



Collaborative Research: Integration of Conceptual Learning throughout the Core Chemical Engineering Curriculum – Year 4

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Overview and Objectives

We report on the progress of the fourth 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, are 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 (*ConceptTests*) are more effective for student learning than traditional lecture.¹⁷⁻²⁸ This project intends to encourage and shift the focus of learning in chemical engineering classes by providing a resource of high quality *ConceptTests* 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 2,200 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 *ConceptTests* with student response (clickers, laptops, cell phones), concept inventories to evaluate student learning (or student preparation for a course), exam and homework problems. Figure 1 shows one form of the student user interface that was recently developed, a mobile app. A web-based interface is also available.

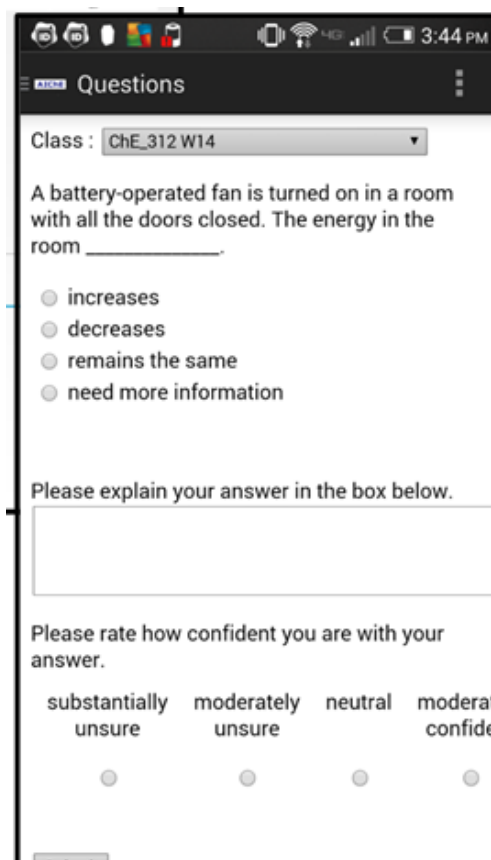


Figure 1. Screenshot of student interface on mobile student app.

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 Fall 2014 issue can be found in Appendix 1. To help orient new users, we are hosting webinars titled "Getting Started" and "ConceptTests: 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 shown in Figure 2, the Concept Warehouse has been enthusiastically adopted by the Chemical Engineering community. In approximately 2.5 years since being made available to the community, 650 engineering faculty members across the US and internationally from approximately 150 institutions have used it. Over 400,000 answers have been submitted by students. The website is currently being expanded to include other instructional tools including inquiry based activities,³⁰ formative class reflection questions,³¹ surveys, and virtual laboratories, all of which are focused on assessing and improving students' conceptual understanding.

