

Collaborative Research: Integration of Conceptual Learning throughout the Core Chemical Engineering Curriculum – Year 3

Dr. Milo Koretsky, Oregon State University

Milo Koretsky is a Professor of Chemical Engineering at Oregon State University. He received his B.S. and M.S. degrees from UC San Diego and his Ph.D. from UC Berkeley, all in Chemical Engineering. He currently has research activity in areas related engineering education and is interested in integrating technology into effective educational practices and in promoting the use of higher-level cognitive skills in engineering problem solving. His research interests particularly focus on what prevents students from being able to integrate and extend the knowledge developed in specific courses in the core curriculum to the more complex, authentic problems and projects they face as professionals. Dr. Koretsky is one of the founding members of the Center for Lifelong STEM Education Research at OSU.

Prof. John L. Falconer, University of Colorado Boulder

John L. Falconer is the Mel and Virginia Clark Professor of Chemical and Biological Engineering and a President's Teaching Scholar at the University of Colorado Boulder. He has published more than 225 papers and has 12 patents in the areas of zeolite membranes, heterogeneous catalysis, photocatalysis, and atomic and molecular deposition. He has directed the effort at the University of Colorado to prepare screencasts, ConcepTests, and interactive simulations for chemical engineering courses (www.LearnChemE.com).

Dr. David L. Silverstein P.E., University of Kentucky

David L. Silverstein is the PJC Engineering Professor of Chemical Engineering at the University of Kentucky. He is also the Director of the College of Engineering's Extended Campus Programs in Paducah, Kentucky, where he has taught for 14 years. His PhD and MS studies in ChE were completed at Vanderbilt University, and his BSChE at the University of Alabama. Silverstein's research interests include conceptual learning tools and training, and he has particular interests in faculty development. He is the recipient of several ASEE awards, including the Fahein award for young faculty teaching and educational scholarship, the Cororan award for best article in the journal Chemical Engineering Education (twice), and the Martin award for best paper in the ChE Division at the ASEE Annual Meeting.

Dr. Bill Jay Brooks, Oregon State University

Bill Brooks is a postdoctoral scholar in the School of Chemical, Biological, and Environmental Engineering at Oregon State University. His Ph.D used written explanations to concept questions to investigate technology mediated active learning in the undergraduate chemical engineering classroom. He current interests involve using technology to enhance educational practices in promoting conceptual understanding. He is the primary programmer of the AIChE Concept Warehouse and his current focus is on its continued development, specifically creating and integrating Interactive Virtual Labs.

Dr. Debra M. Gilbuena, Oregon State University

Debra Gilbuena is a postdoctoral scholar in the School of Chemical, Biological, and Environmental Engineering at Oregon State University. Debra has an M.B.A, an M.S, and four years of industrial experience including a position in sensor development. Sensor development is also an area in which she holds a patent. She currently has research focused on student learning in virtual laboratories and the diffusion of educational interventions and practices.

Christina Smith, Oregon State University

Christina Smith is a graduate student in the School of Chemical, Biological, and Environmental Engineering at Oregon State University. She received her B.S. from the University of Utah in chemical engineering and is pursuing her PhD also in chemical engineering with an emphasis on engineering education. Her research interests include diffusion of innovations and student personal epistemology.

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Overview and Objectives

We report on the progress of the third year of a CCLI Type 3 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 2,000 concept questions in chemical engineering available for searching, viewing, and using in courses through the user interfaces. Additionally, there is a pilot trial in physics, chemistry, and mathematics. 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.

In order to foster community engagement, several activities are ongoing. Special sessions and workshops have been presented at the ASEE Annual Conference, the AIChE Annual Meeting, and the ASEE Chemical Engineering Faculty Summer School. A newsletter, dubbed the Concept Warehouse Quarterly, was also started with the inaugural issue emailed to AIChE Concept Warehouse users in December, 2012. A copy of the Summer 2013 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 has also made one independent department visit to a large chemical engineering program. 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.

As of January 2014, the AIChE Concept Warehouse has approximately 350 faculty accounts representing over 130 institutions and has collected over 175,000 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 Faculty Accounts	No of Students	Electronic Answers Submitted	Questions Used	
				In-class	Downloaded
135	358	5,008	Over 175,000	3,457	2,481

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 – Summer 2013



CONCEPT WAREHOUSE QUARTERLY

Summer 2013

Welcome!

Dear Concept Warehouse Community,

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. 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!

We appreciate your use, continued support, and feedback!

