EFFECTIVE TEACHING PRACTICES AND ASSESSMENT STRATEGIES THAT PROMOTE LEARNING IN UNDERGRADUATE BIOCHEMISTRY

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A little about me

With a little help from my friends...

Seattle University
- Jennifer Loertscher

University of South Florida
- Jennifer Lewis
- Sachel Villafañe
Starting from Outcomes

“Only when we grasp the logic required by a focus on student understanding and performance as opposed to the logic of content will we see how nonpurposeful and ineffective traditional curricula have been.”


Teaching to Outcomes

Assessing Outcomes

Design Teaching Strategy to Outcomes

Formative Assessment

Adjust Instruction—Just in Time Teaching

Revise Teaching Strategy

Summative Assessment

Revise Assessment

Collect Validity Evidence and Revise

Administer Assessment
Teaching and Assessment are Linked

Design Teaching Strategy-to Outcomes
Formative Assessment
Adjust Instruction-Just in Time Teaching
Revise Teaching Strategy

Summative Assessment
Design Assessment based on Outcomes
Collect Validity Evidence and Revise
Revise Assessment
Administer Assessment

Some Useful Definitions

- **Formative Assessment**
  - Not associated with a grade or score
  - Used to provide feedback in order to improve performance

- **Summative Assessment**
  - Associated with a grade or score
  - While the opportunity to improve is there, the evaluation has been made.

Outcome- Example

- **OUTCOME**: Students should be able to use the principles of chemical structure (polarity and non-covalent interactions etc.) to predict the effects different interactions have on enzyme inhibition.
Teaching to Outcomes

- Use Pre/post test data—prior knowledge
- Formative Assessment
- Adjust Instruction—Just in Time Teaching
- Revise Teaching Strategy
- Summative Assessment
- Design Teaching Strategy—to Outcomes

Prior knowledge influences learning

Fish is Fish by Leo Leoni

- What do we know about student prior knowledge?
- How can we learn more?
Instrument Design – A Community Effort

- Over 40 faculty were involved in
  - Identifying concepts to be included
  - Writing and revising test questions
  - Administering the test and providing feedback
  - Changing instructional approaches based on test results


Instrument to Assess Prior Knowledge

- 21 question multiple choice test to be administered as a pre and posttest
- Community of experts and education literature were used to identify concepts from prerequisite courses that are important for learning in biochemistry

Concepts Included in Instrument

- Bond energy
- pH/pKa
- Free energy
- Hydrogen bonding
- Equilibrium
- Structure of protein α helix
- Consequence of mutation on protein function
**Most Recent Data**

- Test administered in Fall 2011
- Nine institutions
- 446 students
- Scores out of 21 questions

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<th>Posttest Mean</th>
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**Common Incorrect Ideas**

- Concepts | Most common incorrect “idea” chosen by students
- Hydrogen Bonding | A covalent bond with hydrogen is a hydrogen bond.
- Enthalpy | Breaking an individual bond releases energy.
- α Helix Structure | R-groups of amino acids points towards the inside of the α helix.
- Energy | The free energy change for a process indicates whether or not the process releases heat and if the reaction proceeds quickly.

**Fish is Fish … Biochem is Biochem**

- Image of a fish structure with biological components.
Teaching to Outcomes

- Use Pre/post test data—prior knowledge
- Use active learning

Our Classroom – POGIL Biochemistry

- Process Oriented Guided Inquiry Learning
  - Guided inquiry activities help students achieve content learning outcomes.
  - Classroom structure helps students develop transferrable skills including teamwork, problem solving and critical reflection.

POGIL Course Structure

POGIL Instructional Materials

- Set of 36 activities intended to be used in place of lecture
  - Macromolecular structure and function
  - Metabolism

Outcome- Example

- OUTCOME: Students should be able to use the principles of chemical structure (polarity and non-covalent interactions etc.) to predict the effects different interactions have on enzyme inhibition.

Teaching to Outcomes

- Use Pre/post test data—prior knowledge
- Use active learning
- Review fundamental interactions in several contexts
- Explore enzyme inhibition
- Interpretation enzyme inhibition data
- Identify chemical features of good inhibitors
- Predict additional inhibitors
Teaching to Outcomes

- Design Teaching Strategy to Outcomes
- Formative Assessment
- Summative Assessment
- Revise Teaching Strategy

- This is real time assessment to improve performance
- Examples are clickers, monitoring student’s work, reporting out responses to entire class

Teaching to Outcomes

- Design Teaching Strategy to Outcomes
- Formative Assessment
- Summative Assessment
- Revise Teaching Strategy

- Just in Time Teaching
- Propose additional question or problems

Teaching to Outcomes

- Design Teaching Strategy to Outcomes
- Formative Assessment
- Summative Assessment
- Revise Teaching Strategy

