Metacognition and Motivation: Advancing STEM Learning for ALL Students!

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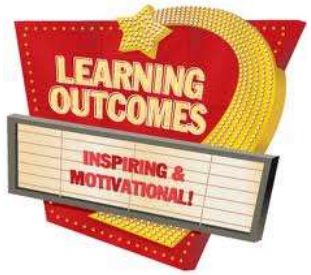
Transforming STEM Education: Inquiry, Innovation, Inclusion, and Evidence

will bring together… STEM faculty and academic leaders… to share innovations, evidence, and practical strategies for succeeding in the dual STEM challenges of:

- **Reversing the dramatic U.S. loss of needed talent in STEM disciplines**, using evidence-based practices that increase persistence and achievement for all students
- **Ensuring that all STEM graduates build--**from the outset of their studies--the **multi-disciplinary knowledge, research skills, and mindsets** needed to address the complex challenges to be faced in every sphere of society.

Desired outcomes



- We will understand why many STEM students do not know how to learn
- We will have concrete learning strategies that faculty can teach students to increase learning
- 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 understand how metacognition and increased motivation increase student success

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

Flavell, J. H. (1976). Metacognitive aspects of problem solving. In L. B. Resnick (Ed.), The nature of intelligence (pp.231-236). Hillsdale, NJ: Erlbaum

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

Faculty Must *Help Students Make the Transition to College*

Help students identify and **close "the gap"**

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

productive *behavior* → ***desired grades***

Turn Students into Expert Learners:

Teach Them Metacognitive Learning Strategies!

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

Travis, *junior psychology student*

47, 52, 82, 86

Problem: Reading Comprehension

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

*Develop anticipatory set

Christopher Columbus Discovering America

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

Dooling, J.D. and Lachman, R. Effects of Comprehension on Retention of Prose, *Journal of Experimental Psychology,* (1971), Vol. 88, No. 2, 216-222

Anticipatory set CAN interfere!

Let's look at the car on the next slide…


Dillard's

Dana, *first year physics student*

80, 54, 91, 97, 90 (final)

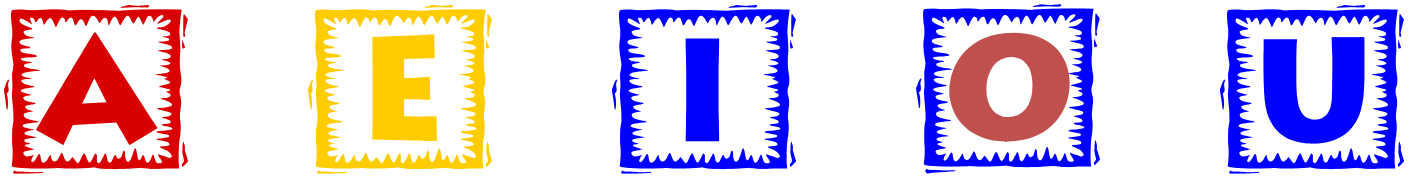
Problem: Memorizing formulas and using www.cramster.com

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
Dice
Tricycle
Four-leaf Clover
Hand
Six-Pack
Seven-Up
Octopus

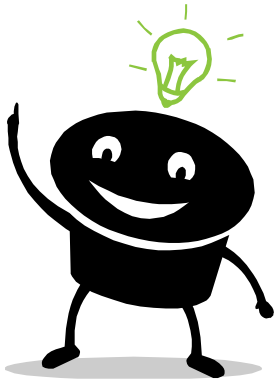
Cat Lives
Bowling Pins
Football Team
Dozen Eggs
Unlucky Friday
Valentine’s Day
Quarter Hour

