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

Homework
**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**

Given $P$
- Step 4
- Step 3
- Step 2
- Step 1
Find $T$

**Exam**

---

**Teaching Problem Solving: Conceptual Approach**

**Example 1**

**TOPIC 1**

Concept $\alpha$
Teaching Problem Solving: Conceptual Approach

**TOPIC 1**

Example 1

Concept α

Concept β

Example 2
Teaching Problem Solving: Conceptual Approach

Example 1

Homework 1

Concept γ

Concept α

Concept β

→ Homework 2

Example 2

TOPIC 1

Exam
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?
Why Concept Based Learning?

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

Students are more likely to develop conceptual understanding when learning through Interactive Engagement (Freeman et al., 2014; Hake, 1998).
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 \( R_3 \)?

• Question 2
When the value of \( R_6 \) increases, the current through \( R_3 \)
\[ \text{______}. \]

A) Increases  B) decreases  C) remains constant?
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 \( R_3 \)?

• 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
Inside the Concept Warehouse

- 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 CO₂ at 2 atm. Nitrogen is injected into the tank. What happens to the partial pressure of CO₂ if it all remains in the tank? Assume ideal gases and an isothermal system.

A. Decreases
B. Increases
C. Stays the same
A constant-volume tank contains CO₂ at 2 atm. Nitrogen is injected into the tank. What happens to the partial pressure of CO₂ if it all remains in the tank? Assume ideal gases and an isothermal system.

13  A. Decreases
32  B. Increases
6   (chance is 17)

Example ConcepTest: What students see when you assign online

Question text:

Plus Figure:

An ideal gas flows steadily through the piping system and valve shown below. The inlet pressure and temperature are P₁ and T₁ and the outlet is after the valve is closed (P₂ and T₂). A schematic of the piping system is shown. A flow of gas is directed from the valve to the vessel and the temperature of the gas increases. What is the relationship of the outlet temperature T₂ to the inlet temperature T₁?

- P₁ > P₂, because work is done on the gas and it is compressed through the valve opening
- T₁ = T₂, because temperature must decrease if pressure decreases since the volume and number of moles both stay the same
- T₁ = T₂, because rapid expansion of an ideal gas does not affect temperature
- Can’t answer exactly the type of gas flowing is specified

Please explain your answer in the box below:

Please rate how confident you are with your answer:

- slightly
- somewhat
- confident

Submit
Example ConcepTest:
What students see when you assign online

Question text:

An ideal gas flows steadily through the piping system and valve shown below. The inlet pressure and temperature are $P_1$ and $T_1$, and the pressure drops through the valve to a lower value, $P_2$.

Assuming the valve is well insulated and all outlet pipes connected to the valve are the same diameter, what is the relationship of the outlet temperature $T_2$ to the inlet temperature $T_1$?

- $T_2 > T_1$ because work is done on the gas and it is compressed through the valve opening
- $T_2 = T_1$ because temperature must decrease if entropy decreases since the volume and number of moles both stay the same
- $T_2 < T_1$ because rapid expansion of an ideal gas does not affect temperature
- Not clear above where the type of gas flowing is specified

Please explain your answer in the box below.

Please rate how confident you are with your answer:

- Substantially more confident
- Moderately more confident
- Substantially less confident
- Moderately less confident
- Not at all confident

Submit

Example ConcepTest:
What students see when you assign online

Question text:

An ideal gas flows steadily through the piping system and valve shown below. The inlet pressure and temperature are $P_1$ and $T_1$, and the pressure drops through the valve to a lower value, $P_2$.

Assuming the valve is well insulated and all outlet pipes connected to the valve are the same diameter, what is the relationship of the outlet temperature $T_2$ to the inlet temperature $T_1$?

