Get Engineering Students to Focus on Learning Instead of Grades: Teach Them HOW to Learn!

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Ret. Assistant Vice Chancellor & Professor of Chemistry
Director Emerita, Center for Academic Success
Louisiana State University
Metacognition: The Key to Learning

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?

It wasn’t necessary in high school
Data from UCLA Higher Education Research Institute (HERI)
First Year Student Survey – 2010 - 2014

<table>
<thead>
<tr>
<th>Year of Survey</th>
<th>% who spent &lt; 6 hrs/wk on homework</th>
<th>% who graduated with an A average</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>62.7</td>
<td>48.4</td>
</tr>
<tr>
<td>2011</td>
<td>60.5</td>
<td>49.7</td>
</tr>
<tr>
<td>2012</td>
<td>61.6</td>
<td>49.5</td>
</tr>
<tr>
<td>2013</td>
<td>58.6</td>
<td>52.8</td>
</tr>
<tr>
<td>2014</td>
<td>57.1</td>
<td>53.1</td>
</tr>
</tbody>
</table>

http://www.heri.ucla.edu/
How do you think most students would answer the following?

- What did most of your teachers in high school do the *day before the test*?
- What did they *do* during this activity?
- What grade would you have made on the test if you had gone to class *only* on the day before the test?
EXECUTIVE SUMMARY

The College Board’s 2013 SAT® Report on College & Career Readiness reveals that fewer than half of all SAT takers in the class of 2013 graduated from high school academically prepared for the rigors of college-level course work. This number has remained virtually unchanged during the last five years, underscoring a need to dramatically increase...
Help students identify and close "the gap"

current behavior $\rightarrow$ current grades

productive behavior $\rightarrow$ desired grades
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
A Reading Strategy that Works: SQ3R (4R or 5R)

- **Survey** (look at intro, summary, bold print, italicized words, etc.)
- **Question** (devise questions survey that you think the reading will answer)
- **Read** (one paragraph at a time)
- **Recite** (summarize in your own words)
- **Record or wRite** (annotate in margins)
- **Review** (summarize the information in your words)
- **Reflect** (other views, remaining questions)
Problem: Reading Comprehension

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

*Develop anticipatory set
First Voyage of Christopher Columbus

WITH HOCKED GEMS FINANCING HIM/ OUR HERO BRAVELY DEFIED 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 online homework aids

Solution: Solve problems with no external aids and test mastery of concepts
Homework system that can be taught

• Study information before looking at the problems/questions
• Work example problems (without looking at the solutions) until you get to the answer
• Check to see if answer is correct
• If answer is not correct, figure out where mistake was made, without consulting solution
• Work homework problems/answer questions as if taking a test
Why Can Students Make Such a Fast and Dramatic Increase?

It’s all about the *strategies*!
Counting Vowels in 45 seconds

How accurate are you?

Count the vowels in the words on the next slide.
How many *words* or *phrases* from the list do you remember?
Let’s look at the words again...

What are they arranged according to?
<table>
<thead>
<tr>
<th>Dollar Bill</th>
<th>Cat Lives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dice</td>
<td>Bowling Pins</td>
</tr>
<tr>
<td>Tricycle</td>
<td>Football Team</td>
</tr>
<tr>
<td>Four-leaf Clover</td>
<td>Dozen Eggs</td>
</tr>
<tr>
<td>Hand</td>
<td>Unlucky Friday</td>
</tr>
<tr>
<td>Six-Pack</td>
<td>Valentine’s Day</td>
</tr>
<tr>
<td>Seven-Up</td>
<td>Quarter Hour</td>
</tr>
<tr>
<td>Octopus</td>
<td></td>
</tr>
</tbody>
</table>
NOW, how many *words* or *phrases* from the list do you remember?
What were two major *differences* between the 1\textsuperscript{st} and 2\textsuperscript{nd} attempts?
1. We knew what the task was

2. We knew how the information was organized
An Excellent Introduction

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

Creating
- Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing.

Evaluating
- Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure.

Analyzing
- 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.

Understanding
- Retrieving, recognizing, and recalling relevant knowledge from long-term memory.

Remembering
- Making judgments based on criteria and standards through checking and critiquing.

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/llschult/blooms_taxonomy.htm
When we teach students about Bloom’s Taxonomy...

They GET it!
How do you think students answered?

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

1. Remembering
2. Understanding
3. Applying
4. Analyzing
5. Evaluating
6. Creating
At what level of Bloom’s did you have to operate to make A’s and B’s in high school?

A. Remembering
B. Understanding
C. Applying
D. Analyzing
E. Evaluating
F. Creating
How do you think students answered?

At what level of Bloom’s do you think you’ll need to operate to make A’s in college courses?

