How do we use research on teaching and learning to influence our teaching?

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Some problems you see?

- Students “check out” during class
  - Not paying attention
  - On cell phones
- Don’t study notes or read textbook from one class to the next
- Only interested in getting the answer (or good grade), not in understanding
- Don’t know how to logically answer a question or problem
Any others?
What is chemical education research?

- A bridge between
  - Problems we see in student learning
    - And
  - What we know about how the brain operates
Chemical Education Research

- Investigate real issues from the classroom involving learning and teaching

- Why bother?
  - Well informed and executed research should lead to new insights
    - Won’t always definitively answer the question asked
      - May lead to other research
Some things that we know about Learning

- Brain has a limited short term memory
  - Experts maximize use of this space by chunking their knowledge
  - Novices are limited by the parameters of the brain
    - Extend space by offloading knowledge
      - Write things down
How do we exceed our students’ short term memory?

Two examples of “cognitive overload”

- Provide continuous stream of new information
  - Without providing time for students to integrate new knowledge with previous knowledge
  - Need time
    - To write it down
    - Integrate
    - Ask questions or test their understanding

- Ask questions or problems with extraneous information
  - Before students have experience analyzing them
What is happening in Cognitive Overload?

- **Short term memory**
  - Involves incoming information
    - Ex. Lecture or reading problem description
  - Retrieval of pertinent information from long term memory
  - Provides space and time for the integration of the incoming and stored information

- **Information provided after capacity is exceeded**
  - Is not processed
Overload in Lecture

- Professor prepares well structured lecture with demos
  - How long can students pay attention?
    - 50 minutes?
- Experiment to investigate how long students pay attention in class
Methodology


- Three general chemistry courses:
  - Chem (I) Engineering Majors
  - Chem (II) Nursing Majors
  - Chem (III) Nonscience Majors

- Clickers keyed to computer in back of room
  - Students clicked when they noticed their attention had lapsed
  - Teacher’s activity noted every 30 sec on same computer

- Student attention data and teaching activity integrated.

- Data collected for 6 weeks (initial 2 weeks not analyzed).
During 10 min Lecture Segment

- Chem (I) Engineering
  - Purple line
- Chem (II) Nursing
  - Black line
  - Significant
- Chem (III) Nonscience Major
  - Red line

Similarity in peaks of attention lapses
- 0 → 0.50 min
- 4.5 → 5.5 min
- 7 → 8 min
- 9 → 10 min
Common declines of attention in lecture reported over time for three courses.

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Comparison of Initial 10 min lecture to Second 10 min lecture after
- Demonstration
- Clicker Question/Discussion

Results
- Significantly fewer attention lapses compared to initial lecture for two nonlecture segments
  - Clicker ($F_{1,67} = 26.71$, $p=0.000$)
  - Demonstration ($F_{1,86} = 7.22$, $p=0.009$)
- No significant difference in effect on lecture between the interactive pedagogies
  - Clicker ($F_{1,66} = 8.70$, $p=0.004$)
  - Demonstration ($F_{1,64} = 4.25$, $p=0.043$)
Summary

Teaching Outcome

- Even when lecture lasts only 10 min
  - Student attention lapses exist
- Student–active pedagogies (clicker or demonstration) kept students engaged more than lecture
- Benefit of student–active pedagogies persists into the next 10 min lecture

Theoretical Reason

- Students have time to integrate new knowledge with stored knowledge in short term memory during the “break” in lecture (clicker or demo)
How can we engage students in lecture?

- Provide opportunities for audience to engage with material
  - Work on a problem alone or in groups
  - Report out results using classroom software
  - Use clicker questions to test their understanding

- Why does this work? (Cognitive psychology)
  - If people are held personally accountable, they will engage
    - Involve people’s ego, and they will stay engaged.
What other types of questions can Chemical Education Research address?

- Look at structure of course
  - Decide what works and what doesn’t work and why
  - US Naval Academy Case Study
    - Use of study resources and study approaches used by Plebes (Freshmen) in General Chemistry
Population

- 1015 freshman enrolled in General Chemistry for Science Majors (Fall 2013)

- 28 different instructors
  - Teach 2–3 sections of lecture and lab
    - 20 students per section
    - No teaching assistants

- Course design
  - One syllabus
  - One Textbook
  - Common multiple choice exams administered
    - 6–weeks, 12–weeks, final exam
Teaching/Learning at USNA

- No time in class to address learning needs of students of different achievement levels

- Students have little study time outside of class

- Many students appear to succeed based on
  - Test-taking skills
  - Math ability
  - Memorization

