Prepare Students for the Challenges of Research: Teach Them *How* to Learn!

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Why is Research Challenging?

It requires many skills in different domains

- **Cognitive - Thinking Skills**
  - Information Processing
  - Problem Solving

- **Affective – Attitudes and Feelings**
  - Confidence
  - Curiosity
  - Enthusiasm

- **Psychomotor – manual or physical skills**
  - Performing Laboratory Procedures
  - Handling Instruments
Cognitive Skills Needed for Research*

- Deep and broad knowledge base
- Ability to read, comprehend, and evaluate research literature
- Ability to critically evaluate experiments and results
- Creativity and Imagination
- Ability to interpret and question data
- Ability to pose questions and propose studies to answer the questions

*From survey of LSU research mentors, March 2008
But many students have not developed these abilities.

But they can develop them if we...

- Teach students *how* to learn
- Help them develop the right mindset
Metacognition: The Key to Improving Cognitive Skills

The ability to:

- think about one’s own thinking
- be consciously aware of oneself as a problem solver
- monitor, plan, and control one’s mental processing (e.g. “Am I understanding this material, or just memorizing it?”)
- accurately judge one’s level of learning

Why haven’t most students developed metacognitive skills?
According to data from the entering class of 2011...*

- **It wasn’t necessary in high school**
  - 60.5% of 2011 (down from 63% in 2010) entering first year students spent less than six hours per week doing homework in 12th grade.
  - 49.7% of these students said they graduated from high school with an “A” average.*

- **Students’ confidence level is high**
  - 70.9% believe their academic ability is above average or in the highest 10 percent among people their age

*2011 Higher Education Research Institute Study
Help students identify and close “the gap”

- **current behavior** ➔ **current results**

- **productive behavior** ➔ **desired results**

Faculty Must Help Students Make the Transition to College
Reflection Questions

• What’s the difference, if any, between *studying* and *learning*?

• For which task would you work harder?
  A. Make an A on the test
  B. Teach the material to the class
The Story of Two Students

- **Travis**, *junior psychology student*
  - 47, 52, **82, 86**  
    - B in course

- **Dana**, *first year physics student*
  - 80, 54, **91, 97, 90 (final)**  
    - A in course
Problem: Reading Comprehension

Solution: Preview text before reading*
Develop questions*
Read one paragraph at a time and paraphrase information

*Develop anticipatory set
WITH HOCKED GEMS FINANCING HIM/ OUR HERO BRAVELY DEFINED ALL SCORNFUL LAUGHTER/ THAT TRIED TO PREVENT HIS SCHEME/ YOUR EYES DECEIVE/ HE HAD SAID/ AN EGG/ NOT A TABLE/ CORRECTLY TYPifies THIS UNEXPLORED PLANET/ NOW THREE STURDY SISTERS SOUGHT PROOF/ FORGING ALONG SOMETIMES THROUGH CALM VASTNESS/ YET MORE OFTEN OVER TURBULENT PEAKS AND VALLEYS/ DAYS BECAME WEEKS/ AS MANY DOUBTERS SPREAD FEARFUL RUMORS ABOUT THE EDGE/ AT LAST/ FROM NOWHERE/ WELCOME WINGED CREATURES APPEARED/ SIGNIFYING MOMENTOUS SUCCESS

Anticipatory set CAN interfere!

Let’s look at the car on the next slide...
Is this a 2-door or 4-door car?
Dana, first year physics student
80, 54, 91, 97, 90 (final)

Problem: Memorizing formulas and using www.cramster.com

Solution: Solve problems with no external aids and test mastery of concepts
Why the Fast and Dramatic Increase?

It’s all about the strategies, and getting them to engage their brains!
Counting Vowels in 45 seconds

How accurate are you?

Count all the vowels in the words on the next slide.
Dollar Bill
Dice
Tricycle
Four-leaf Clover
Hand
Six-Pack
Seven-Up
Octopus
Cat Lives
Bowling Pins
Football Team
Dozen Eggs
Unlucky Friday
Valentine’s Day
Quarter Hour
How many *words* or *phrases* do you remember?
Let’s look at the words again...

What are they arranged according to?
| Dollar Bill | Cat Lives          |
|            |                   |
| Dice       | Bowling Pins      |
| Tricycle   | Football Team     |
| Four-leaf Clover | Dozen Eggs    |
| Hand       | Unlucky Friday    |
| Six-Pack   | Valentine’s Day   |
| Seven-Up   | Quarter Hour      |
| Octopus    |                   |
NOW, how many words or phrases do you remember?
What were two major differences between the two attempts?