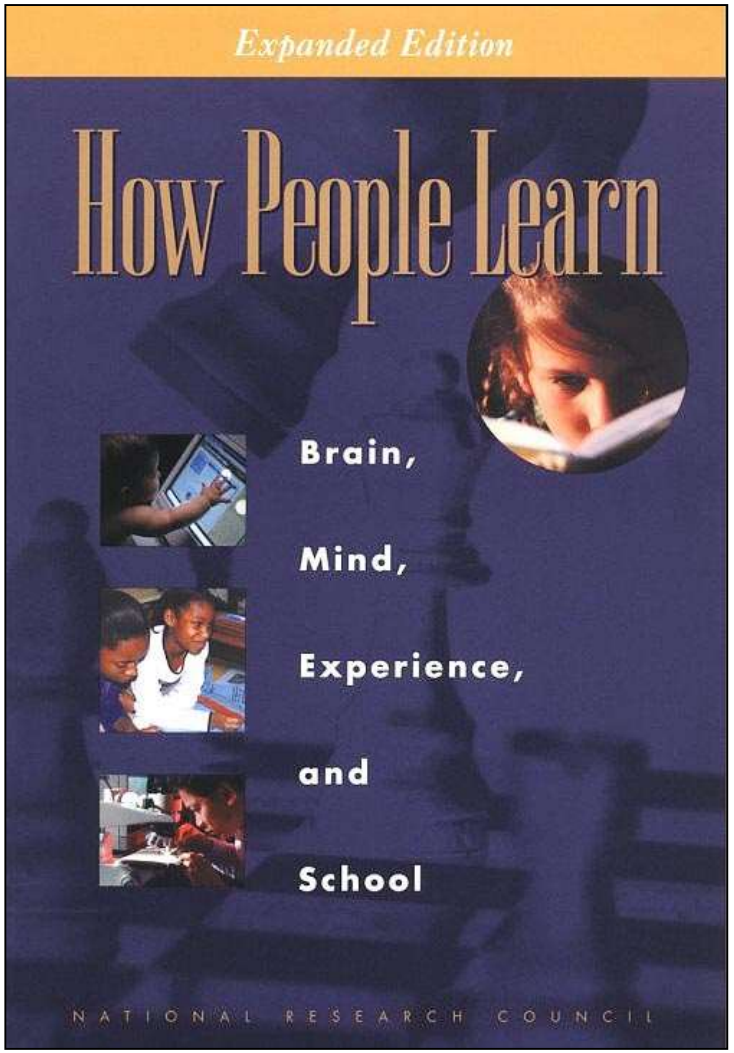
NOW, how many words or phrases do you remember?

What were two major *differences* between the two attempts?

1. We knew what the task was

2. We knew how the information was organized





Bransford, J.D., Brown, A.L., Cocking, R.R. (Eds.), 2000. *How people learn: Brain, Mind, Experience, and School.* Washington, DC: National Academy Press.

What we know about learning

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

- Thinking about thinking is important
  – Metacognition**

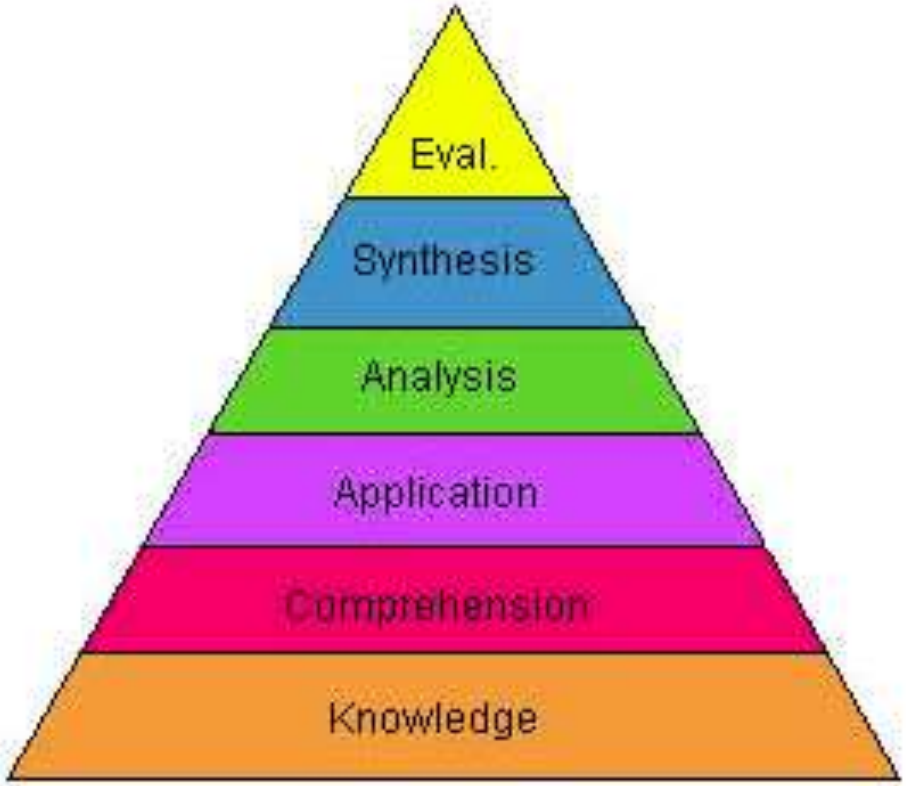
- The level at which learning occurs is important
  – Bloom's Taxonomy***