- Exams
- Homework
- Other graded work
Teaching to Outcomes

- Reflect on success of strategy in light of formative and summative assessments
- Design improvements to instruction

See “Creating a Facilitation Plan”

Assessing Outcomes

OUTCOMES: Students should be able to use the principles of chemical structure (polarity and non-covalent interactions) to predict the effects different interactions have on enzyme inhibition.
Research Goal-Biochemistry Assessment

As part of our NSF grant

- Provide a model for documentation for specific students learning outcomes in biochemistry.
- Generate a stable instrument to measure higher order thinking

Assessing Outcomes

- Must apply content in NEW context
- High Bloom’s level-question -- thinking and reasoning to assess skill development in ability to apply and integrate concepts

- Must work for large classes
- Must allow for free response
- Detailed rubric must support question scoring
Assessing Outcomes

- **Content**
  - **PROTEIN STRUCTURE:**
    - Binding of a protein to kidney tissue
    - A cartoon drawing is provided
  - **ENZYME INHIBITION:**
    - ID₅₀ data values are provided
    - Structures of inhibitors provided

Assessing Outcomes

- **Structure**
  - Questions 1-5 assure that students understand the model in the question
  - Questions 6-10 address higher order questions and problem solving

Assessing Outcomes

- **Content validity**
  - Question content and format validity-faculty
  - Question content and format validity-students
  - Rubric content and format validity-faculty
Assessing Outcomes

- Question included on final exams or midterms
- 7 institutions used the assessment, 193 students
- Exams copied and sent to us
- Responses scored by two independent faculty

Embedded question went through the cycle three times before it was deemed acceptable.
- 18 faculty evaluated Bloom’s level of questions

RESULTS

- Questions 1-5 are determining if the model in the question has been understood.
- Low Bloom’s level
  - Saturable binding
  - 4 true/false questions about meaning of ID_{50}
RESULTS Question 1-5

CONCLUSIONS Q:1-5

- The majority of students understood the new context of the problem

RESULTS Questions 6-8

- Question 6a asks students to agree with a prediction about the pI of the binding protein from the ID₅₀ data.
  - Choices are true, false or not enough information
  - 37% answered correctly

- Question 6b students justify their 6a selection
RESULTS Questions 6-8

- Question 7 - structural characteristics of a good inhibitor
  - 57% used the data effectively
  - 38% received partial
RESULTS Questions 6-8

- Question 8a, 8b ask students to make statements about structural features of the binding site

- 51% and 64% earned full credit for 8a and 8b
- 18% and 16% earned partial credit for 8a and 8b

Results of Questions 6-8:

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<tr>
<td>Q6a</td>
<td>Q6b</td>
<td>Q7</td>
</tr>
<tr>
<td>Q8a</td>
<td>Q8b</td>
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</table>

Use of Student Data to Inform Instruction

- Free responses give instructor insight into persistent incorrect or incomplete ideas on molecular characteristics that govern protein structure and binding events.
- The question on pI revealed not all students thinking in an integrated manner.
A Community-based process was used

- Concepts to be covered
- Content and format to be used
- Testing the instrument in classrooms
- Developing and piloting the rubric
- Revising the instrument and rubric after classroom piloting

Study Conclusions

- An iterative, community-based process successfully created a stable instrument to measure understanding of protein structure and inhibition.
- Working with a community of faculty to create common resources can boost productivity and quality of materials.

Implications of Research

- It takes a lot to change misconceptions or incomplete knowledge that students bring to biochemistry
- An instructor cannot address misconceptions without knowing them
  - Pre/posttest
  - Homework and exams
  - Interaction with students in the classroom or laboratory
  - Reflective assignments
  - Specially-designed embedded question to measure understanding of biochemistry concepts
Thanks!

- Biochemistry students
- Cheryl Bailey, Bob Bateman, Theresa Beaty, Danielle Cass, Adam Cassano, Calleen Conway, Cheryl Coolidge, Melanie Cooper, Kathleen Cornely, John Dawson, Elizabeth Darland, Michele Dubois, Shari Dunham, Stephen Dunham, Matthew Fisher, Pamela Hay, Tim Hoyes, Bruce Heyen, Pamela Higgins, Thomas Holmes, Anne Kruchten, Michael Klymkowski, Julie Lively, Ashley Mahoney, Sunil Malapati, Larry Martin, David Merkle, Tracey Murray, Terry Platt, Robert Potter, Charlotte Pratt, Christine Renes, Joner Schattel, John Shabb, Jeffrey Signan, Kathy Sukukki, Andy Thomas, Carin Thoma, David Thores, David Vosburg, Linette Watkins, Harold White, Susan White, Adele Wolfson

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