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

Problem-Solving through Think-Alouds

Jeremy McCallum
Department of Chemistry and Biochemistry
Loyola Marymount University, Los Angeles, CA

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

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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

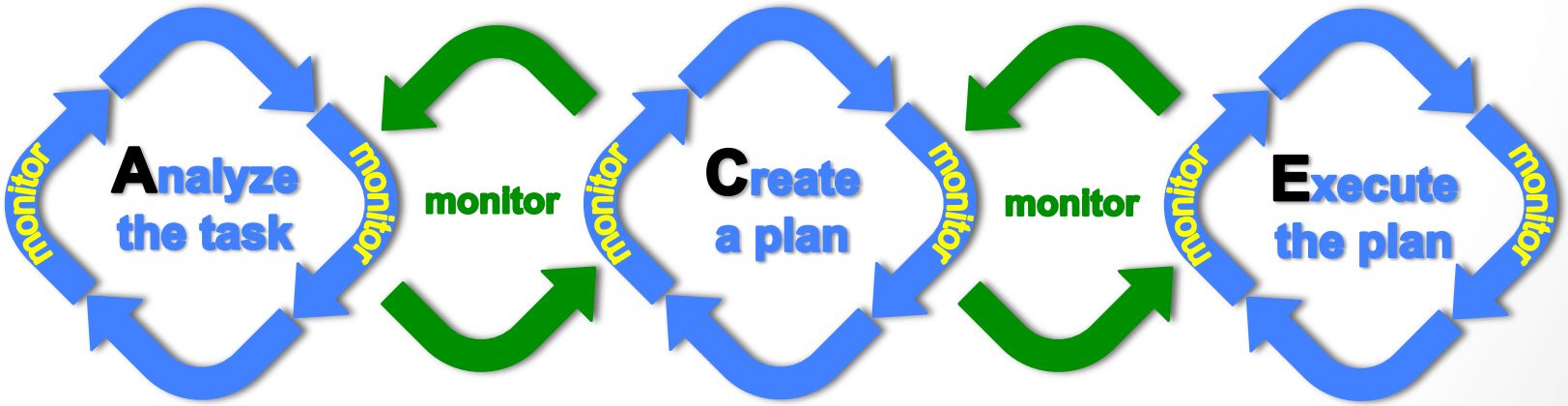
Think-alouds

- 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.

Berardi-Coletta, B., Dominowski, R. L., Buyer, L. S., & Rellinger, E. R. (1995). *Metacognition and problem solving: A process-oriented approach*. Journal of Experimental Psychology: Learning, Memory, and Cognition, **21**, 205-223.

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 **[level1]**
   - 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.

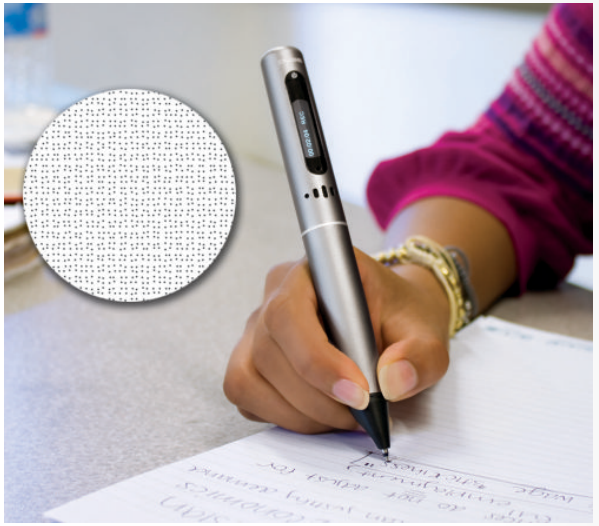
2. Student created **[levels 2 and 3]**
   - Use student created think-alouds as homework and to discuss the problem solving process in class

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]

< or >

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)