*Cross, Patricia, "Opening Windows on Learning" League for Innovation in the Community College, June 1998, p. 21.

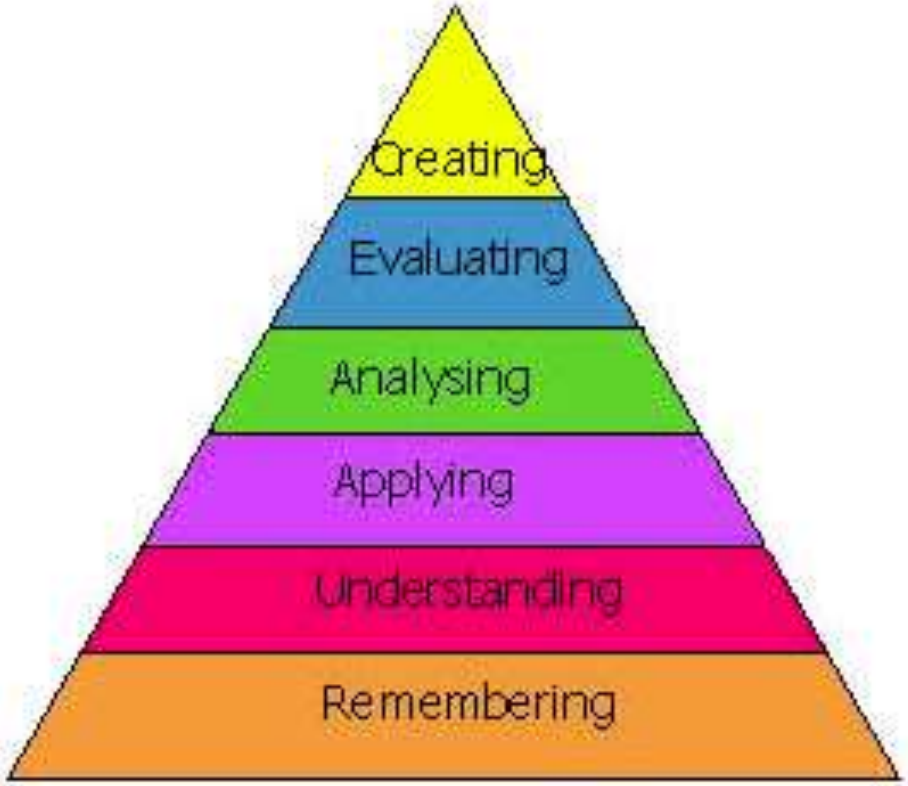
** Flavell, John, "Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry." *American Psychologist*, Vol 34(10), Oct 1979, 906-911.

