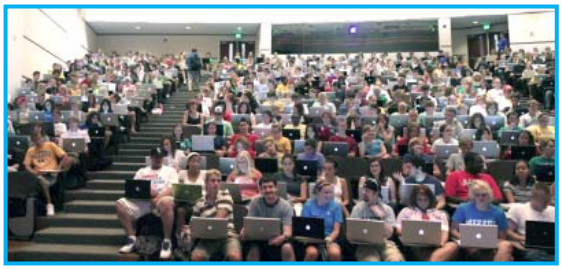
Concept Warehouse: AIChE Education Division Webinar

24 January 2017

Milo Koretsky

Oregon State University



AIChE Education Division CONCEPT WAREHOUSE

AIChE Concept Warehouse

Cyber-enabled infrastructure for conceptual questions

- Create a community of Learning within the discipline of chemical engineering focused on concept-based instruction

AIChE Concept Warehouse

Cyber-enabled infrastructure for conceptual questions

- Create a community of Learning within the discipline of chemical engineering focused on concept-based instruction
- Lower the activation barrier to promote implementation of concept-based instruction and active learning

Why Concept-Based Instruction

Problem Solving: Procedural Approach

Given *T*
- Step 1
- Step 2
- Step 3
- Step 4

Find *P*

Example

Problem Solving: Procedural Approach

Given *T*
- Step 1
- Step 2
- Step 3
- Step 4

Find *P*

Example

Given *T*
- Step 1
- Step 2
- Step 3
- Step 4

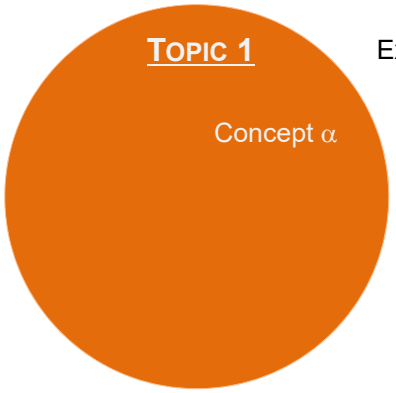
Find *P*

Homework

Problem Solving: Procedural Approach

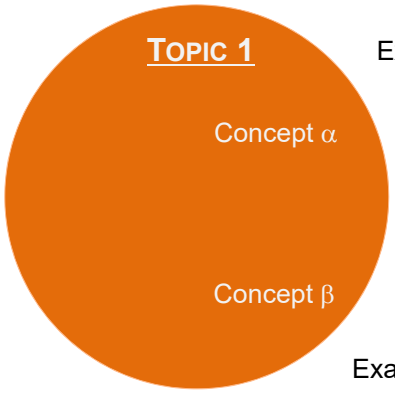
Example	Homework	Exam
Given *T*	Given *T*	Given *P*
Step 1	Step 1	Step 4
Step 2	Step 2	Step 3
Step 3	Step 3	Step 2
Step 4	Step 4	Step 1
Find *P*	Find *P*	Find *T*

Teaching Problem Solving: Conceptual Approach



Example 1

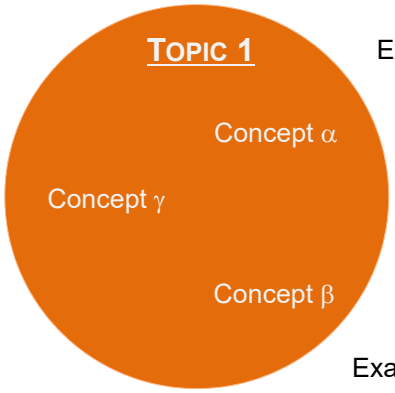
Teaching Problem Solving: Conceptual Approach



Example 1

Example 2

Teaching Problem Solving: Conceptual Approach

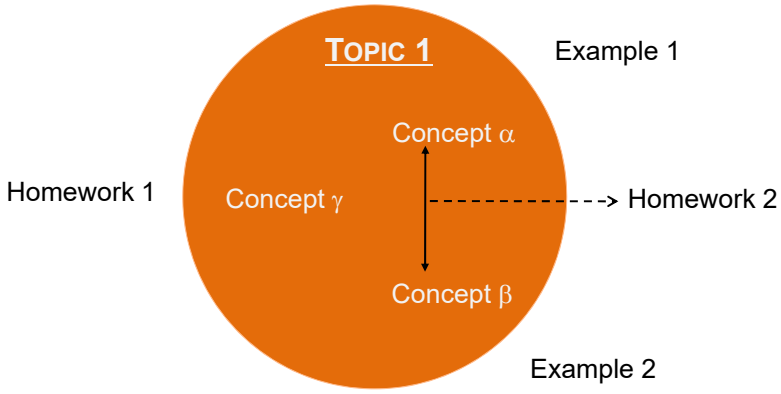


Homework 1

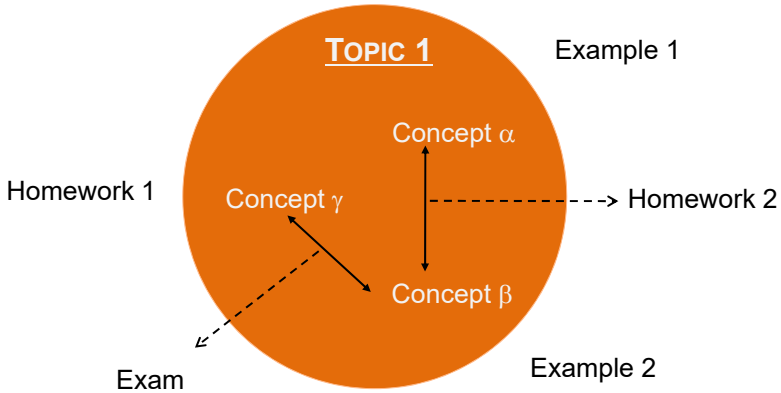
Example 1

Example 2

Teaching Problem Solving: Conceptual Approach

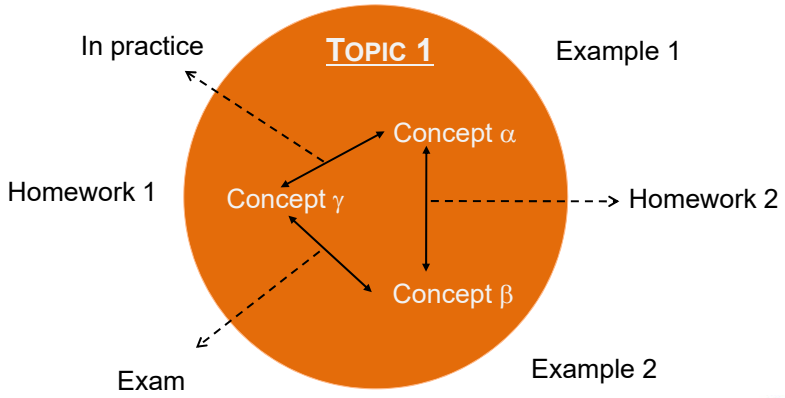


Teaching Problem Solving: Conceptual Approach



Teaching Problem Solving: Conceptual Approach

Integrated Conceptual Knowledge Structure



Slowly the problem revealed itself: many students concentrate on learning 'recipes', or 'problem solving strategies' as they are called in textbooks, without bothering to be attentive to the underlying concepts.

