Metacognition: The Key to Improving Brain-Based Learning

Saundra Yancy McGuire, Ph.D.
Asst. Vice Chancellor for Learning, Teaching, & Retention
Professor, Department of Chemistry
Past Director, Center for Academic Success
Fellow, American Chemical Society & AAAS

2011 Lilly Conference
Desired outcomes

• We will understand why students spend little time studying and do not know how to learn
• We will have concrete learning strategies that faculty can teach students to increase learning, and we will be committed to trying them
• We will have more resources for our students
• We will view our students differently
• We will see positive changes in our students’ performance and self-perception
• We will spend time reflecting on improving our teaching and our students’ learning
Metacognition

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 don’t most students know how to learn or how to study?
According to data from the entering class of 2010...

• *It wasn’t necessary in high school*
  - 63% of 2010 entering first year students spent less than six hours per week doing homework in 12th grade.
  - More than 48% of these students said they graduated from high school with an “A” average.

• *Students’ confidence level is high*
  - 71.2% believe their academic ability is above average or in the highest 10 percent among people their age

*2010 Higher Education Research Institute Study*
How do you think most students would answer the following?

- What did most of your teachers in high school do the \textit{day before the test}?

- What did they \textit{do} during this activity?

- What grade would you have made on the test if you had gone to class \textit{only} on the day before the test?
Faculty Must Help Students Make the Transition to College

Help students identify and close “the gap”

**current behavior** → **current grades**

**MIND THE GAP**

**efficacious behavior** → **desired grades**
Reflection Questions

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

• For which task would you study more?
  A. Make an A on the test
  B. Teach the material to the class
Turn Students into Expert Learners:

Teach Them Metacognitive Learning Strategies!
The Story of Three Students

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

- **Maryam**, first year art student
  57, **87**
  B in course

- **Dana**, first year physics student
  80, 54, **91, 97, 90 (final)**
  A in course
<table>
<thead>
<tr>
<th>Course</th>
<th>Grade</th>
<th>Hrs Carried</th>
<th>Hrs Earned</th>
<th>Qual Pts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>A</td>
<td>3.00</td>
<td>3.00</td>
<td>12.00</td>
</tr>
<tr>
<td>Comp Sci</td>
<td>A</td>
<td>3.00</td>
<td>3.00</td>
<td>12.00</td>
</tr>
<tr>
<td>Math</td>
<td>A</td>
<td>4.00</td>
<td>4.00</td>
<td>16.00</td>
</tr>
<tr>
<td>Med. Phys</td>
<td>A</td>
<td>3.00</td>
<td>3.00</td>
<td>12.00</td>
</tr>
<tr>
<td>Mechanics</td>
<td>A</td>
<td>3.00</td>
<td>3.00</td>
<td>12.00</td>
</tr>
</tbody>
</table>

Cumulative GPA: 3.88
# Dana’s Fall 2010 Grades

## Courses

<table>
<thead>
<tr>
<th>Dept</th>
<th>Course</th>
<th>Grade</th>
<th>Hrs Carried</th>
<th>Hrs Earned</th>
<th>Qual Pts</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL</td>
<td>1202</td>
<td>B</td>
<td>3.00</td>
<td>3.00</td>
<td>9.00</td>
</tr>
<tr>
<td>CHEM</td>
<td>1201</td>
<td>A</td>
<td>3.00</td>
<td>3.00</td>
<td>12.00</td>
</tr>
<tr>
<td>KIN</td>
<td>2500</td>
<td>B</td>
<td>3.00</td>
<td>4.00</td>
<td>9.00</td>
</tr>
<tr>
<td>PHYS</td>
<td>2231</td>
<td>B</td>
<td>3.00</td>
<td>3.00</td>
<td>9.00</td>
</tr>
<tr>
<td>PHYS</td>
<td>2411</td>
<td>A</td>
<td>3.00</td>
<td>3.00</td>
<td>12.00</td>
</tr>
</tbody>
</table>

