objective is to lower the activation barrier for using conceptual instruction and assessment so that many more chemical engineering faculty will incorporate concept-based learning into their classes.

The specific objectives of this project are to:

1. Develop the AIChE Concept Warehouse, a flexible database-driven website for conceptual questions in the core chemical engineering sciences. Features of the AIChE Concept Warehouse include:
   a. Making concept questions available in different formats to facilitate widespread use.
   b. Allowing integration of questions within a course and from different courses so students can link concepts to one another and form a more cohesive cognitive structure.
   c. Populating the site with conceptual questions that are submitted and reviewed by faculty, and are catalogued, rated and linked for ease of use.

2. Develop and deliver workshops that explain and promote conceptual learning in Chemical Engineering.
   a. Present workshops at the ASEE Chemical Engineering Faculty Summer School, the Fall AIChE Annual Meeting, and the Summer ASEE Annual meeting.
   b. Present workshops to faculty and future faculty through department site visits.
   c. Assess the participant's perception of the workshops and follow up with faculty to determine the extent of curricular integration of concept questions.

Concept-based Learning tools

For approximately the last 20 years, the physics education research community has shown the effectiveness of concept-based learning tools in promoting learning. Two seminal works are particularly noteworthy. First, the Force Concept Inventory (FCI) provided an instrument to measure students' fundamental conceptual understanding of Newtonian mechanics.[1,2] The questions were designed to test a student's ability to apply the fundamental laws and principles in a way that does not require computation. Second, Eric Mazur published his book *Peer Instruction*, which describes the use of *ConcepTests* to engage students in conceptual learning during lecture.[3] This structured questioning process actively involves all students in the class.

Peer instruction encourages students to reflect on the problem, think through the arguments being developed, and put them into their own words. Just as important, it provides both student and instructor with feedback regarding student understanding of the concept.

Concept Inventories have emerged in many science and engineering fields.[4-16] Similarly numerous studies in physics, chemistry, and biology classrooms have shown that active learning pedagogies that are based on concept questions (*ConcepTests*) are more effective for student learning than traditional lecture.[17-27] This project intends to encourage and shift the focus of learning in chemical engineering classes by providing a resource of high quality *ConcepTests* and Concept Inventories for instructors to use.

Project Status

This poster will present the status of the interactive AIChE Concept Warehouse software. The software structure is based on a synergy between a web-based user interface (programmed using PHP 5.3) and a commercial database (MySQL 5.5). Currently, the AIChE Concept Warehouse has approximately 1,700 concept questions available for searching, viewing, and using in courses through the user interfaces. The student and instructor interfaces are available at http://cw.edudiv.org for the community, and university faculty can obtain an account through this site. In order to maximize compatibility with the current practices of potential adopters, we designed and continue to improve the instructor interface to be familiar and user-friendly. The software allows interactive electronic use, as well as PowerPoint, and Word formats to be automatically generated so that conceptual learning and evaluation can be incorporated into instruction in various forms: in-class ConcepTests with student response (clickers, laptops, cell phones), concept inventories to evaluate student learning (or student preparation for a course), exam and homework problems.

A five-step design process was used to develop functions in the user interfaces. The steps include: (i) Developing a function list for the pages; (ii) Creating storyboards each page that included the listed functions; (iii) Implementing the storyboard concept in live webpages; (iv) Design team testing of live webpages and modification to enhance functionality and usability; and (v) External testing of live webpages and modification to enhance functionality and usability. A paper providing a more detailed description of the development process was presented at the 2012 ASEE Annual Conference and Exposition.[28]

In order to foster community engagement, several activities are ongoing. Special sessions and workshops have been presented at the ASEE Annual Conference and the AIChE Annual Meeting and will be presented in future years. The website was fully launched and made broadly available at the ASEE Chemical Engineering Faculty Summer School in July, 2012 where eighty-four faculty members attended a 3-hour, two-part workshop on the AIChE Concept Warehouse. A newsletter, dubbed the Concept Warehouse Quarterly, was also started with the inaugural issue emailed to AIChE Concept Warehouse users on December 7, 2012. A copy of this Fall 2012 issue can be found in Appendix 1. To help orient new users, we are hosting webinars titled "Getting Started" and "ConcepTests: What are they and how can I make a good one?" The project team is also available for independent department visits. If interested in hosting a department workshop, please contact the corresponding author. In general, the activities are intended to help faculty who are interested in incorporating educational methods and tools into

their classrooms to encourage students to think more deeply about concepts central to chemical engineering. To date the AIChE Concept Warehouse has 201 faculty accounts representing 93 institutions and has collected over 80,000 answers submitted by students. A further summary of AIChE Concept Warehouse statistics is presented in Table 1.

Table 1. AIChE Concept Warehouse Statistics

No. of Institutions	No. of Students	Electronic Answers Submitted	No. of Faculty Accounts	Questions Used	
				In-class	Downloaded
93	2,890	Over 80,000	201	2,023	1,541

The website is currently being expanded to include other instructional tools including inquiry based activities,[29] formative class reflection questions,[30] surveys, and virtual laboratories, all of which are focused on assessing and improving students' conceptual understanding.

Involvement of chemical engineering educators is crucial for the success of the *AIChE Concept Warehouse*. If you would like to use the *AIChE Concept Warehouse*, the address is http://cw.edudiv.org

Acknowledgements

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Appendices

Appendix 1: Concept Warehouse Quarterly – Fall 2012

AIChE Education Division

CONCEPT WAREHOUSE QUARTERLY

Fall 2012

In this newsletter…

cw.edudiv.org

*The goal of this tool is to create a **community of learning** within the discipline of **chemical engineering** that is focused on **concept-based instruction**.*

Developed under NSF DUE 1023099, 1022957, 1022875, 1022785

Welcome!