*** Bloom Benjamin. S. (1956). *Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain.* New York: David McKay Co Inc.

Bloom's Taxonomy



Old Version



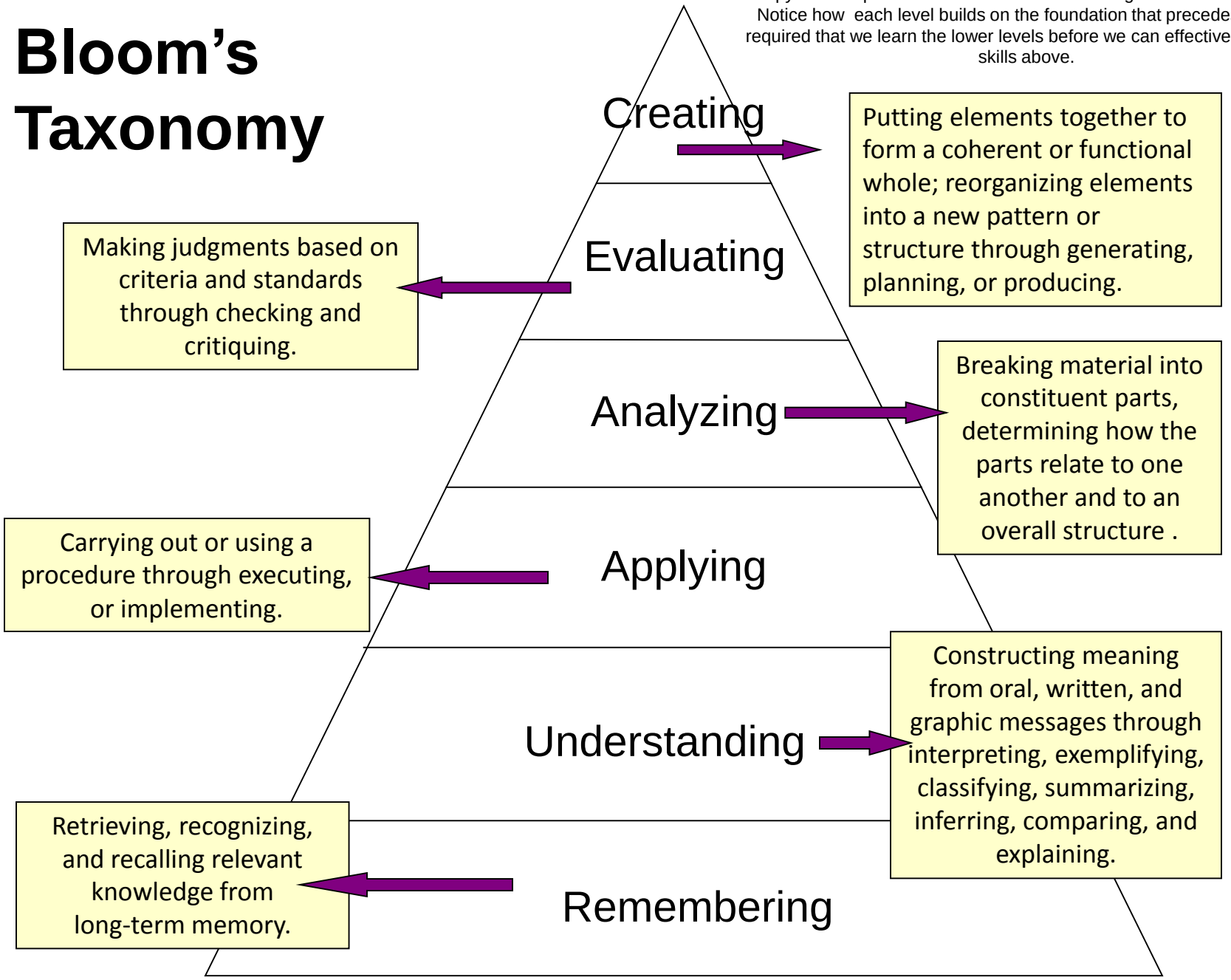
New Version

Anderson & Krathwohl, 2001

http://projects.coe.uga.edu/epltt/index.php?title=Bloom's_Taxonomy

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.