**Semester GPA: 3.4**
## Dana’s Spring 2011 Grades

### Courses

<table>
<thead>
<tr>
<th>Dept</th>
<th>Course</th>
<th>Grade</th>
<th>Hrs Carried</th>
<th>Hrs Earned</th>
<th>Qual Pts</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL</td>
<td>2160</td>
<td>A</td>
<td>3.00</td>
<td>3.00</td>
<td>12.00</td>
</tr>
<tr>
<td>CHEM</td>
<td>1202</td>
<td>A</td>
<td>3.00</td>
<td>3.00</td>
<td>12.00</td>
</tr>
<tr>
<td>CHEM</td>
<td>1212</td>
<td>A</td>
<td>2.00</td>
<td>4.00</td>
<td>8.00</td>
</tr>
<tr>
<td>PHYS</td>
<td>4058</td>
<td>A</td>
<td>3.00</td>
<td>3.00</td>
<td>12.00</td>
</tr>
<tr>
<td>PHYS</td>
<td>4132</td>
<td>A</td>
<td>3.00</td>
<td>3.00</td>
<td>12.00</td>
</tr>
</tbody>
</table>

*Cumulative GPA after six semesters: 3.83*
### Dana’s Fall 2011 Mid-term Grades

#### Courses

<table>
<thead>
<tr>
<th>Dept</th>
<th>Course</th>
<th>Grade</th>
<th>Hrs Carried</th>
<th>Hrs Earned</th>
<th>Qual Pts</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM</td>
<td>2060</td>
<td>A</td>
<td>3.00</td>
<td>3.00</td>
<td>12.00</td>
</tr>
<tr>
<td>ENG</td>
<td>2123</td>
<td>A</td>
<td>3.00</td>
<td>3.00</td>
<td>12.00</td>
</tr>
<tr>
<td>MEDP</td>
<td>4331</td>
<td>A</td>
<td>2.00</td>
<td>4.00</td>
<td>8.00</td>
</tr>
<tr>
<td>MEDP</td>
<td>4332</td>
<td>A</td>
<td>3.00</td>
<td>3.00</td>
<td>12.00</td>
</tr>
<tr>
<td>MEDP</td>
<td>4351</td>
<td>A</td>
<td>3.00</td>
<td>3.00</td>
<td>12.00</td>
</tr>
</tbody>
</table>

**Potential Cumulative GPA in Dec: 3.86!**
How’d They Do It?

- They used *metacognitive strategies*
- They began *thinking about their thinking*
- They focused on *learning instead of grades*
Problem:  Reading Comprehension

Solution:  Preview text before reading
Develop questions
Read one paragraph at a time
and paraphrase information
Maryam, freshman art student
57, 87

Problem: Not seeing the underlying structure of different types of art

Solution: Focus on characteristics of different artists’ work in order to identify the painter of an unfamiliar piece of art
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  | 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     |              |
How many words or phrases do you remember?
Let’s look at the words again...

What are they arranged according to?
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
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

- 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

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.

- **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.

[http://www.odu.edu/educ/llschult/blooms_taxonomy.htm](http://www.odu.edu/educ/llschult/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 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?

### Intense Study Sessions

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Set a Goal</td>
<td>1-2</td>
</tr>
<tr>
<td>2</td>
<td>Study with Focus</td>
<td>30-50</td>
</tr>
<tr>
<td>3</td>
<td>Reward Yourself</td>
<td>10-15</td>
</tr>
<tr>
<td>4</td>
<td>Review</td>
<td>5</td>
</tr>
</tbody>
</table>

**Decide what you want to accomplish in your study session**

**Interact with material** – organize, concept map, summarize, process, re-read, fill-in notes, reflect, etc.

**Take a break** – call a friend, play a short game, get a snack

**Go over what you just studied**

---

Center for Academic Success
B-31 Coates Hall • 225.578.2872 • www.cas.lsu.edu
Effective Metacognitive Strategies

- Always ask why, how, and what if
- Use SQ5R for reading assignments (survey, question, read, recite, review, write, reflect)
- Test understanding by giving “mini lectures” on concepts
- Always solve problems without looking at an example or the solution
- Use the Study Cycle with Intense Study Sessions
Metacognitive Get Acquainted Activity*

• What do you believe is important to understand and learn in ____________________?

• What do you believe to be critical characteristics of successful students in __________?

• How will you study and prepare for exams in ________________________________?