1. Remembering
2. Understanding
3. Applying
4. Analyzing
5. Evaluating
6. Creating
At what level of Bloom’s do you think you’ll need to operate to make A’s in college?

1. Remembering
2. Understanding
3. Applying
4. Analyzing
5. Evaluating
6. Creating

How students answered (in 2015): 47% creating, 20% analyzing, 13% evaluating, 10% applying, 10% understanding, 0% remembering.
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

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

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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
Compare and Contrast

Thermodynamic Control  Kinetic Control

How are they similar?

How are they different?
Two Valuable References


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
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 General Chemistry 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!

Performance in Gen Chem 1202 Sp 2013 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>71.33%</td>
<td>69.27%</td>
</tr>
<tr>
<td>Homework Total</td>
<td>169.8</td>
<td>119.1</td>
</tr>
<tr>
<td>Final course Avg*:</td>
<td>82.36%</td>
<td>67.71%</td>
</tr>
<tr>
<td><strong>Final Course Grade:</strong></td>
<td><strong>B</strong></td>
<td><strong>D</strong></td>
</tr>
</tbody>
</table>

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

Ningfeng Zhao¹, Jeffrey Wadeska¹, Saundra McGuire², Elzbieta Cook²

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

*March/April 2014 issue of JCST, Vol. 43, No. 4, pages 48-54
Sharing Strategies that Have Worked for Others Can Be Very Motivational
Top 5 Reasons Students 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
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
Email from ENG Professor at New Mexico State Univ.  
Received on 10/22/2013

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>Self-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>
Comments from Engineering Students about what they changed for Test 3*

• I changed my study habits by doing the homework early. I also started reading some of the material before going to the class. The most effective was spending more time on the material.

• I started studying for the exam sooner. I also took more time to do the homework. I reviewed/rewrote my notes from class.

• I studied for the class as close to everyday as possible.

• I got together with other classmates and helped them with their weakness and of course they helped me with mine as well.

*class average increased from 61% to 77%! 
Mr. Lorenzo Foster’s Physics I AP Class Test Scores

*Strategies, Dedication and Hard Work PAID OFF!*

<table>
<thead>
<tr>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>73</td>
<td>95</td>
<td>100</td>
</tr>
<tr>
<td>90</td>
<td>86</td>
<td>100</td>
</tr>
<tr>
<td>50</td>
<td>90</td>
<td>67</td>
</tr>
<tr>
<td>83</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>57</td>
<td>98</td>
<td>93</td>
</tr>
<tr>
<td>80</td>
<td>85</td>
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<td>50</td>
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<td>37</td>
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<td>85</td>
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<td>90</td>
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<td>67</td>
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<td>90</td>
<td>97</td>
<td>93.5</td>
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<td>100</td>
<td>85</td>
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<td>42</td>
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<td>22</td>
<td>86</td>
<td>98</td>
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<td>99</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>53</td>
<td>69</td>
<td>100</td>
</tr>
</tbody>
</table>

**Average Scores:**

- Exam 1: 66.88
- Exam 2: 86.786
- Exam 3: 95.58
Physics I AP Students
After Learning Their Test 2 Scores
Physics I AP Students After Learning Their Test 3 Scores
<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
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.
When you came to our biochem class to talk about improving study habits...I was very worried about my present ineffective study strategies for physics. I also was hoping to improve my biochem 2 grade... You gave me some of the best advice I have received in my three years of undergrad. **You told me to start** 1) working out homework problems **without** the internet on paper, 2) going to every class, 3) reviewing what would be taught in class 4) getting help from the professor as a last resort when I couldn't figure out a problem rather than turning to the internet, and finally 5) **keeping my phone off as much as possible and not listening to music as I work.** After hearing all this... I really didn't think it would work for me... However, after talking to you, I decided to try some of the strategies. **I started working out 1-3 homework problems before class in a quiet room during my 1 hour break between classes. I also reviewed the chapter before going to class. I started keeping my phone off except for certain times like lunch or when I had to meet up with someone. The results were surprisingly drastic [sic]. The next exam after talking to you I got over 20 points higher than the class average... I was so excited and couldn't wait to tell you...I decided to also try to do as many odd-numbered end of chapter problems as possible to help prepare me for the next test... Again, I improved from the last test...
We can significantly increase learning by...

- teaching students *how* to learn
- making learning *visible*
- making the implicit *explicit*
- *not judging* student potential on initial performance
- Implementing *small interventions* to address psychological factors
- encouraging the use of *metacognitive tools*
- supporting the *campus learning center*!
Final Reflection Questions

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, grades, 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.stemfye.org
- www.cas.lsu.edu
- www.howtostudy.org
- www.vark-learn.com
- www.drearlbloch.com
Additional References


*Excellent student reference*