-Eric Mazur
Qualitative vs. quantitative thinking: are we teaching the right thing?
Optics and Photonics News. 3(2), 38 (1992).

Why Concept Based Learning?

A coherent conceptual framework does not usually result from traditional instruction. Scientific reasoning skills must be expressly cultivated. *(McDermott, 1993).*

Rote Memorization ← Problem Solving by Procedural Approach

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~~Rote Memorization~~ ← Problem Solving by Procedural Approach

Conceptual Understanding → Transfer to Different Problems

Students are more likely to develop conceptual understanding when learning through Interactive Engagement

(Freeman et al., 2014; Hake, 1998)

How to develop conceptual understanding

How to develop conceptual understanding

- Ask conceptual questions!

Two Questions – What Types of Learning?

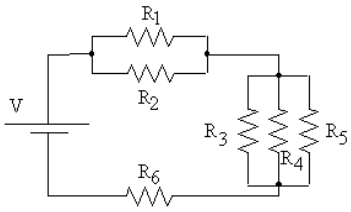
- Question 1

In the circuit,

$V = 25V$, $R_1 = R_2 = 10\Omega$,

$R_3 = R_4 = R_5 = 15\Omega$, $R_6 = 50\Omega$.

What is the current through resistor R_3?



Michael Dubson
University of Colorado

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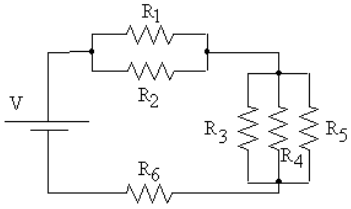

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- Question 2

When the value of R_6 increases, the current through R_3 _____.

A) Increases B) decreases C) remains constant?

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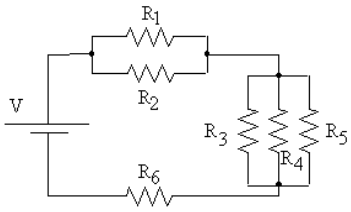

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- Question 2

When the value of R_6 increases, the current through R_3 _____.

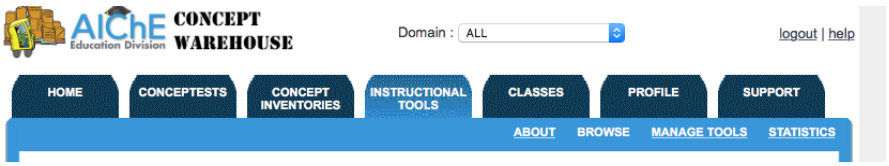
A) Increases B) decreases C) remains constant?

1. Identify one thing these questions have in common
2. Identify one way they are different

The Concept Warehouse

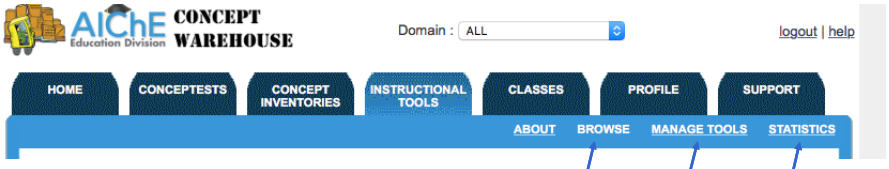
(video)

Inside the Concept Warehouse



- ConcepTests
- Concept Inventories
- Instructional Tools
  - Reflection Activities
  - Interactive Virtual Labs
  - Inquiry-Based Activities
- Classes (Course Management)
- Support

Inside the Concept Warehouse



Select

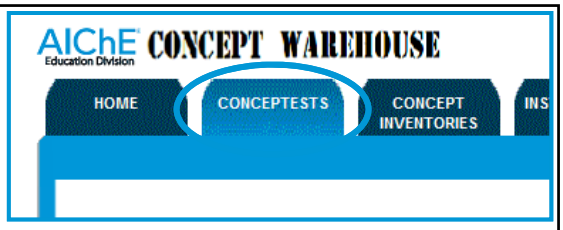
Assign to class

Analytics

- ConcepTests
- Concept Inventories
- Instructional Tools
  - Reflection Activities
  - Interactive Virtual Labs
  - Inquiry-Based Activities
- Classes (Course Management)
- Support

ConcepTests

(about **3,000 available**)



ConcepTests are questions selected or written by the instructor

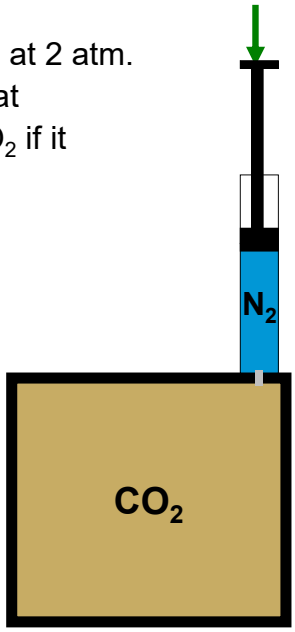
- Typically used in class.
- Helps the students develop understanding of engineering concepts.
- Helps faculty and students identify level of mastery.
- Should be used in a "low stakes" environment.
- Effective in large classes to promote greater engagement.

A constant-volume tank contains CO_2 at 2 atm. Nitrogen is injected into the tank. What happens to the partial pressure of CO_2 if it all remains in the tank? Assume ideal gases and an isothermal system.

