Using technology to improve problem-solving skills and flip classroom learning in organic chemistry:

Problem-Solving through Think-Alouds

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(Organic chemistry class sizes 25-50, 3x50 min lectures, no 4th hour)
The issues……

**Problem Solving**
- Students think memorization is an effective way to solve complex problems and have difficulties when they are presented with new, related problems.
- Students solve problems by attempting to mimic text book examples where mistakes or alternative solutions are not always valued or illustrated.
- Focus is usually on the refined end product of problem-solving, written solutions.
- Generally, a holistic process for problem solving is not explicitly taught!

**Time**
- We don’t have enough time to adequately cover content and discuss problem solving in class
My goal

- To explicitly focus on problem solving and the problem solving process in organic chemistry
  - Actively teach problem solving process
  - Spend more time analyzing problem solving and the problem solving process in class activities and as homework assignments

- Use technology
  - to flip classroom learning (hybrid classroom) so I have more time in class to achieve these goals
  - Study the process
Targeting problem solving: The PENS project
(Problem-solving Examples with Narration for Students)

- NSF TUES grant
- Physics, Chemistry, Mathematics, and School of Ed.
- The PENS project is creating and assessing instructional materials that target problem-solving.
- Instead of focusing solely on solutions, students are instructed on how to focus explicitly on the problem solving process, with particular attention paid to self-regulation.
- Instructors and students will record think-alouds
- Integrate analysis into class activities to assist students in actively learning and reflecting on how to problem solve through the analysis and interpretation of these recordings
Think-alouds

- Think-alouds can help to make the internal problem-solving process explicit.

- Berardi-Coletta showed that with targeted instruction, verbalization led to more effective problem-solving.

- Verbalization helps students become aware of their thought process, thereby improving their ability to identify and correct own errors.

ACE Problem Solving Process

- Analyze the task: interpret and understand what is provided in the task.
- Create a plan: connect the given information and goal with models/concepts/relationships
- Execute the plan: follow the plan until the goal is attained
3 Types of think-alouds

- **Expert created**
  - Answer keys, example problems
  - Pre-lecture videos – flipped learning [level 1]

- **Student created**
  - Highly dependent on level of students
  - Two types of assignments:
    1. Student created/student observed: students watch other students’ think-alouds to evaluate and reflect on the problem solving process (can be right or wrong) [level 2]
    2. Student created/instructor observed: students create pencasts and instructor provides feedback on content and problem solving process [level 3]
The Technology

1. **Expert think-alouds [level 1]**
   - Students watch these videos before they come to class (1-2 times per week) and answer a few questions about the assignment to demonstrate basic understanding.
   - In class, we review the assignment and cover more complicated examples.

2. **Student created [levels 2 and 3]**
   - Use student created think-alouds as homework and to discuss the problem solving process in class.
Use Doceri for pre-lecture videos (expert think-alouds)

- Doceri app and software
  - Free (but includes watermarks)
  - Software - $30
  - iPad App - $5
- Can use iPad as white board to draw and annotate
- Can annotate over computer screen (through wifi)
- Video capture incorporated into app
- Implement 1-2 times per week (~15 min)
Livescribe pens technology

- Students use Livescribe smartpens to record and share think-alouds (pencasts).
- Livescribe pens record audio and pen strokes in real time.
- Can be emailed, replayed in notebook, on computers, tablets, and smartphone
- I assign pencasts as HW each week
  - **Level 2**: students must watch, reflect, and correct student created pencasts or
  - **Level 3**: create their own pencasts for instructor feedback
Comparing Technologies

**Used for expert think-alouds**

The good:
- Software Free (not iPad)
- Multicolored text/drawing
- Can rewind (correct errors)
- Video capture built-in

The bad:
- Need an iPad
- Longer upload times

**Used for student think-alouds**

The good:
- Relatively inexpensive ($100)
- Easy to share
- Faster uploads

The bad:
- Proprietary file format (or pdf)
- Graphics issues when drawing over previous drawing
- No color options
Implementation of the 3 Types of think-alouds

**Level 1. Expert created (1-2 times per week)**
- Pre-lecture videos – flipped learning

**Level 2. Students watch other students’ pencasts as HW (1 time week)**
- Pencasts can be correct or incorrect, have “good” or “bad” problem solving
- Evaluate and reflect on correctness and the problem solving process (HW and in-class activities) [rubric]
  
**Level 3. Students create think-alouds, submit to instructor, and receive feedback (every other week)**
- Students pick own problems to submit (encourage difficult problems)
- Instructor provides feedback on content and problem solving process – individualized feedback
- “Forced office hours”
Implementation: Organic Chemistry I (2 sections)

Measure effect of flipped learning [level 1] and impact of student viewed pencast HW assignments [level 2]

1. **2012 - Section 1:**
   - Incorporated pre-lecture videos (flipped learning) [level 1] and watching and analyzing pencast think-alouds as HW [level 2]

2. **2012 - Section 2:**
   - Incorporated pre-lecture videos (flipped learning) [level 1] and online HW

3. **2011:** just online HW

(Actively taught problem solving process in both sections 2012)
Exam Performance - Organic Chemistry I

Average Score

- EXAM 1
- EXAM 2
- Exam 3
- Exam 4

- 2012 - phase 1 and 2
- 2012 - phase 1
- 2011 control
Implementation: Organic Chemistry 2 (1 sections)

Measure effect of flipped learning [level 1] and impact of student created/instructor viewed HW assignments [level 3]

1. 2013 - Section 1:
   - Incorporated pre-lecture videos (flipped learning) [level 1] and recording pencast think-alouds as HW [level 3]

2. 2011: just online HW

   (Actively taught problem solving process in 2013 section)
Exam Performance - Organic Chemistry 2

Exam 1

- Spring 2013: 75
- Spring 2011: 70
- Spring 2011 (2): 65

Exam 2

- Spring 2013: 90
- Spring 2011: 65
- Spring 2011 (2): 60

Average Score
Assessment Tools

• Pre/post surveys and test
  • Survey of Scientific & Learning Beliefs
  • Scientific reasoning test (cognitive skills)

• During/after the course
  • End of course survey
  • Content: Common exams / questions

• Critical Thinking Assessment Test (TennesseeTech. Univ.)
Summary: Lessons learned

- Level 1: Student viewed expert created think-alouds (flipping)
  - Students find these extremely useful
  - Allowed more time in class to focus on problem solving
  - **Full day of working problems before exams results in gains**

- Level 2: Students view authentic student think-alouds (correct and incorrect)
  - Students mixed on effectiveness
  - No significance
  - **Challenging to get effective pencasts that target every student**

- Students need practice and feedback to generate effective, authentic pencasts

- Level 3: Students create pencasts, instructor provides feedback
  - Students mixed on effectiveness
  - Very time consuming – hard to scale/maintain (peer to peer?)
  - Tool for online courses?
Acknowledgements

- NSF
- Jeff Phillips, Thomas Zachariah, Katharine Clemmer, and Joe Russo
- LMU iPEP project

For more information on our PENS Project:
- Visit http://www.pensproject.com
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