1. We knew what the task was

2. We knew how the information was organized
What we know about learning

• Active learning is more lasting than passive learning
  -- Passive learning is an oxymoron*

• Thinking about thinking is important
  – Metacognition**

• The level at which learning occurs is important
  – Bloom’s Taxonomy***

Bloom’s Taxonomy

Anderson & Krathwohl, 2001

Bloom’s Taxonomy

- **Remembering**: Retrieving, recognizing, and recalling relevant knowledge from long-term memory.
- **Understanding**: Constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.
- **Applying**: Carrying out or using a procedure through executing, or implementing.
- **Analyzing**: Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure.
- **Evaluating**: Making judgments based on criteria and standards through checking and critiquing.
- **Creating**: Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing.

This pyramid depicts the different levels of thinking we use when learning. Notice how each level builds on the foundation that precedes it. It is required that we learn the lower levels before we can effectively use the skills above.

http://www.odu.edu/educ/lischt/blooms_taxonomy.htm
When we teach students about Bloom’s Taxonomy...

They GET it!
At what level of Bloom’s did you have to operate to make A’s or B’s in high school?

1. Knowledge
2. Comprehension
3. Application
4. Analysis
5. Synthesis
6. Evaluation
At what level of Bloom’s did you have to operate to make A’s or B’s in high school?

1. Knowledge
2. Comprehension
3. Application
4. Analysis
5. Synthesis
6. Evaluation
How students answered (in 2008)

At what level of Bloom’s do you think you’ll need to be to make an A in Chem 1201?

1. Knowledge
2. Comprehension
3. Application
4. Analysis
5. Synthesis
6. Evaluation
How students answered (in 2013)

At what level of Bloom’s do you think you’ll need to be to make an A in Chem 1201?

1. Knowledge
2. Comprehension
3. Application
4. Analysis
5. Synthesis
6. Evaluation
How do we teach students to move higher on Bloom’s Taxonomy?

Teach them the Study Cycle*

*adapted from Frank Christ’s PLRS system
**The Study Cycle**

**Preview**

*Preview before class* – Skim the chapter, note headings and boldface words, review summaries and chapter objectives, and come up with questions you’d like the lecture to answer for you.

**Attend**

*Attend class* – GO TO CLASS! Answer and ask questions and take meaningful notes.

**Review**

*Review after class* – As soon after class as possible, read notes, fill in gaps and note any questions.

**Study**

*Study* – Repetition is the key. Ask questions such as ‘why’, ‘how’, and ‘what if’.

- Intense Study Sessions* - 3-5 short study sessions per day
- Weekend Review – Read notes and material from the week to make connections

**Assess**

*Assess your Learning* – Periodically perform reality checks

- Am I using study methods that are effective?
- Do I understand the material enough to teach it to others?

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**Intense Study Sessions**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Set a Goal</td>
<td>1-2 min</td>
<td>Decide what you want to accomplish in your study session</td>
</tr>
<tr>
<td>2</td>
<td>Study with Focus</td>
<td>30-50 min</td>
<td>Interact with material - organize, concept map, summarize, process, re-read, fill-in notes, reflect, etc.</td>
</tr>
<tr>
<td>3</td>
<td>Reward Yourself</td>
<td>10-15 min</td>
<td>Take a break – call a friend, play a short game, get a snack</td>
</tr>
<tr>
<td>4</td>
<td>Review</td>
<td>5 min</td>
<td>Go over what you just studied</td>
</tr>
</tbody>
</table>

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Center for Academic Success
B-31 Coates Hall • 225.578.2872 • www.cas.lsu.edu
Concept maps can develop ability to think critically

And there are many different forms of concept maps
Chapter/Paper Map

Title of Chapter/Paper

Primary Headings

Subheadings

Secondary Subheadings
Compare and Contrast

Thermodynamic Control

How are they similar?

How are they different?