A. Decreases

B. Increases

C. Stays the same



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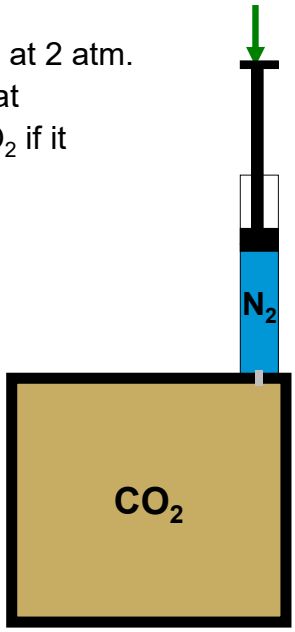
13 A. Decreases

32 B. Increases

6

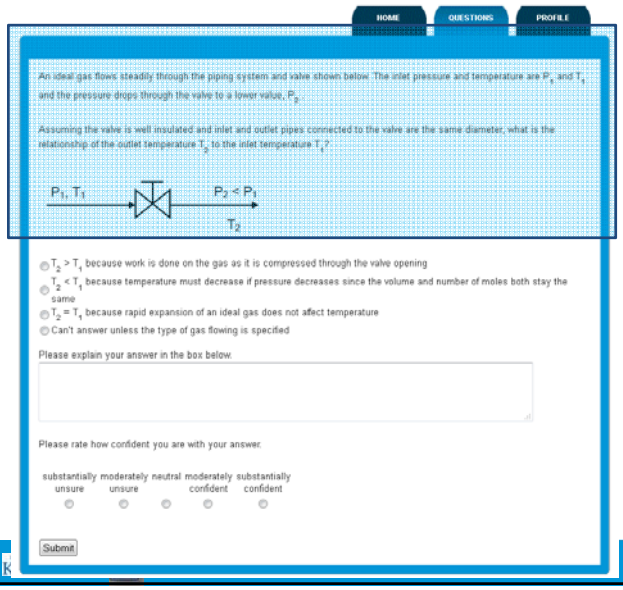
(chance is 17)



Example ConcepTest: What students see when you assign online

Question text

Plus Figure



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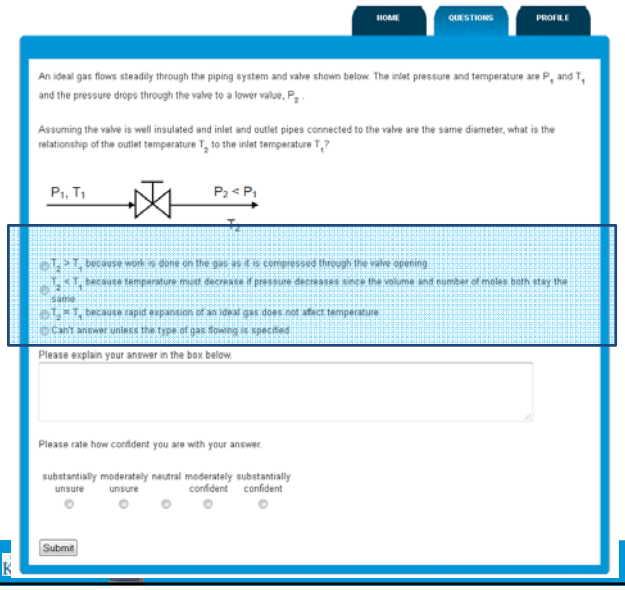

Multiple Choice Answer Selections

Example ConcepTest: What students see when you assign online

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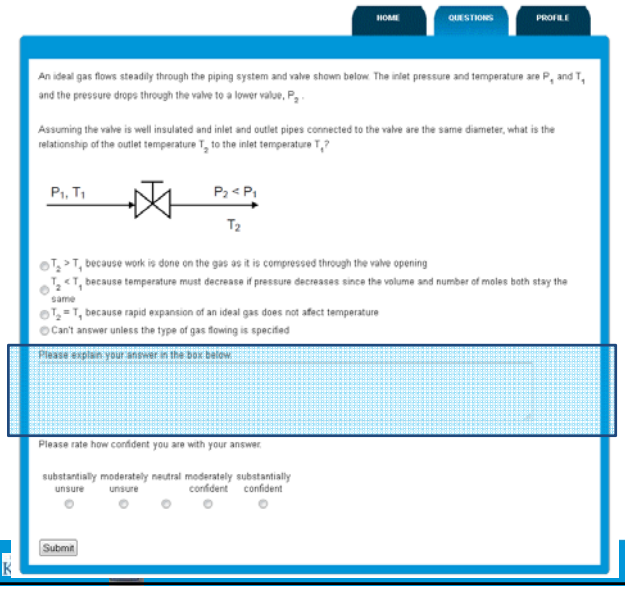


Multiple Choice Answer Selections

Written Reflection (optional)

Example ConcepTest: What students see when you assign online

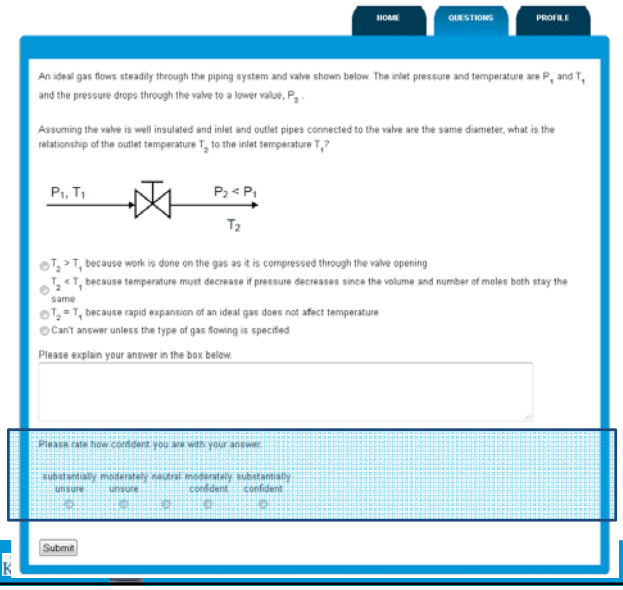
Question text

Plus Figure

Written Reflection (optional)

Confidence (optional)