- Historical Background on Study Strategies
- Developmental Education and Learning Assistance Today
- Diverse Populations in the Classroom
- Students’ Beliefs about Study Strategies
- Theory, Research, and **Best Practices**
- Assessment and Evaluation
Another Valuable Reference

Effective Strategies for Teaching Unprepared Students*

- Establish High Expectations
- Emphasize Consistent Contact
- Determine Students’ Learning Styles
- Define Student Success
- Clarify Student Responsibility
- Establish a Learning Community of Scholars
- Meet Students Where They Are
- Interweave Assessment and Teaching

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
Mindset determines reactions to

- **Challenges** – avoid vs. embrace
- **Obstacles** – give up easily vs. persist
- **Tasks requiring effort** – fruitless vs. path to mastery
- **Criticism** – ignore vs. learn from
- **Success of Others** – feel threatened by vs. find lessons and inspiration in
What happens when we teach metacognitive learning strategies, Bloom’s Taxonomy, and the Study Cycle to an entire class, not just individuals?
Fall 2010 chain of events...

Aug. 23: **657 students were enrolled** at the start of the course

Sept. 25: 632 students took Exam 1:
  - **123 (19.5%)** students failed Exam 1
  - **86 students** failed Exam 1 but **stayed in the course**

Sept. 27: **461 students attended** metacognition talk; **156 did not**

Oct. 20: **617 students took Exam 2**

<table>
<thead>
<tr>
<th></th>
<th>Attended</th>
<th>Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam 1 Avg.:</td>
<td>72.35%</td>
<td>70.11%</td>
</tr>
<tr>
<td>Improvement on Exam 2:</td>
<td>230 (50%)</td>
<td>55 (35%)</td>
</tr>
<tr>
<td>Decline on Exam 2:</td>
<td>127 (27.5%)</td>
<td>70 (45%)</td>
</tr>
<tr>
<td>No change on Exam 2:</td>
<td>104 (22.5%)</td>
<td>31 (20%)</td>
</tr>
</tbody>
</table>
Performance in Gen Chem I 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>72.35%</td>
<td>70.11%</td>
</tr>
<tr>
<td>Exam 2 Avg.:</td>
<td>76.01%</td>
<td>68.74%</td>
</tr>
<tr>
<td>Final course Avg*.:</td>
<td>82.48%</td>
<td>72.61%</td>
</tr>
<tr>
<td><strong>Final Course Grade:</strong></td>
<td><strong>B</strong></td>
<td><strong>C</strong></td>
</tr>
</tbody>
</table>

Even one 50-min presentation on study and learning strategies may mean an improvement of one full letter grade!

Note: 15% of the final course grade was determined by homework; students could also earn ~5% for extra credit activities.
Fall 2011 chain of events...

Aug. 22: 718 students were enrolled at the start of the semester

Sept. 23: 502 students attended McGuire’s talk; 216 did not

Oct. 11: 695 students took Exam 2

<table>
<thead>
<tr>
<th></th>
<th>Attended</th>
<th>Absent</th>
<th>Entire Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam 1 Avg.:</td>
<td>71.65%</td>
<td>70.45%</td>
<td>71.30%</td>
</tr>
<tr>
<td>Exam 2 Avg.:</td>
<td>77.18%</td>
<td>68.90%</td>
<td>74.74%</td>
</tr>
<tr>
<td>Exam 1 to Exam 2 Change</td>
<td>+5.53%</td>
<td>-1.55%</td>
<td>+3.34%</td>
</tr>
<tr>
<td>Net change:</td>
<td></td>
<td></td>
<td>+7.08%</td>
</tr>
</tbody>
</table>

One 50-min presentation on study and learning strategies resulted in an improvement of over 2/3 of a letter grade
# Intro Chem Results Spring 2007

<table>
<thead>
<tr>
<th></th>
<th>Test 1</th>
<th>Test 2</th>
<th>Final</th>
<th>Total points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attended lecture on metacog. 3/2*</td>
<td>156</td>
<td>109</td>
<td>214</td>
<td>801 (B)</td>
</tr>
<tr>
<td>Did not attend</td>
<td>154</td>
<td>93</td>
<td>153</td>
<td>563 (D)</td>
</tr>
<tr>
<td>Class average</td>
<td>153</td>
<td>100</td>
<td>176</td>
<td>662 (C)</td>
</tr>
</tbody>
</table>

*Approximately 80 attendees out of 200 students because session was on a Friday afternoon. Exam 1 was Wednesday, March 7.
How do we teach metacognitive strategies to students on warning or probation?
IMPACT Your GPA
Spring 2011
Workshop for First Year Students

Attend one of the following:
Session 1
January 14
1:00-3:00 PM
Session 2
January 27
5:00-7:00 PM
Session 3
February 12
1:00-3:00 PM

All sessions held in 130 Nicholson Hall.