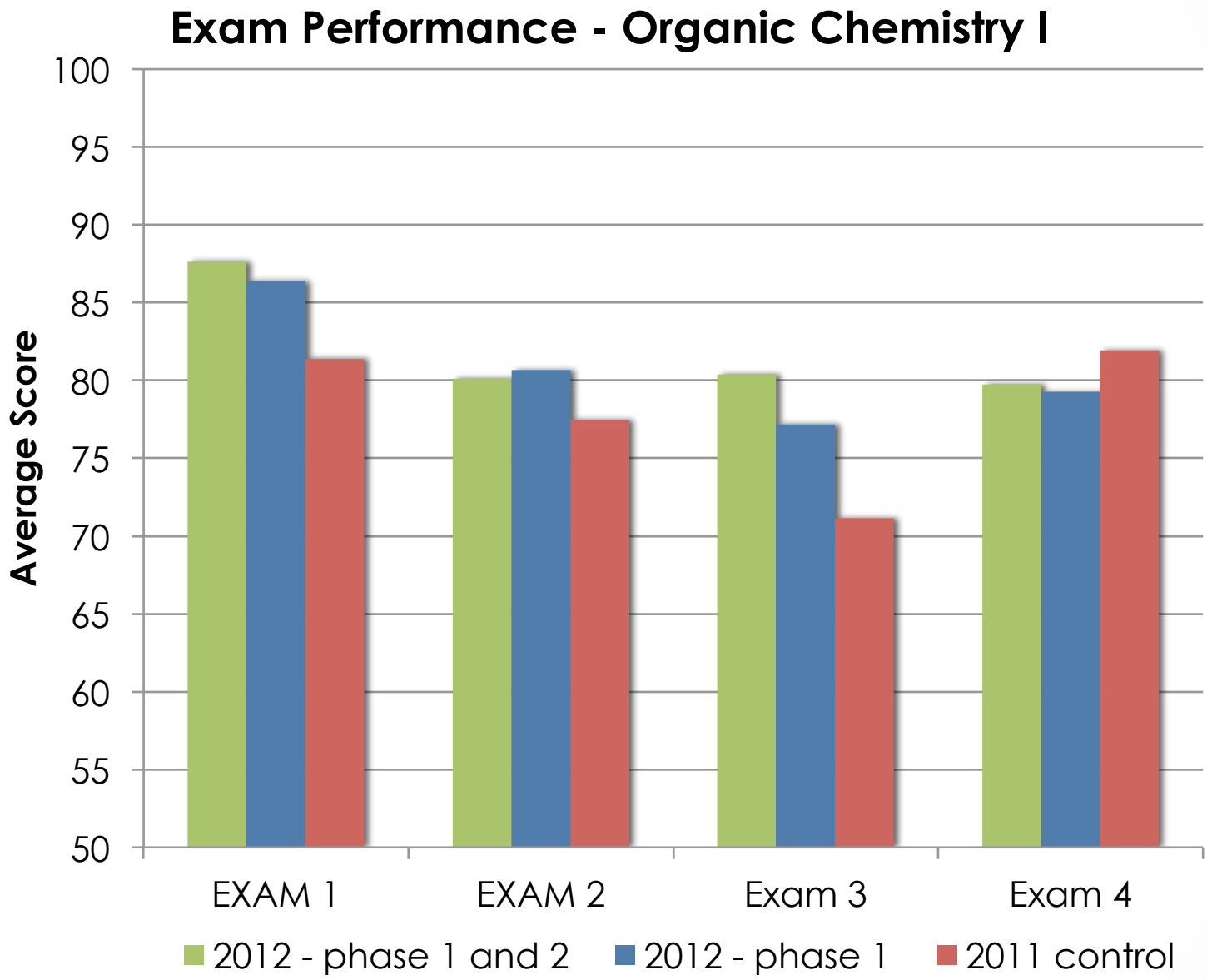
Measure effect of flipped learning [level 1] and impact of student viewed pencast HW assignments [level 2]

1. 2012 - Section 1:
   - Incorporated pre-lecture videos (flipped learning) [level1] 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
100
95
90
85
80
75
70
65
60
55
50
EXAM 1
EXAM 2
Exam 3
Exam 4
2012 - phase 1 and 2
2012 - phase 1
2011 control