http://www.odu.edu/educ/llschult/blooms_taxonomy.htm·

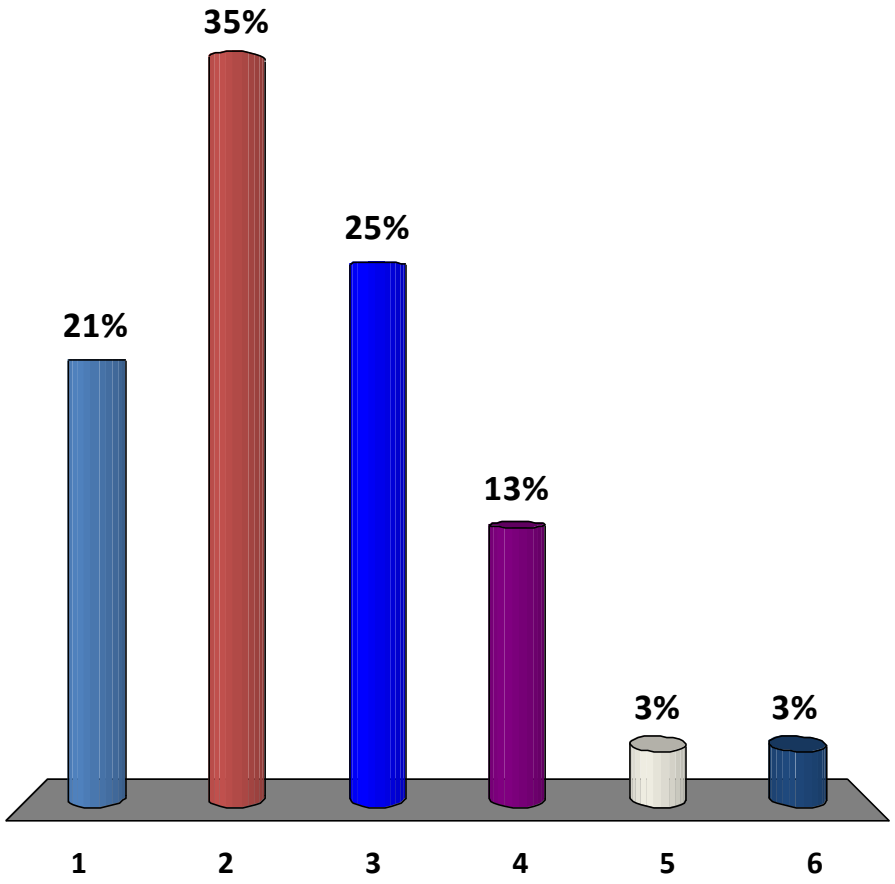
When we teach students about Bloom's Taxonomy…

They GET it!

How students answered (2008)

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 (2013)