- $T_2 > T_1$ because work is done on the gas and it is compressed through the valve opening
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Submit
Example ConcepTest: What students see when you assign online

Question text

Plus Figure

Written Reflection (optional)

Confidence (optional)

Peer Instruction

Instructor assigns a ConcepTest
Instructor assigns a ConceptTest

Students answer individually

Peer Instruction

Instructor assigns a ConceptTest

Students answer individually

Students discuss in groups
Peer Instruction

Instructor assigns a ConceptTest

Students answer individually

Students discuss in groups

Instructor reassigns the ConceptTest

Peer Instruction

Instructor assigns a ConceptTest

Students answer individually

Students discuss in groups

Instructor reassigns the ConceptTest

Students re-answer individually
Peer Instruction

Instructor assigns a ConcepTest → Students answer individually → Students discuss in groups

Instructor reassigns the ConcepTest → Students re-answer individually → Instructor shows class response and discusses

https://www.youtube.com/watch?v=N1KxrTqJu2U

Traditional Lecture vs. Peer Instruction Using the AIChE 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.
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)
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)

<table>
<thead>
<tr>
<th>Surprised</th>
<th>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.</th>
<th>HW1</th>
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<tr>
<td>Muddiest</td>
<td>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.</td>
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Out of 132 responses total
### Sample Responses (01/19/17)

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<tr>
<td>Surprised</td>
<td>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.</td>
<td>Studio</td>
</tr>
</tbody>
</table>
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

**Question Prompt**
- Guided Questions
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?

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

<table>
<thead>
<tr>
<th>Option</th>
<th>Type</th>
<th>Delivery Mode</th>
<th>Effectiveness (Explanation)</th>
<th>Ease of Use (Explanation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Physical Experiment</td>
<td>Performed by students</td>
<td>High (details)</td>
<td>Higher Effort (details)</td>
</tr>
<tr>
<td>2</td>
<td>Instructor demonstration</td>
<td>Performed by students</td>
<td>Medium (details)</td>
<td>Moderate Effort (details)</td>
</tr>
<tr>
<td>3</td>
<td>Simulation</td>
<td>Instructor demonstration</td>
<td>Medium (details)</td>
<td>Low Effort (details)</td>
</tr>
<tr>
<td>4</td>
<td>Thought Experiment</td>
<td>Instructor-led discussion</td>
<td>Low (details)</td>
<td>Low Effort (details)</td>
</tr>
</tbody>
</table>

- Activity 1 (Cooling Beverages) Delivery Options
- Activity 2 (Melting Ice) Delivery Options
- Faculty Evaluation
Inquiry Based Activities

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

1) Navigate to "ConceptTexts" 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.

If the thickness of a plane wall is doubled from \( x \) to \( 2x \) while maintaining the same temperatures on each side of the wall, the conductive heat transfer rate (q)

[Figure 1: Example question to add to the AICHE Concept Warehouse]

Page 1 of 8
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
Debra Gilbuena, PostDoc
Bill Brooks, PostDoc
Christina Smith, PhD
Kritsa Chinandon, PhD
Alec Bowen, HBS
Rachel White, BS
Daniel Reid, BS
Matt Boggess, BS
Cole Morgan, BS
Matt Kirsch, BS

Faculty
John Falconer, University of Colorado
Adam Higgins, Oregon State University
Steve Krause, Arizona State University
Carl Lira, Michigan State University
Marina Miletic, Miletic Educational Consulting
Ron Miller, Colorado School of Mines
Mike Prince, Bucknell University
Brian Self, Cal Poly SLO
David Silverstein, University of Kentucky
Margot Vigeant, Bucknell University

• Tom Ekstedt, Programmer
• Beta Testers
• The developing community who has contributed to and used the Concept Warehouse

Acknowledgements

• National Science Foundation
  • DUE - 1023099, 1022957, 1022875, 1022785
  • DUE - 1245482,
  • DUE - 1225456 (Krause Lead)
  • DUE - 1225221 (Vigeant Lead).

• 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.
http://cw.edudiv.org