Kinetic Control
Help Students Develop the Right Mindset


**Mindset** is Important!

- **Fixed Intelligence Mindset**
  Intelligence is static
  You have a certain amount of it

- **Growth Intelligence Mindset**
  Intelligence can be developed
  You can grow it with actions

New York: Random House Publishing
### Responses to Many Situations are Based on Mindset

<table>
<thead>
<tr>
<th></th>
<th>Fixed Intelligence Mindset Response</th>
<th>Growth Intelligence Mindset Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Challenges</td>
<td>Avoid</td>
<td>Embrace</td>
</tr>
<tr>
<td>Obstacles</td>
<td>Give up easily</td>
<td>Persist</td>
</tr>
<tr>
<td>Tasks requiring effort</td>
<td>Fruitless to Try</td>
<td>Path to mastery</td>
</tr>
<tr>
<td>Criticism</td>
<td>Ignore it</td>
<td>Learn from it</td>
</tr>
<tr>
<td>Success of Others</td>
<td>Threatening</td>
<td>Inspirational</td>
</tr>
</tbody>
</table>
Email from a Spring 2011 Chem 1201 student

“…Personally, I am not so good at chemistry and unfortunately, at this point my grade for that class is reflecting exactly that. I am emailing you inquiring about a possibility of you tutoring me.”

April 6, 2011

“I made a 68, 50, (50), 87, 87, and a 97 on my final. I ended up earning a 90 (A) in the course, but I started with a 60 (D). I think what I did different was make sidenotes in each chapter and as I progressed onto the next chapter I was able to refer to these notes. I would say that in chemistry everything builds from the previous topic.

May 13, 2011

Semester GPA: 3.8
What happens when we teach metacognitive learning strategies, Bloom’s Taxonomy, and the Study Cycle to an entire class, not just individuals?
Performance in Gen Chem I in 2011
Based on One Learning Strategies Session

<table>
<thead>
<tr>
<th></th>
<th>Attended</th>
<th>Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam 1 Avg.:</td>
<td>71.65%</td>
<td>70.45%</td>
</tr>
<tr>
<td>Exam 2 Avg.:</td>
<td>77.18%</td>
<td>68.90%</td>
</tr>
<tr>
<td>Final course Avg:</td>
<td>81.60%</td>
<td>70.43%</td>
</tr>
<tr>
<td><strong>Final Course Grade:</strong></td>
<td><strong>B</strong></td>
<td><strong>C</strong></td>
</tr>
</tbody>
</table>

The one 50-min presentation on study and learning strategies resulted in an improvement of one full letter grade!
Metacognition: An Effective Tool to Promote Success in College Science Learning*

Ninfeng Zhao¹, Jeffrey Wardeska¹, Saundra McGuire², Elzbieta Cook²

¹Department of Chemistry, East Tennessee State University
²Department of Chemistry, Louisiana State University

*Accepted for publication April 2013
Sharing Strategies that Have Worked for Others Can Be Very Motivational
Before and After

- Robert, freshman chemistry student
  42, **100, 100, 100** A in course
- Michael, senior pre-med organic student
  30, 28, **80, 91** B in course
- Miriam, freshman calculus student
  37.5, **83, 93** B in course
- Ifeanyi, sophomore thermodynamics student
  67, 54, 68, **95** B in course
- Terrence, junior Bio Engineering student
  GPA 1.67 cum, **3.54** (F 03), 3.8 (S 04)
Top 5 Reasons Folks Did Not Do Well on Test 1 in General Chemistry*

1. Didn’t spend enough time on the material
2. Started the homework too late
3. Didn’t memorize the information I needed to memorize
4. Did not use the book
5. Assumed I understood information that I had read and re-read, but had not applied

*McGuire’s Survey of General Chemistry Students
Top 5 Reasons Students Made an A on Test 1:

1. Did preview-review for every class
2. Did a little of the homework at a time
3. Used the book and did the suggested problems
4. Made flashcards of the information to be memorized
5. Practiced explaining the information to others
At the end of a 60 minute learning strategies presentation by the professor, students were given a survey to determine their self-assessment of whether they were using or not using the strategies. The average scores of the different groups on the first two exams are shown below.