- Deep understanding of chemistry not always evident in students
Current learning resources for students

- Help on demand from instructor outside of class (EI)
- Resource room staffed by instructors 5 days a week till 3 PM
- Upper classmen–run study sessions at night
  - Midshipman Group Study Program—MGSP
- Prior common exams and answer keys posted on departmental website
- On-line HW available for review after grading
- College–Wide Academic Center offers free
  - Non–credit help classes
  - Group tutoring
  - Tutoring on demand
Need for something more…

- Research Question
- How can teachers encourage deeper understanding vs. memorization of chemistry?
  - Do the learning resources used by students and the way they use them foster understanding or memorizing chemistry?
Break research question into smaller questions that can be investigated

- What are students doing?
  - Do students match the resource used to the type of test?
  - Is there a difference among students of differing achievement levels in the resources they choose?
  - How do students use the resource they choose?
Proposed Outcome of Research

- Results should help teachers determine
  - what they can do to help students emphasize understanding over memorization
  - Which study resources are used primarily by which group of students
Group of 5 chemistry instructors plus one in–residence chemical education researcher

- Survey developed, implemented, analyzed
  - Administered online to 1015 students who were encouraged to voluntarily answer it
    - Asked students what resource(s) they used to study
  - Administered 4 times during semester
    - After two common exams (multiple–choice questions) and two instructor–written exams (any type of question)

- 57 students volunteered to be interviewed after third survey
  - Asked to describe the
    - resource chosen and how they used it
  - Interviews
    - Validate researchers’ interpretation of survey
    - Expand interpretation of results
Survey Data—4 Administrations

First instructor assessment

- Web: 2.5%
- Personal help: 14.3%
- Study guide: 7.0%
- Notes: 41.0%
- Prior assessments: 15.4%
- Labs: 0.7%
- Online Homework: 6.1%

Six-week common Exam

- Web: 1.7%
- Personal help: 19.2%
- Study guide: 5.5%
- Notes: 21.0%
- Prior assessments: 46.4%
- Online Homework: 1.0%
- Textbook: 5.2%

Twelve-week common exam

- Web: 1.0%
- Personal help: 11.8%
- Study guide: 4.2%
- Notes: 17.0%
- Prior assessments: 54.3%
- Online Homework: 4.2%
- Textbook: 7.5%

Last instructor assessment

- Web: 0.5%
- Personal help: 14.8%
- Study guide: 8.7%
- Notes: 33.9%
- Prior assessments: 22.4%
- Online Homework: 10.9%
- Textbook: 8.7%

Most common resources

1. Prior Assessments
2. Notes
3. Personal Help
4. Textbook
Research Question: Do students match the resource used to the type of test?

- Students choose different learning resources depending on the type of exam
  - **Instructor-written**
    - Any format
      - Use notes, prior assessments and personal help
  - **Common exams**
    - Multiple choice only
      - Use prior assessments, notes, and personal help

- Pattern appears stable across semester
Research Question: Do students of different achievement levels use different resources to study?

- Achievement levels set by final course grade
  - A/B
  - C
  - D/F

- Breakdown of resource used by achievement level for each of the 4 exams
  - 1st instructor exam
  - 6-wk common exam
  - 12-week common exam
  - 2nd instructor exam
Choice of Main Study Method by Achievement

First instructor assessment

Six–week common exam

Twelve–week common exam

Last instructor assessment

Prior Assessments
Notes
Personal Help
Results

- A/B and C students choose more appropriate study resources for tests throughout semester
  - Instructor exam: notes
  - Common exam: prior assessment
- C students rely less on personal help and more on independent learning resources as the semester progresses.
- D/F students change to more appropriate resources as semester progresses slower than other grade groups
  - Continue to rely on personal help more than other students
Research Question
How did students use resources?

- Interviews
  - Quotes dealing with
    - Use of prior assessments for common exams
Interview Comments – Prior Assessments

“A/B” student
- “That’s (prior assessment) usually the very first thing that I do because then you know what you really need to study and what you don’t really need to study ... I used that to direct where my studying will go.”

“C” Student
- “…Anything I got wrong (on prior assessment), I went back and looked and say ok what did I do wrong and if I still didn't understand, I went and got help from a classmate .... ”

“D” Student
- “Just go through (prior assessment) and see if there are any huge concepts that I didn't cover.”
Second Research Question
How do students use study resources?