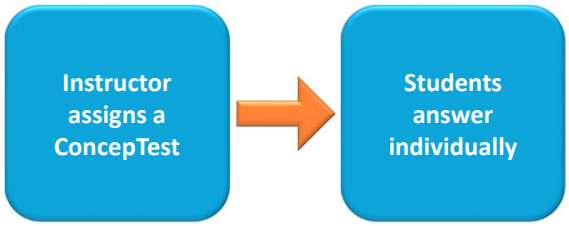
Multiple Choice Answer Selections



Peer Instruction

Instructor assigns a ConcepTest

Peer Instruction



Peer Instruction

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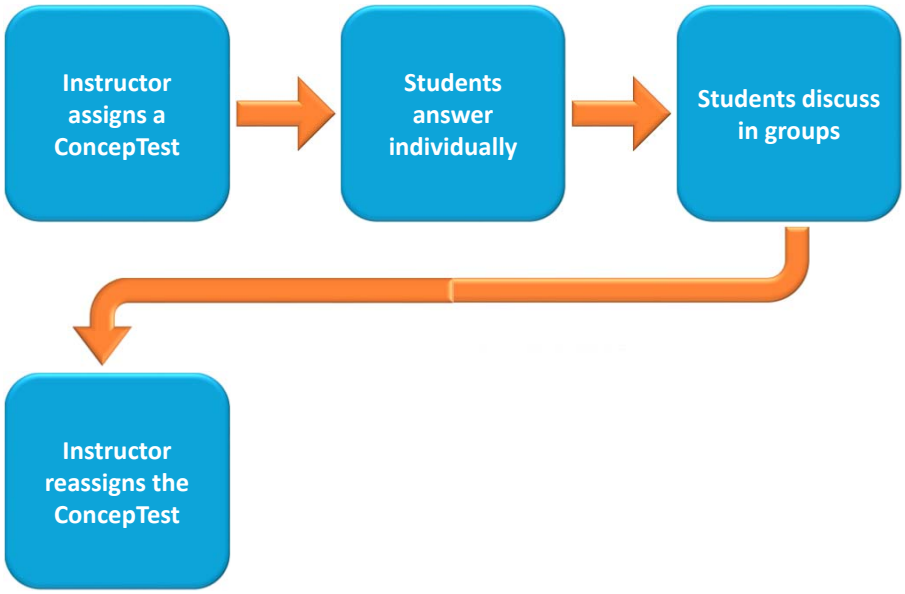

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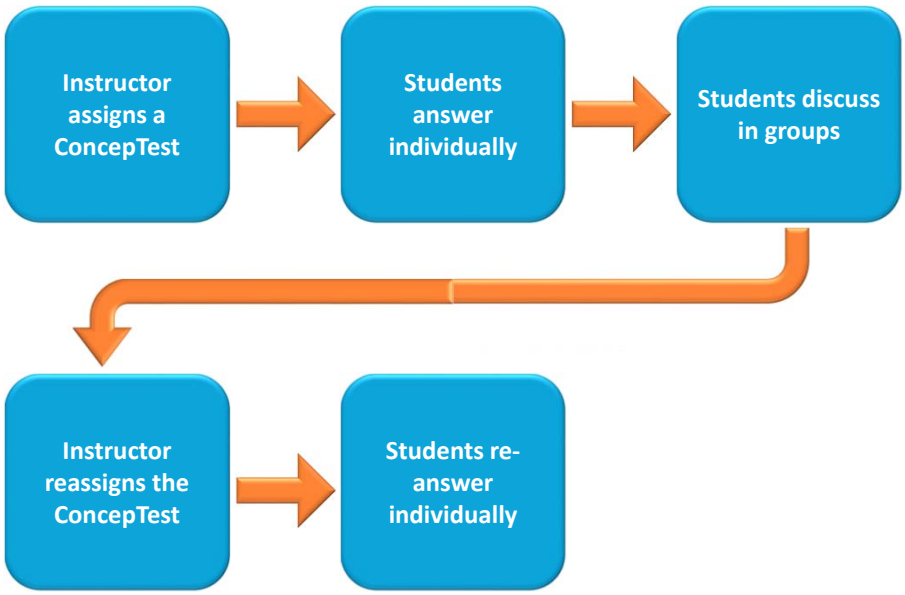

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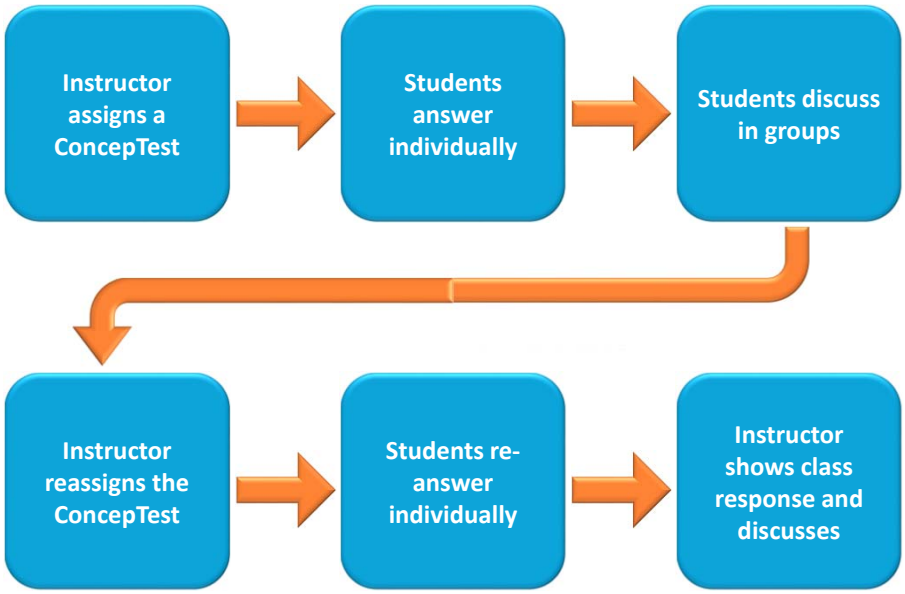


https://www.youtube.com/watch?v=N1KxrTqIu2U

Traditional Lecture vs. Peer Instruction Using the AIChE Concept Warehouse

AIChE Education Division
CONCEPT WAREHOUSE

Reasons to Use ConcepTests & Peer Instruction in your Course

- Students teach/learn from fellow students
  Encourages cooperation
- Results in a more engaged class
  - Students articulate reasoning through written explanations and discussion
  - Students hear alternate explanations
- Students determine how well they understand the material
- Instructor collects feedback from everyone
- Students are motivated to be prepared; class attendance higher

Concept Inventories

Concept Inventories (CIs) are "valid and reliable instruments" i.e., pre-assembled tests meant to help instructors determine the extent of conceptual understanding about specific science or engineering subjects.

- Usually used at the start and end of a term to measure the "learning gains" and compare different instructional designs.
- Each CI is has sets of questions (scales), each constructed around an important concept in the topic.