Dear Concept Warehouse Community,

It is our pleasure to introduce the first issue of our *Concept Warehouse Quarterly*! We appreciate your enthusiastic response since we made the tool publicly available during the *ASEE Chemical Engineering Division Summer School*.

The Concept Warehouse is intended to be a versatile tool that can be readily incorporated to fit an individual faculty member's teaching philosophy and her/his learning environment. Based on this design strategy we foresee many ways that this tool may be deployed and many opportunities to learn from one another. To further create a community of learning, if you have a colleague who may find the tool useful we encourage you to let them know!

Thank you for registering to use this resource and feel free to ask for help and offer suggestions. Our goal is to help create a community resource which will help your students learn.

We appreciate your use, continued support, and feedback!

The AIChE Concept Warehouse Leadership Team


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John Falconer
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Ron Miller
Colorado School of Mines


David Silverstein
University of Kentucky


Marina Miletic

Recent Activity

ASEE Chemical Engineering Division Summer School Workshop: Tools and Techniques for Conceptual Learning

We delivered three workshops at the 2012 ASEE Summer School in July at the University of Maine. Each workshop provided a framework for concept-based learning, illustrated the use of ConcepTests and Concept Inventories, and demonstrated how the AIChE Concept Warehouse can help instructors implement conceptual learning in their classes. During the workshop, participants interactively answered concept questions, developed their own questions, and learned how to navigate and use the Concept Warehouse.

The workshop was both highly attended and enthusiastically received. 98% of participants found the workshop either "useful" or "very useful" and 92% said they would recommend the AIChE Concept Warehouse to a colleague. One participant wrote that they would tell colleagues: "remember how you have been complaining that the students don't understand the fundamentals...I heard about this awesome resource that will help you test them on concepts during lectures..."

Eighty-four faculty members attended the three workshops. Since then we have authorized approximately 200 new faculty accounts and the number keeps growing daily!

Email: aicheconceptwarehouse@gmail.com Phone: (541) 737-4591 Fax: (541) 737-4600

Appendix 1 Continued: Concept Warehouse Quarterly – Fall 2012

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AIChE Concept Warehouse Stats

No. of Institutions	No. of Students	Electronic Answers Submitted	No. of Faculty Accounts	Questions Used	
				In-class	Downloaded
85	1,954	Over 50,000	186	1,405	1,226

Upcoming Webinars

To register for a webinar, navigate to the blue "Support" tab in the AIChE Concept Warehouse. Select the webinar you would like to attend and provide any requests you may have, we may address these during the webinar. You will receive an email with a link a couple of days prior to the event. There will also be time at the end of the each webinar for questions and comments.

Getting Started Webinar

Getting Started - December 19th, 2012 - 9am PST (noon EST)
Getting Started - January 2nd, 2013 - 9am PST (noon EST)

You might benefit from this webinar if you are new user interested in understanding the basic features available in the AIChE Concept Warehouse. This webinar will guide you through getting started using the AIChE Concept Warehouse. It may include the following steps:

* Setting up clickers - Turning Point technologies
* Assigning tests
* Viewing results
* Using student accounts
* Creating a class
* Adding students to a class
* Finding and adding questions
* Managing tests

ConcepTests: What are they and how can I make a good one?

How to Write a ConcepTest - December 21st, 2012 - 9am PST (noon EST)
How to Write a ConcepTest - January 3rd, 2013 - 9am PST (noon EST)

What is a ConcepTest? What makes a high quality concept question? This webinar is intended to help instructors understand what components make a good conceptual question and how they can be used in the classroom. The use of Concept Inventories and how they can improve your classes will also be addressed.

Ways to be Involved!

Dr. Koretsky's graduate students are currently studying the spread and adoption of the AIChE Concept Warehouse. The purpose of the investigation is to help improve the tool itself and reflect on the best way to help faculty use it. They are hoping that this reflection will be beneficial to other educators who develop and share their innovations with the broader community.

They would like to invite anyone who is interested in sharing their thoughts and experiences regarding the AIChE Concept Warehouse to participate in a phone interview. If you are interested and willing to talk with these grad students, contact them at the following email address:

aicheconceptwarehouse@gmail.com

Please contact them by Dec. 21st, 2012. Participation in this study would be greatly appreciated and will only take an hour of your time!

If you attended the ASEE Summer School workshop, the informed consent form is now available electronically under the "Profile" tab in the *Informed Consent* submenu. Check it out!

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Appendix 1 Continued: Concept Warehouse Quarterly – Fall 2012

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Highlighted Website Features

Quick Start Guides

Quick Start guides have been developed to introduce and walk you through a few of the basic ways you can use the Concept Warehouse in your classes. These guides offer step-by-step instructions located in the "Support" tab, submenu *Quick Start* (see figure) for creating and adding students to your class, finding and adding questions, making a test, etc. Each can be viewed individually or as a complete pdf and contain screenshots of each step to further guide you. Have questions the quick starts don't answer? Don't hesitate to contact us at aicheconceptwarehouse@gmail.com .

Instructor Email Options

Once you have added students to your class, how do you contact them and let them know they need to register with a student account in the Concept Warehouse? Now there is a streamlined instructor email option that will automate this for you!

Navigate to the "Classes" tab, submenu *Manage Class* and open the *Student Accounts Status* crate (see figure). After you have added student emails to the class you have created, you have the option to send them one of three emails. The email contains a welcome to your class, a link to the website along with steps on how to activate their account. This helps to ensure that all of your students have been informed of their role in the activation process.

Upcoming Website Features

Instructional Tools

This tab will be the home of the test preparation survey (Felder), muddiest point assessment (Krause), heat and energy misconception intervention (Prince and Vigeant), interactive virtual laboratories and other tools. Keep checking to see how you can use these tools

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