Study Approaches

- **Deep Approach** emphasizes
  - relating ideas
  - comprehension
  - logically using evidence to arrive at an answer

- **Surface Approach** emphasizes
  - rote memorization of unrelated information
  - demonstrates lack of purpose
  - fear of failure
Do students’ study approaches, regardless of which resource they choose, differ by their achievement level in the course?
A study skills inventory, based on the literature, modified to better match teaching situation at the Naval Academy

- Modified Approaches and Study Skill Inventory for Students (MASSIST)
  - 31 questions
    - 7 questions referring to Deep Approach to studying
    - 6 questions for Surface Approach
### Selected Deep Approach Items

**Q2:** I go over the work I’ve done carefully to check the reasoning and that it makes sense.

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<th>Agree somewhat</th>
<th>Unsure</th>
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<td>C</td>
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<td>71%</td>
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**Q18:** Before starting work on an assignment or exam question, I think first how best to tackle it.

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**Q23:** Before tackling a problem or assignment, I first try to work out what lies behind it.

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<th></th>
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<td>C</td>
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<td>D/F</td>
<td>52%</td>
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**Response**
- **Agree**
- **Agree somewhat**
- **Unsure**
- **Disagree somewhat**
- **Disagree**
Selected Surface Approach Items

Q3: Often I feel I’m drowning in the sheer amount of material we’re having to cope with.

- A/B: 34% Agree, 16% Agree somewhat, 9% Unsure, 12% Disagree somewhat, 49% Disagree
- C: 60% Agree, 18% Agree somewhat, 12% Unsure, 9% Disagree somewhat, 22% Disagree
- D/F: 79% Agree, 13% Agree somewhat, 9% Unsure, 9% Disagree somewhat, 9% Disagree

Q9: Much of what I’m studying in this course makes little sense: it’s like unrelated bits and pieces.

- A/B: 17% Agree, 9% Agree somewhat, 12% Unsure, 17% Disagree somewhat, 75% Disagree
- C: 35% Agree, 17% Agree somewhat, 13% Unsure, 17% Disagree somewhat, 48% Disagree
- D/F: 61% Agree, 13% Agree somewhat, 13% Unsure, 13% Disagree somewhat, 26% Disagree

Q24: I often have trouble in making sense of the things I have to remember.

- A/B: 29% Agree, 15% Agree somewhat, 15% Unsure, 9% Disagree somewhat, 55% Disagree
- C: 57% Agree, 20% Agree somewhat, 20% Unsure, 9% Disagree somewhat, 23% Disagree
- D/F: 74% Agree, 9% Agree somewhat, 9% Unsure, 9% Disagree somewhat, 17% Disagree

Response: Agree, Agree somewhat, Unsure, Disagree somewhat, Disagree
Analysis
Differences in response to Deep Approach Questions by achievement levels
- Little overlap in Deep study approaches between A and D/F students

- C students act more like D/F students
Analysis
Differences in response to Surface Approach Questions by achievement levels
No overlap in use of Surface approaches by all three achievement levels

- C students are in between A/B and D/F students in their use of Surface approaches
What did we learn?

- Lower ability students (D/F) seek help more often from resources that have a person available to help them.
  - C students demonstrate intermediate behavior
    - use personal help more often than A/B students and less than D/F students

- Higher ability students (A/B) primarily employ Deep approaches to learning
  - D/F use Surface Approaches
  - C students use both Deep and Surface approaches
Interpretation

- When D/F students come for personal help, they should be helped to
  - Answer their immediate questions
  - Increase their metacognition (being aware of what they know and what they don’t know)
  - Learn the meaning of the concepts involved and how they fit together
C students are in transition in their approach to studying between surface and deep. They should be encouraged to

- Look beyond an answer to understanding the underlying concept
- Integrate new knowledge with knowledge they already have
- Be more metacognitive
  - Aware of what they know and what they don’t know
Overall Results

- Developed answers to questions that were important to teachers through discipline-based research

- Engaged teachers in thinking about classroom problems as
  - Cognitive psychology questions regarding
    - How learning takes place
    - How different approaches to learning manifest themselves in student behavior
    - What teachers can do to help move students to a higher learning approach
What does Chemical Education Research offer?

- More insight into how students learn
  - With implications for how we can better match our teaching practices to student learning

- Investigation of how resources are used by students beyond counting # of uses

- An experimental approach to teaching and learning that is based on data and theories
  - Not unlike traditional science approaches
Thanks

- Dr. Charles Atwood

My research collaborators
  - Paying attention in Lecture
    - Dr. Kelly Neiles
    - Ms. Elizabeth Flens
  - USNA study
    - Dr. Regis Komperda
    - Dr. Debra Dillner
    - Dr. Maria Schroeder
    - Dr. Shirley Lin
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