HOME | CONCEPTESTS | CONCEPT INVENTORIES | INSTRUCTIONAL TOOLS | CLASSES | PROFILE | SUPPORT

ABOUT BROWSE MANAGE INVENTORIES STATISTICS

Back to Browse **Heat and Energy Concept Inventory** Add

OVERVIEW
QUESTIONS
ANSWER KEY
DEVELOPMENT HISTORY
RESEARCH DATA

ID:2366 **HECI 1: 1 of 4**

You would like to melt ice which is at 0°C using hot blocks of metal as an energy source. One option is to use one metal block at a temperature of 200°C and a second option is to use two metal blocks each at a temperature of 100°C. Each individual metal block is made from the same material and has the same mass and surface area. Assume that the heat capacity is not a function of temperature.

If the blocks are placed in identical insulated containers filled with ice water, which option will ultimately melt more ice?
1 Either option will melt the same amount of ice
2 The two 100°C blocks
3 The one 200°C block

ID:2367 **HECI 2: 2 of 4**

Because...
1 2 blocks have twice as much surface area as 1 block so the energy transfer rate will be higher when more blocks are used
2 Using a higher temperature block will melt the ice faster because the larger temperature difference will increase the rate of energy transfer
3 The amount of energy transferred is proportional to the mass of blocks and the change in block temperature during the process
4 The temperature of the hotter block will decrease faster as energy is transferred to the ice water

ID:2368 **HECI 3: 3 of 4**

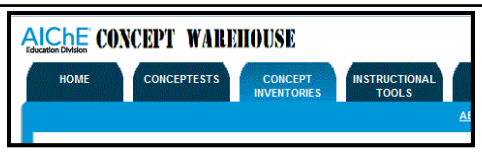
You would like to melt ice which is at 0°C using hot blocks of metal as an energy source. One option is to use one metal block at a temperature of 200°C and a second option is to use

Concept Inventories

The following Concept Inventories (CI) are available:

- Thermodynamics CI (35 items)
- TTCI: Thermodynamics (24 items)
- TTCI: Fluids (26 items)
- Heat and Energy CI (36 items)
- TTCI: Heat Transfer (18 items)
- Materials Science CI (30 items)
- Statistics CI (25 items)
- Dynamics CI (29 items)
- 4 Chemistry CIs (20-31 items)

AIChE Education Division CONCEPT WAREHOUSE



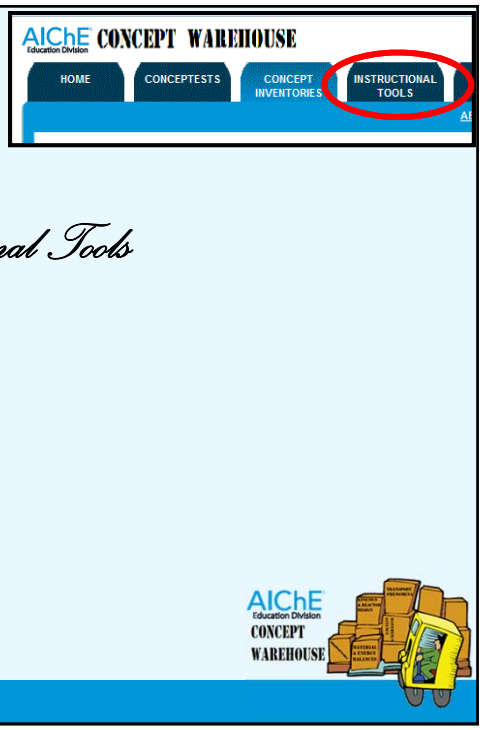
Summary

ConcepTests for formative assessment

ConcepTest: *Comprised of instructor-chosen conceptual questions*

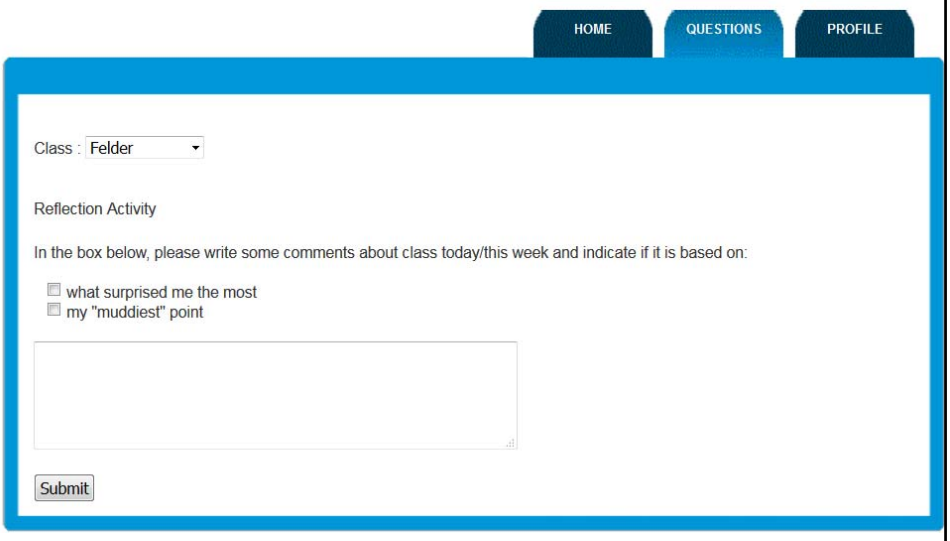
Concept Inventories for summative assessment

Concept Inventory: *Comprised of research-validated conceptual questions designed to assess working knowledge of a subject*



Instructional Tools

Reflection Activities



Sample Responses (01/19/17)

Surprised	The homework taught me that there is no one right way to go about solving a thermodynamics problem. While some ways might be a little more difficult to solve, they are almost always possible no matter how to you choose to start.	HW1
Muddiest	My muddiest point was the homework this week, it was so open ended that it left a lot up to speculation. I would have preferred more guidelines on what was expected.	HW1

Out of 132 responses total

Sample Responses (01/19/17)