<table>
<thead>
<tr>
<th>Reported Use of Strategies</th>
<th>Exam 1</th>
<th>Exam 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did not use the strategies</td>
<td>58</td>
<td>54</td>
</tr>
<tr>
<td>Used metacognitive strategies</td>
<td>95</td>
<td>80</td>
</tr>
</tbody>
</table>
Cognitive Skills Needed for Research*

- Deep and broad knowledge base
- Ability to read, comprehend, and evaluate research literature
- Ability to critically evaluate experiments and results
- Creativity and Imagination
- Ability to interpret and question data
- Ability to pose questions and propose studies to answer the questions

*From survey of LSU research mentors, March 2008
Top 5 Reasons Students Flounder in Research Environments*

1. Don’t spend enough time understanding the basic science
2. Don’t critically read research papers
3. Are operating at lower levels of Bloom’s
4. Don’t accurately predict the amount of time needed for experiments
5. Have a fixed intelligence mentality and avoid challenges, expend minimal effort, and give up when things get difficult

*McGuire’s observations
Top 5 Reasons Students Excel in Research Environments

1. Review and **master the basics**
2. **Understand how their project fits into the larger research picture** in their field
3. Operate at the **higher levels of Bloom’s**
4. **Understand the “culture”** of the group and of the greater research community
5. Have a **growth intelligence mindset** and embrace challenges, expend effort, and persist through difficulties
<table>
<thead>
<tr>
<th>Date</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/04</td>
<td>Failed</td>
</tr>
<tr>
<td>10/04</td>
<td>Failed</td>
</tr>
<tr>
<td>11/04</td>
<td>Failed</td>
</tr>
<tr>
<td>12/04</td>
<td>Failed</td>
</tr>
<tr>
<td>1/05</td>
<td>Passed</td>
</tr>
<tr>
<td>2/05</td>
<td>Failed</td>
</tr>
<tr>
<td>3/05</td>
<td>Failed</td>
</tr>
<tr>
<td>4/05</td>
<td>Failed</td>
</tr>
<tr>
<td>5/05</td>
<td>N/A</td>
</tr>
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<tbody>
<tr>
<td>10/05</td>
<td>Passed</td>
</tr>
<tr>
<td>11/05</td>
<td>Failed</td>
</tr>
<tr>
<td>12/05</td>
<td>Passed best in group</td>
</tr>
<tr>
<td>1/06</td>
<td>Passed</td>
</tr>
<tr>
<td>2/06</td>
<td>Passed</td>
</tr>
<tr>
<td>3/06</td>
<td>Failed</td>
</tr>
<tr>
<td>4/06</td>
<td>Passed last one!</td>
</tr>
<tr>
<td>5/06</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Began work with CAS and the Writing Center in October 2005.
Dr. Algernon Kelley, December 2009
Oct. 17, 2011

Hello Dr. Kelley. ... I am struggling at Xavier and I REALLY want to succeed, but everything I've tried seems to end with a "decent" grade. I'm not the type of person that settles for decent. What you preached during the time you were in Dr. Privett's class last week is still ringing in my head. I really want to know how you were able to do really well even despite your circumstances growing up. I was hoping you could mentor me and guide me down the path that will help me realize my true potential while here at Xavier. Honestly I want to do what you did, but I seriously can't find a way how to. Can I please set up a meeting with you as soon as you’re available so I can learn how to get a handle grades and classes?

Oct. 24, 2011

Hey Dr. Kelley, I made an 84 on my chemistry exam (compared to the 56 on my first one) using your method for 2 days (without prior intense studying). Thanks for pointing me in the right direction. I’ll come by your office Friday and talk to you about the test.

Nov 3, 2011

Hey Dr. Kelley! I have increased my Bio exam grade from a 76% to a 91.5% using your system. Ever since I started your study cycle program, my grades have significantly improved. I have honestly gained a sense of hope and confidence here at Xavier. My family and I are really grateful that you have taken time to get me back on track.
Teaching and Learning Strategies That Work

SCIENCE, VOL 325
4 SEPTEMBER 2009
www.sciencemag.org

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\(^2\)Center for Academic Success and Department of Chemistry, Louisiana State University, Baton Rouge, LA 70803, USA.
Excellent Resource for Students

We can significantly increase students’ preparation for research!

- We must teach students the learning process and provide specific strategies.
- We must not judge student potential on initial performance.
- We must encourage students to persist in the face of initial failure.
- We must encourage the use of metacognitive tools.
Special Note

Please visit the CAS website at www.cas.lsu.edu. We have on-line workshops that will introduce you and your students to effective metacognitive strategies. Please feel free to contact me at smcgui1@lsu.edu.

Have fun teaching your students powerful metacognitive strategies!

Saundra McGuire
Useful Websites

- www.cas.lsu.edu
- www.howtostudy.org
- www.vark-learn.com
- www.drearlbloch.com
- Searches on www.google.com
Additional References


*Excellent student reference*