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
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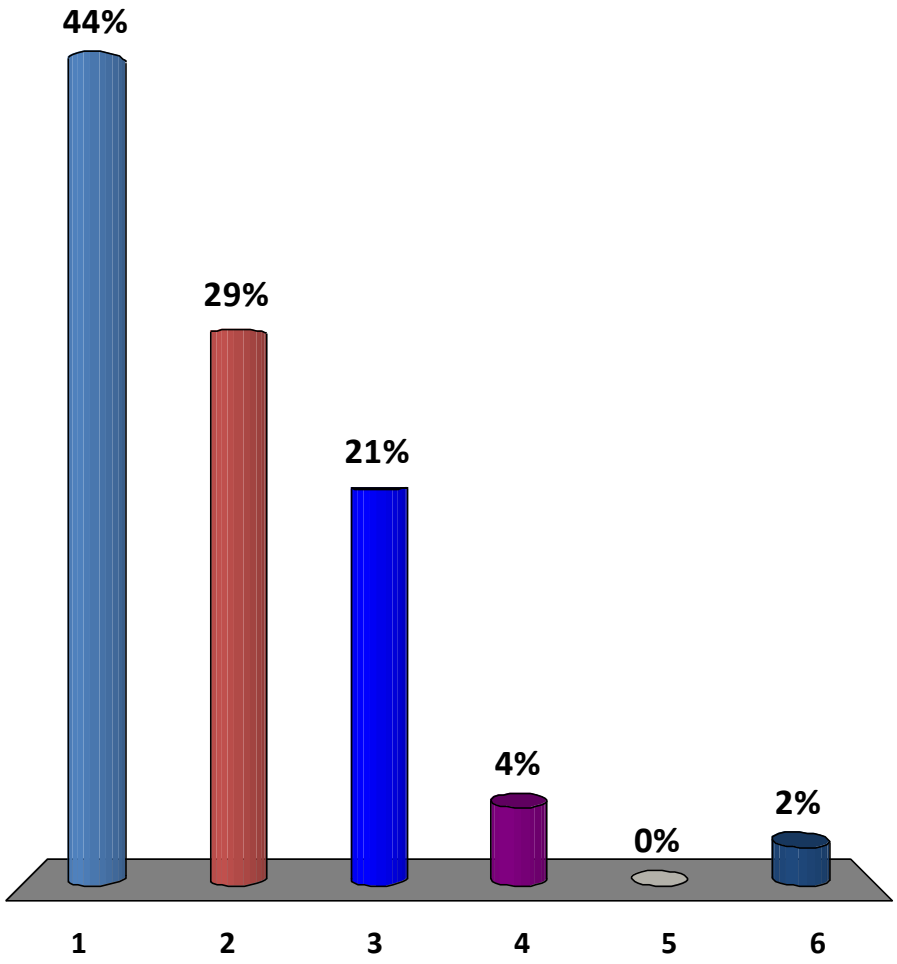
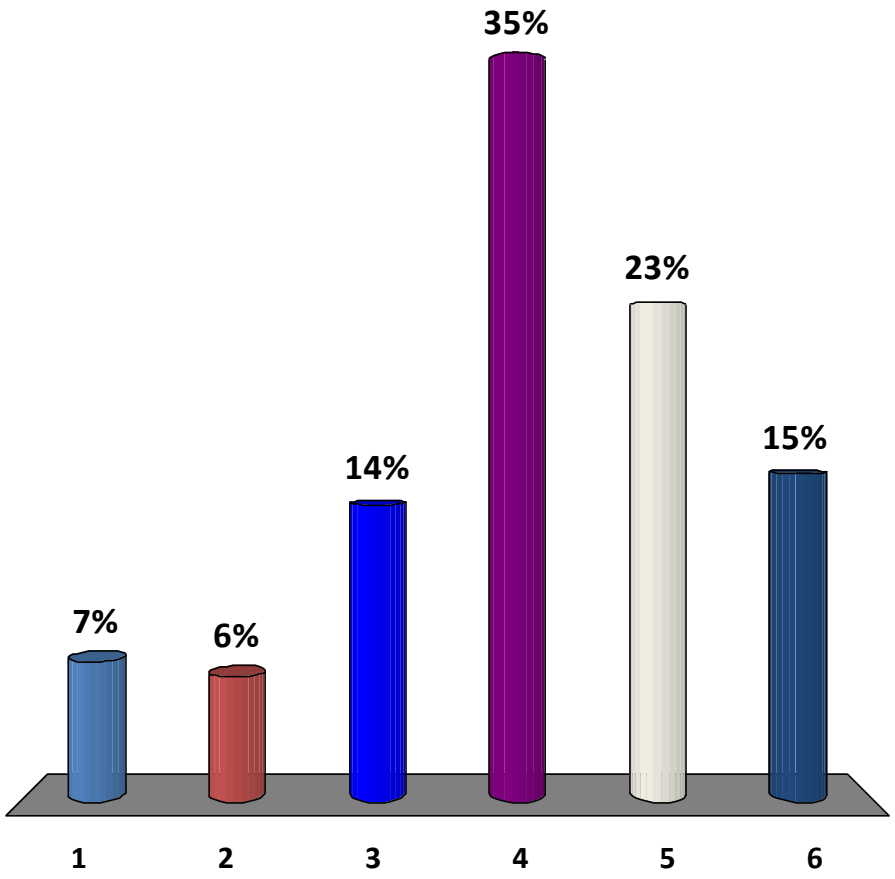


How students answered (in 2008)