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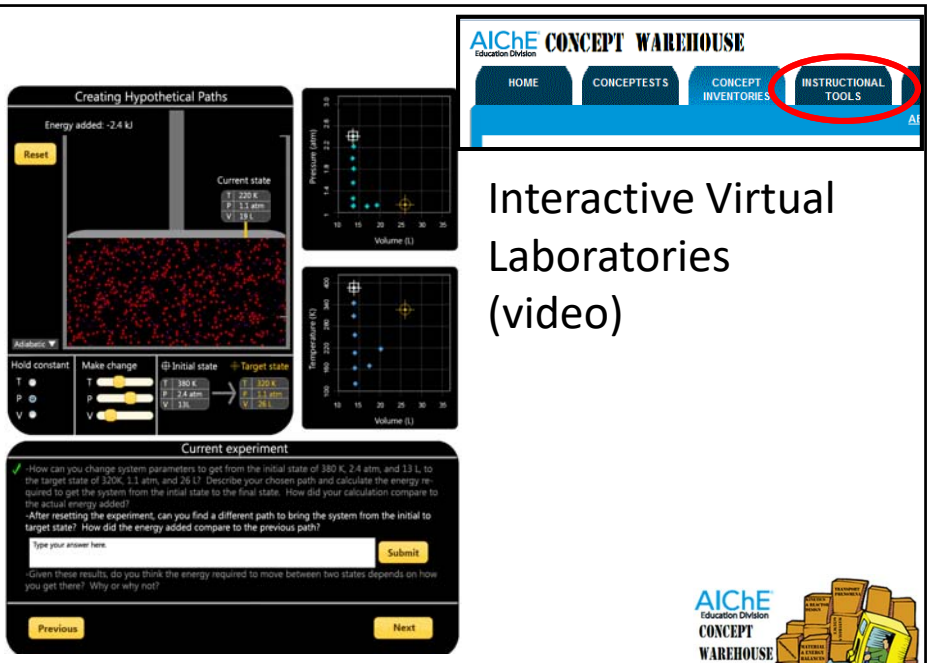
Surprised	I was very surprised that the amount of water required to melt ice is significantly larger in volume.	HW1
Surprised	How beneficial studio learning method is, working in groups in an interactive learning environment made studio very productive. The white boards were a great idea to ensure that everyone participates, especially including different color markers so the TA can tell if someone doesn't participate As for lectures, using concept warehouse helps a lot in understanding the material.	Studio



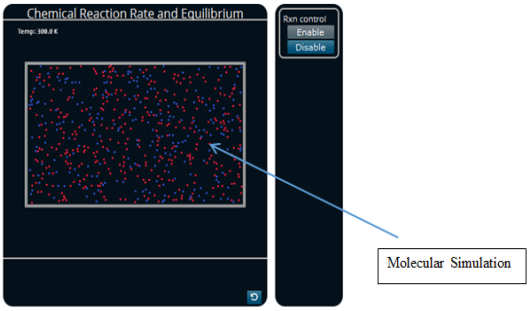
Interactive Virtual Laboratories (video)

IVLs are built around a series of "Frames"

Molecular Simulation

Interactive

Conceptual



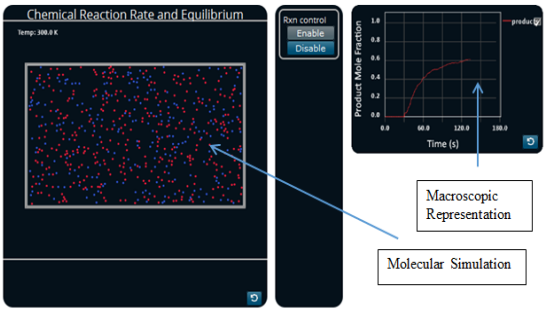
IVLs are built around a series of "Frames"

Molecular Simulation

Interactive
Conceptual

Macroscopic Representation

Graphs
Data



AIChE Education Division CONCEPT WAREHOUSE

IVLs are built around a series of "Frames"

Molecular Simulation

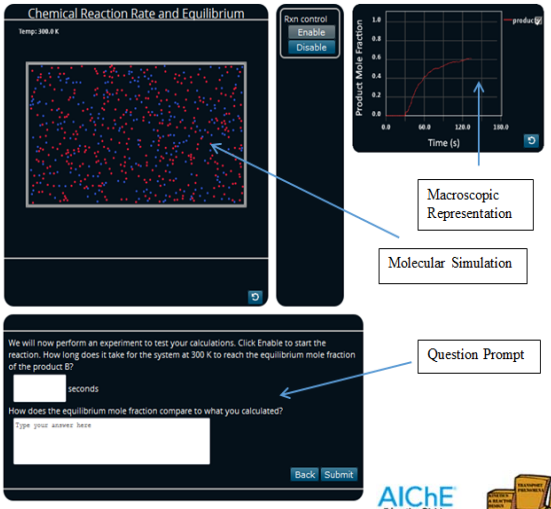
Interactive
Conceptual

Macroscopic Representation

Graphs
Data

Question Prompt

Guided Questions

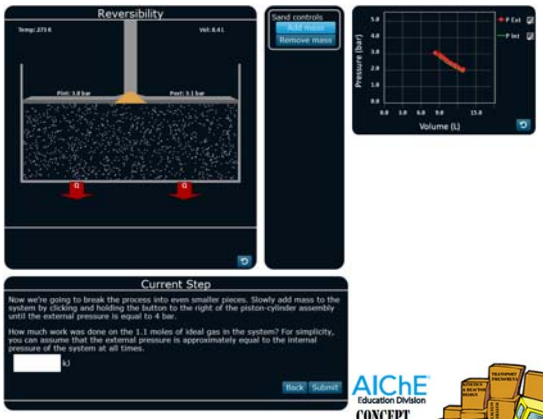


AIChE Education Division CONCEPT WAREHOUSE

Reversibility Interactive Virtual Laboratory

Meyer and Land (2003) define threshold concepts as key concepts required for students to proceed in a subject: Transformative, Irreversible, Integrative, Troublesome

What conditions are necessary for a process to be reversible?



AIChE Education Division CONCEPT WAREHOUSE

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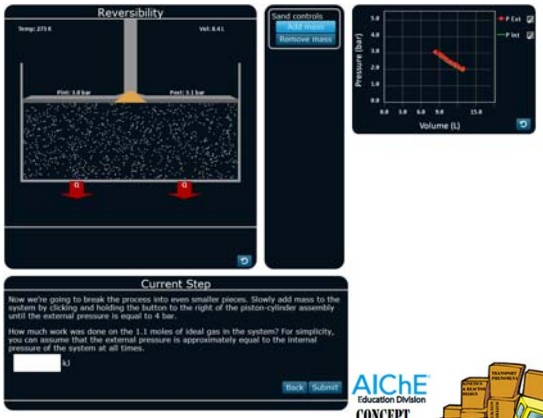
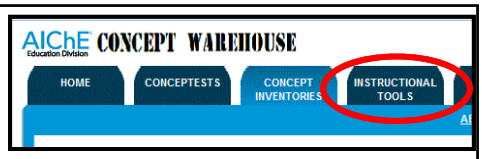
What conditions are necessary for a process to be reversible?