Register Now
cas.lsu.edu

Center for Academic Success
B-31 Coates Hall
225.578.2872

First Year Experience
128 Johnston Hall
225.578.1188
## Results from Spring 2011

### GPA change from Fall 2010 to Spring 2011

<table>
<thead>
<tr>
<th>Group</th>
<th>IMPACT (n=466)</th>
<th>NON-IMPACT (n= 184)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warning or Probation</td>
<td>+.53</td>
<td>-.12</td>
</tr>
</tbody>
</table>

**0.65 Difference!**
Retention from Spring 2011 to Fall 2011

<table>
<thead>
<tr>
<th>Group</th>
<th>IMPACT (n=466)</th>
<th>NON-IMPACT (n=184)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warning or Probation</td>
<td>68%</td>
<td>48%</td>
</tr>
</tbody>
</table>

20% Difference!
• Learning Center Services
• How I Learn
• Super Strategies
  (Bloom’s, Metacognition, Mindset)
• Get Organized
• Reduce My Stress
<table>
<thead>
<tr>
<th>Date</th>
<th>Result</th>
<th>Date</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/04</td>
<td>Failed</td>
<td>10/05</td>
<td>Passed</td>
</tr>
<tr>
<td>10/04</td>
<td>Failed</td>
<td>11/05</td>
<td>Failed</td>
</tr>
<tr>
<td>11/04</td>
<td>Failed</td>
<td>12/05</td>
<td>Passed best in group</td>
</tr>
<tr>
<td>12/04</td>
<td>Failed</td>
<td>1/06</td>
<td>Passed</td>
</tr>
<tr>
<td>1/05</td>
<td>Passed</td>
<td>2/06</td>
<td>Passed</td>
</tr>
<tr>
<td>2/05</td>
<td>Failed</td>
<td>3/06</td>
<td>Failed</td>
</tr>
<tr>
<td>3/05</td>
<td>Failed</td>
<td>4/06</td>
<td>Passed last one!</td>
</tr>
<tr>
<td>4/05</td>
<td>Failed</td>
<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
“…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
... and from the perspective of a faculty member who learned metacognitive strategies as a student

“...I am happy to report to you that many of my students are using the study cycle and all of the outcomes are positive. In summary, students who were failing all of their classes, including my course and in their final semester before being removed from the university are now the top students in their respective classes. I am so proud of these students. Many of the students stated to me that they will continue to use the study cycle.....”

October 15, 2010

Algernon Kelley, Xavier University Chemistry Instructor
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.**
“Faculty started thinking about designing assignments and assessment in terms of metacognitive skills as well as standard outcomes.”

“Faculty agree that investing time up front on teaching metacognitive strategies and raising self-awareness allows the instructor to move students into course-content more easily because expectations are clarified.”
Teaching and Learning Strategies That Work

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

ROALD HOFFMANN\(^1\)* AND SAUNDRA Y. MCGUIRE\(^2\)

\(^1\)Department of Chemistry and Chemical Biology, Cornell University, Baker Laboratory, Ithaca, NY 14853, USA.

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

Learning and Teaching Strategies

Roald Hoffmann and Saundra Y. McGuire
We can significantly increase brain based learning!

- 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.
Final Reflection Question

Who is *primarily* responsible for student learning?

a) the student  
b) the instructor  
c) the institution
Who do you think students say is *primarily* responsible for student learning?

a) the student  
b) the instructor  
c) the institution
The reality is that...

when **all three** of these entities take **full responsibility** for student learning,

we will experience a **significant increase** in student learning, retention, and graduation rates!
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


[http://academic.pg.cc.md.us/~wpeirce/MCCCTR/metacognition.htm](http://academic.pg.cc.md.md.us/~wpeirce/MCCCTR/metacognition.htm)

*Excellent student reference*
QUESTIONS?