The AIChE Concept Warehouse Leadership Team



Milo Koretsky
 Oregon State University



John Falconer
 University of Colorado Boulder



Ron Miller
 Colorado School of Mines



David Silverstein
 University of Kentucky



Marina Miletic

AIChE Concept Warehouse Stats

No. of Institutions	No. of Faculty Accounts	No. of Students	Questions Used		Electronic Answers Submitted
			Online	Downloaded	
108	244	3,117	2,304	1,700	Over 100,000

Upcoming Activities

ASEE Annual Conference and Exposition

- * M357—NSF Grantees' Poster Session
Poster — NSF Grantees Poster Session
Mon. June 24, 2013 10:30 AM—12:00 PM
Georgia World Congress Center, Exhibit Hall A1

"Collaborative Research: Integration of Conceptual Learning throughout the Core Chemical Engineering Curriculum"

- * T212—Grasping the "Concept"
Technical—Chemical Engineering Division
Tue. June 25, 2013 8:45 AM—10:15 AM
Omni CNN Center Hotel, Omni—Jupiter

"Examining the Innovation-Decision Process: A Preliminary Study of the AIChE Concept Warehouse"

- * T506A —Industry Day Session II
Tue. June 25, 2013 2:15 PM—3:45 PM
Georgia World Congress Center, A307

REES 2013 Research in Engineering Education Symposium

- * Presentation
July 4 – 6 2013
Kuala Lumpur, Malaysia

"How Communication Channels Affect Awareness and Adoption of the AIChE Concept Warehouse"

2013 AIChE Annual Meeting

- * Workshop: Concept Warehouse: Bring a Friend
November 3– 8 2013
Hilton San Francisco Union Square, San Francisco, CA

We would love to meet and talk with you after the presentation or any time during the conference or symposium!



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
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1022785

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AICHE
Education Division

CONCEPT WAREHOUSE QUARTERLY

Summer 2013

In this newsletter...

Welcome!

AICHE Concept Warehouse Stats

Upcoming Activities

- Future Conferences

Upcoming Webinars

- Getting Started
- How to Write a ConceptTest

Ways to be involved!

- Wiley call for interview or questionnaire

Highlighted Website Features

- Word Clouds
- Drag and Drop


Upcoming Website Features

- Instructional Tools

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.

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 - July 23th, 2013 - 9am PST (noon EST)
Getting Started - August 6th, 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:

<ul style="list-style-type: none"> * Creating a class * Adding students to a class * Finding and adding questions * Managing tests 	<ul style="list-style-type: none"> * Setting up clickers - Turning Point technologies * Assigning tests * Viewing results * Using student accounts
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ConceptTests: What are they and how can I make a good one?

How to Write a ConceptTest - July 24th, 2013 - 9am PST (noon EST)
How to Write a ConceptTest - August 7th, 2013 - 9am PST (noon EST)

What is a ConceptTest? 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!



Instructors!


Have you used the AICHE Concept Warehouse to enhance your classroom teaching or giving assignments to your students? Do you have ideas for new features and functionality of the warehouse that you would like to share?

The developers of the AICHE Concept Warehouse are exploring collaboration with Wiley publishing to make elements of the warehouse more easily integrated with popular textbooks, online resources, and the other tools you use to teach your courses. If you would be interested in responding to a short questionnaire, or an interview of thirty minutes or less, please send an email to:

jknecht@wiley.com

with "AICHE Concept Warehouse" in the subject line and your contact information in the body of the message. We look forward to hearing from you!



Developed under NSF DUE 1028096, 1028097, 1028098, 1022765

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cw.edudiv.org

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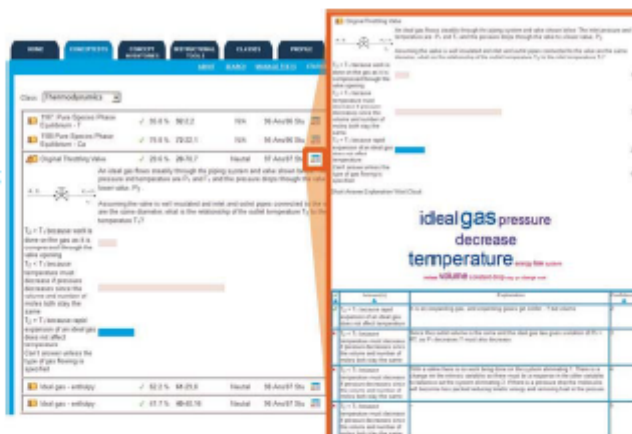
Highlighted Website Features

Word Clouds

Do you have students write short answers to concept questions? Are you interested to know what common words or themes students are writing about at a quick glance?

Word clouds for short answer explanations make it easy for you to see common words students use when explaining their answers to concept questions.

These can be viewed by clicking on the *Detailed Results* button under the *Statistics* submenu in the 'ConceptTests' or 'Concept Inventories' tab.



Drag and Drop

Now managing ConceptTests is easier! Check the "Enable drag and drop for ConceptTest management" option under the *Preferences* sub-menu in the "Profile" tab. This will allow you to use your mouse to drag and drop individual and groupings of ConceptTests while in the *Manage Tests* submenu in the 'ConceptTests' tab.



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 in your classes!



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