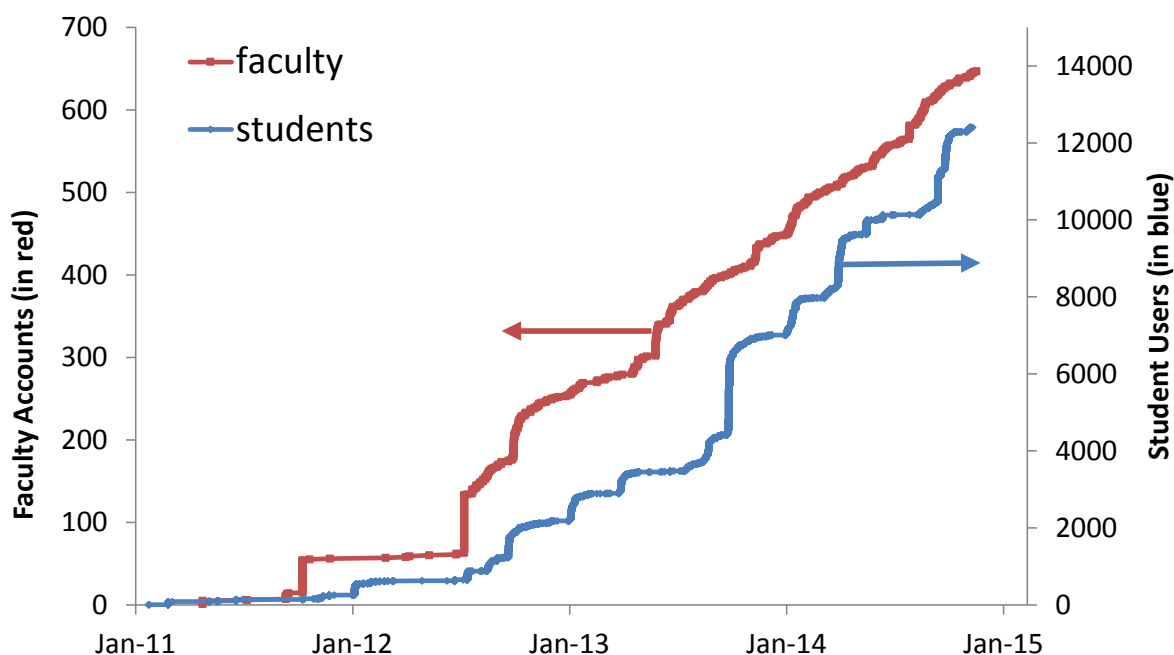


Figure 2. Growth of faculty and student users of the Concept Warehouse

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>

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Appendices

Appendix 1: Concept Warehouse Quarterly – Fall 2014

AIChE[®] Education Division

CONCEPT WAREHOUSE QUARTERLY

Fall 2014

Welcome!

Dear Concept Warehouse Community,

We are excited that you have registered to use this resource and we hope your summer has gone well! As the new semester or term begins, we hope to continue to be a conceptual tool you use to help students learn. As you use the tool, feel free to ask for help and offer suggestions.

We appreciate your use, continued support, and feedback!

The AIChE Concept Warehouse Leadership Team



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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	
181	533	9,607	Over 5,000	Over 4,000	Over 260,000

Upcoming Webinars

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

Are you interested in understanding the basic features available in the Concept Warehouse? This webinar will guide you through getting started and may include the following steps:

- Creating a class
- Adding students to a class
- Finding and adding questions
- Managing tests
- Assigning tests
- Viewing results
- Using student accounts

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

In this newsletter...

Welcome!

AIChE Concept Warehouse Stats

Upcoming Webinars

- Getting Started

New Website Design

New CW Features

- Student Apps—Beta test
- SMS text response
- Label and edit assignments
- Learning tool interoperability

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.



New Website Design!

We have redesigned the Concept Warehouse webpage!

The new interface allows you and your students to easily navigate through the website and sign up for accounts. Check out the videos to take a quick tour or see how you can use Peer Instruction in class!



New Concept Warehouse Features!



Concept Warehouse Mobile Student Apps

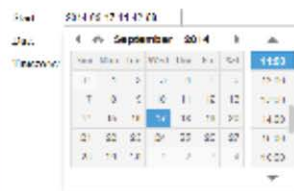
The Android version of the CW Student App is now available for beta testing! It is easy to use and improves the mobile experience of answering concept questions and inventories on a smartphone. It provides an alternative method of answering questions that allow for written explanations and confidence follow ups (unlike clickers). An Apple app will be available soon!

If you are interested in having your students participate in the beta test, contact us at aicheconceptwarehouse@gmail.com.

Involvement with testing includes having students use the app in class and answer a survey about their experiences at the end of their course.

SMS Text Response

Students can now answer concept questions without a smart phone! Enable this feature in your *Preferences* under the Profile tab. Students will have to register their phone in the student interface, similar to clickers. A phone number students can send a text to will appear when a test is assigned. Standard rates apply.



Label and Edit Date/Time of Assignments

You can label assignments with names or directions to help students! You can also edit the date and time of homework assignments using an easy to use calendar time selector. Being able to edit is great if you have assigned concept questions as homework and need to change the deadline.

Learning Tool Interoperability

Do you use a Learning Management System (LMS) like Blackboard, Canvas, Moodle, etc.? We now have the capability to embed concepttests into your LMS! Once you set up this feature, you can download a link for any exercise in the Concept Warehouse and embed it into your LMS to seamlessly allow students to answer without having to go to a third website. Grades will also be visible for students within the LMS! If you are interested in giving us information on the requirements that your institution has for enabling LTI functionality, it will help us document and improve this feature! Please contact us at aicheconceptwarehouse@gmail.com



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