Infinitesimally small changes in driving force (e.g., pressure).



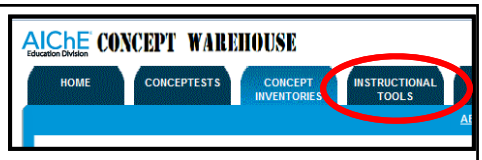
AIChE Education Division CONCEPT WAREHOUSE

Available Interactive Virtual Labs



- *Pv* Work
- Reversibility
- Heat capacity (c_v vs. c_p)
- Hypothetical Paths
  - Chemical Reaction
  - Phase Equilibrium
- Phase Equilibrium
- Reaction Rate and Chemical Equilibrium

Inquiry Based Activities (Bucknell)

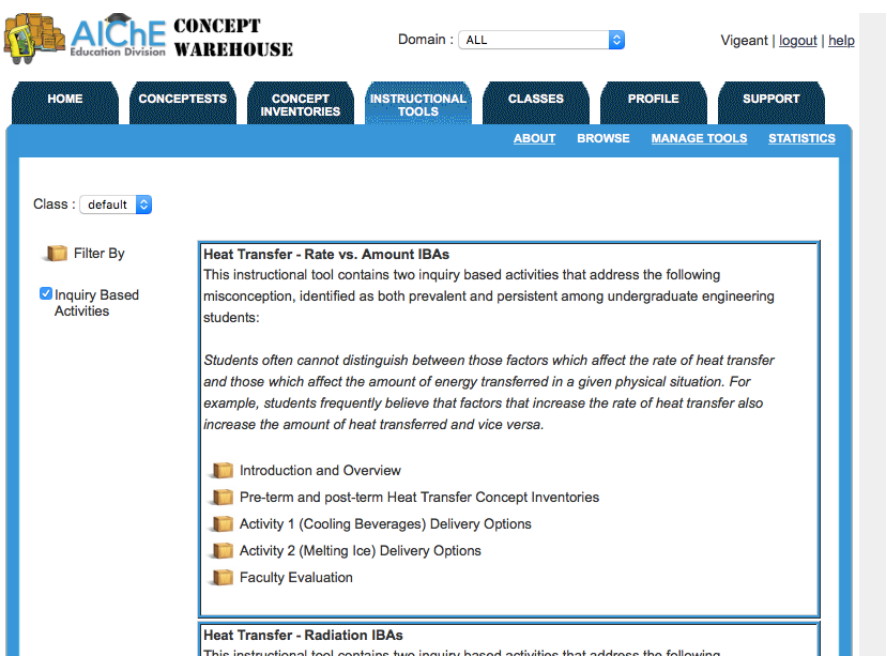


Currently Available for Heat Transfer

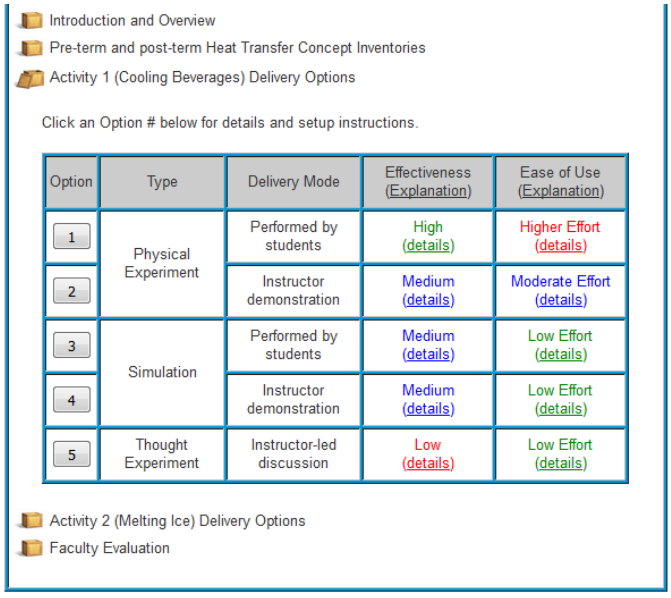
- Rate vs. Amount
- Radiation

5 delivery options available for each activity

(Experiment, Demo, Simulation, DemoSim, & Thought Experiment)



Inquiry Based Activities



Introduction and Overview

Pre-term and post-term Heat Transfer Concept Inventories

Activity 1 (Cooling Beverages) Delivery Options

Click an Option # below for details and setup instructions.

Option	Type	Delivery Mode	Effectiveness (Explanation)	Ease of Use (Explanation)
1	Physical Experiment	Performed by students	High (details)	Higher Effort (details)
2		Instructor demonstration	Medium (details)	Moderate Effort (details)
3	Simulation	Performed by students	Medium (details)	Low Effort (details)
4		Instructor demonstration	Medium (details)	Low Effort (details)
5	Thought Experiment	Instructor-led discussion	Low (details)	Low Effort (details)