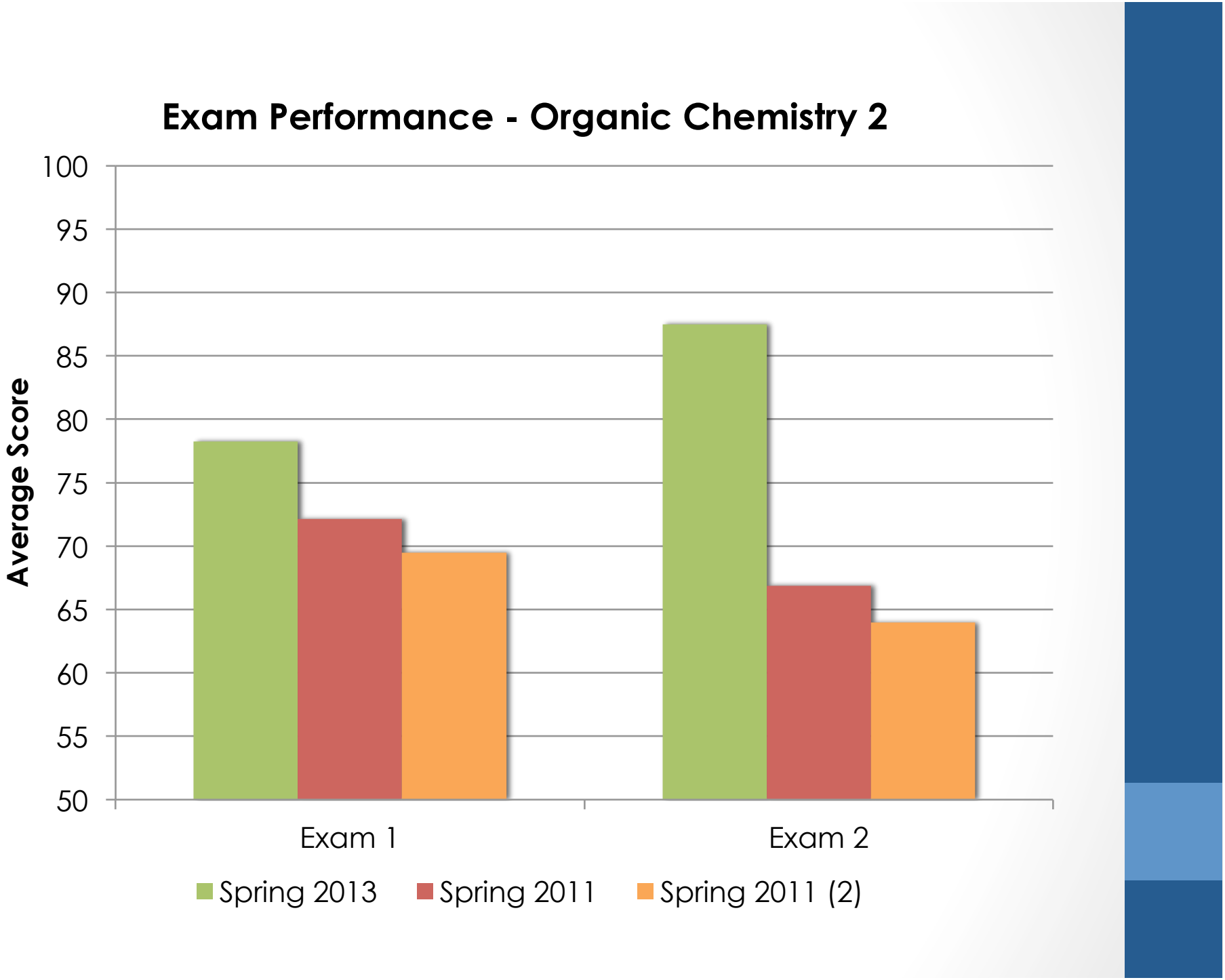
Implementation: Organic Chemistry 2 (1 sections)

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
Average Score
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80
75
70
65
60
55
50
Exam 1
Exam 2
Spring 2013
Spring 2011
Spring 2011 (2)

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
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- For more information on our PENS Project:
  - Visit http://www.pensproject.com
  - Email:
    - Jeremy.McCallum@lmu.edu

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