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

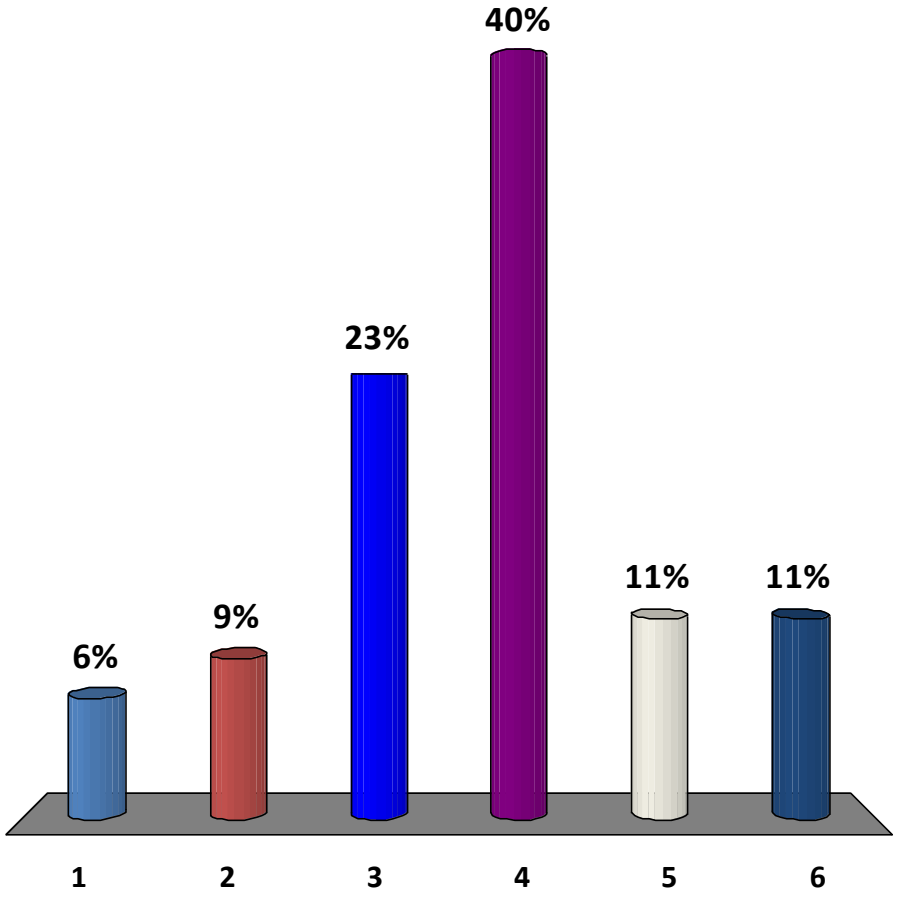
1. Knowledge
2. Comprehension
3. Application
4. Analysis
5. Synthesis
6. Evaluation