Activity 2 (Melting Ice) Delivery Options

Faculty Evaluation

Inquiry Based Activities

Activity 1 (Cooling Beverages) Delivery Options

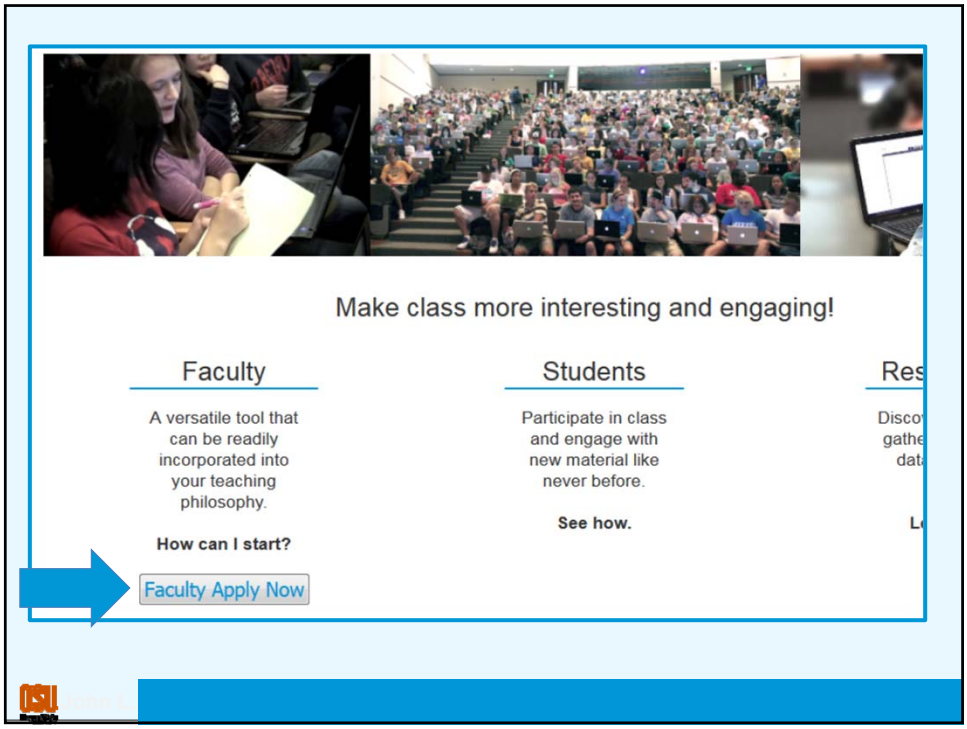
Click an Option # below for details and setup instructions.

Option	Type	Delivery Mode	Effectiveness (Explanation)	Ease of Use (Explanation)
1	Physical Experiment	Performed by students	High (details)	Higher Effort (details)
2		Instructor demonstration	Medium (details)	Moderate Effort (details)
3	Simulation	Performed b students		
4		Instructor demonstratio		
5	Thought Experiment	Instructor-le discussion		

Overall post-test improvement relative to pre-test score:	Normalized gain between 25% and 50%
Post-test improvement relative to control (no activity):	More than 3X the improvement of a typical class
Effect size for post-test improvement relative to pre-test score:	Cohen's d between 0.5 and 1.0

You have Graduated – time to apply for an Instructor Account!

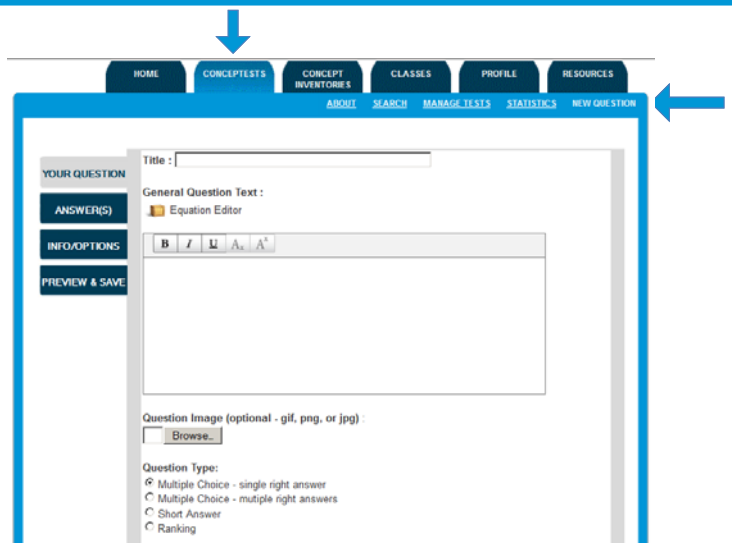
AIChE Education Division CONCEPT WAREHOUSE



Logging in

1. Navigate to http://cw.edudiv.org
2. Click on “Instructor Login” button in the top right corner of the page (shown in Figure 1)
3. Enter your User Name in the “Username” field and your Password in the “Password” field (both shown in Figure 2)

Developing and Entering Questions



Quick start guides available

ADDING A QUESTION TO THE AICHE CONCEPT WAREHOUSE

Page **1** of **8**

1) Navigate to "ConcepTests" main menu tab
2) On the right side of the light blue submenu, click on "New Question." You will be taken to the new question input form. This form has four sections: Your Question, Answer(s), Info/Options, and View & Save. You will be guided through these sections in the following steps. For illustrative purposes, we have chosen a heat transfer question to use as an example throughout this walkthrough. The question, from John Falconer, is shown in Figure 1.

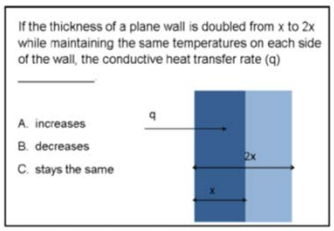
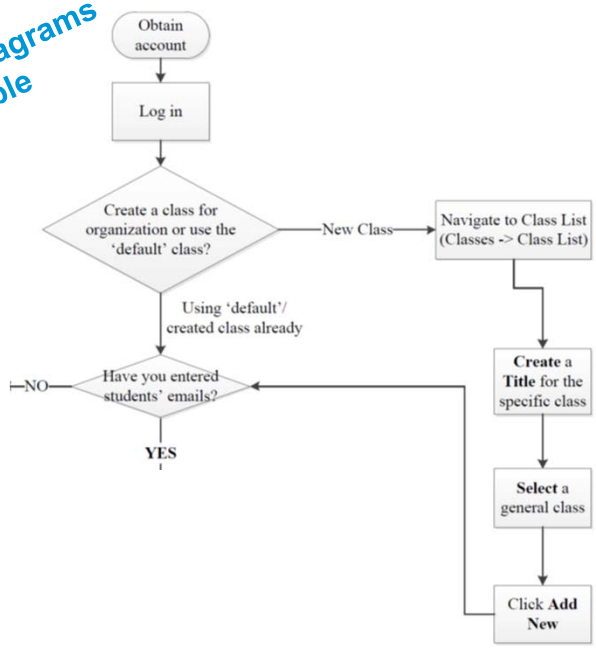


Figure 1. Example question to add to the AIChE Concept Warehouse

Flow diagrams available



Minute Paper

Please write some comments about today's AIChE Education Division webinar.

- What surprised you the most?
- What would you like to learn more about?
- What was unclear?

Collaborators

Student Researchers

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- Mike Prince, Bucknell University
- Brian Self, Cal Poly SLO
- David Silverstein, University of Kentucky
- Margot Vigeant, Bucknell University

- Tom Ekstedt, Programmer
- Beta Testers
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- LL Stewart Scholar Program
- Technology Resource Program

*Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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