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

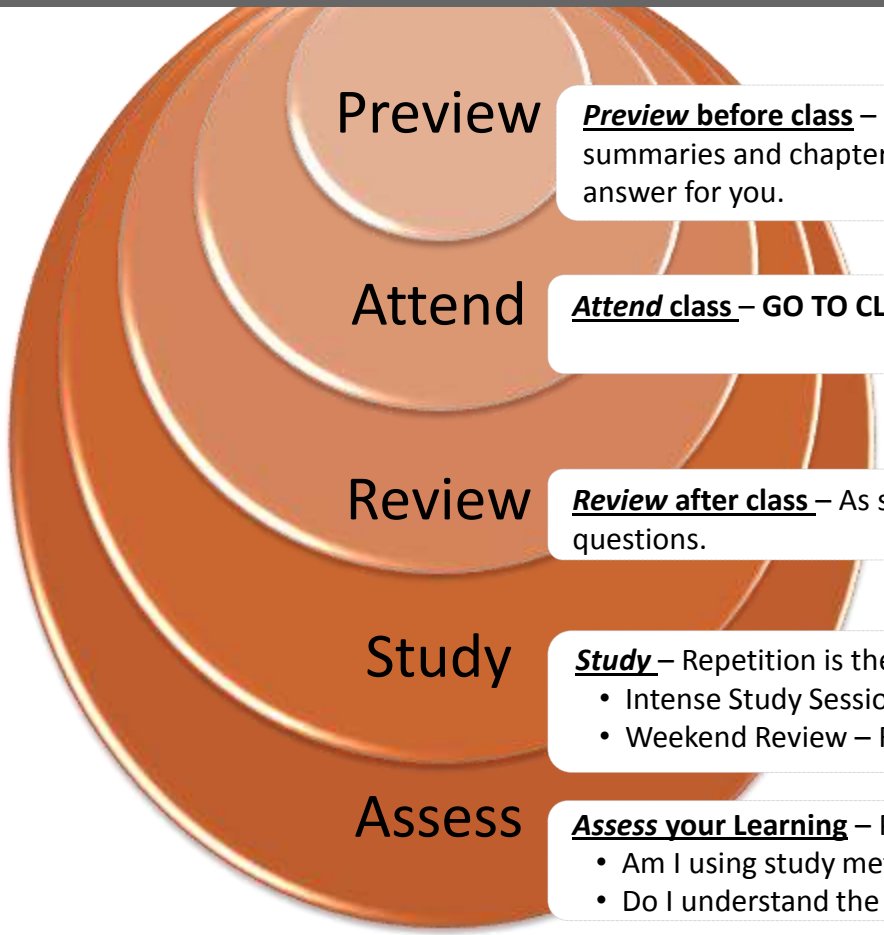


How do we teach students to move higher on Bloom's Taxonomy?

Teach them the Study Cycle*

**adapted from Frank Christ's PLRS system*

The Study Cycle



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

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

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* 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

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

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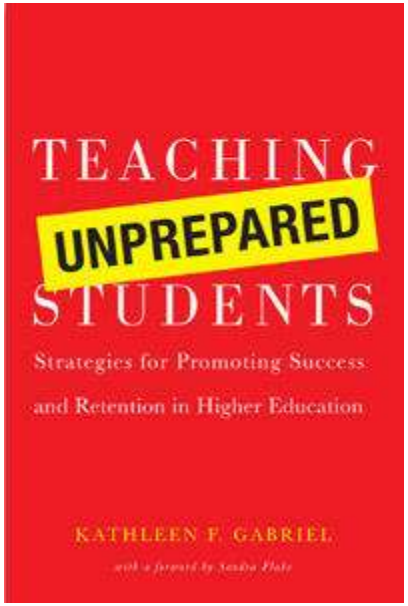
B-31 Coates Hall ▪ 225.578.2872 ▪www.cas.lsu.edu

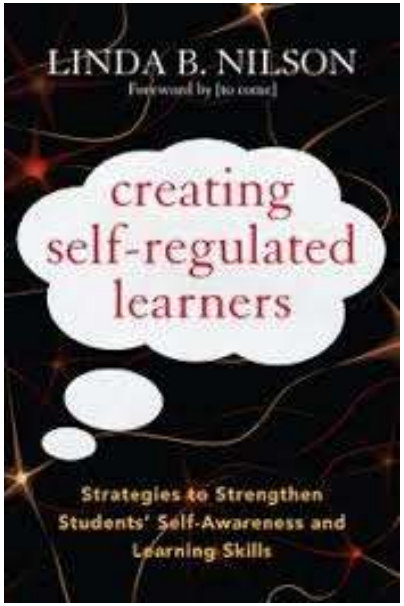
Metacognitive Get Acquainted Activity*

- 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 _____?

***Simpson, M. & Rush, L. (2012) in *Teaching Study Strategies in Developmental Education*, Hodges, Simpson, Stahl eds. New York: Bedford/St. Martin's**

Two Valuable References





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Teaching Unprepared Students.
Sterling, VA: Stylus Publishing

Nilson, Linda. (2013) *Creating Self-regulated Learners*
Sterling, VA: Stylus Publishing

February 7, 2010 Chronicle of Higher Education

How Students Can Improve by Studying Themselves

Researchers at CUNY's Graduate Center push 'self-regulated learning'

Grazyna Niezgoda, a math instructor at New York City College of Technology, says most students eventually appreciate the new methods.

University NEWS

November 1, 2013 64°

Stories by Category

Alumni
Arts & Imaging
Athletics
Business
Computing
Deaf Community

Starting from scratch: RIT program teaches first-year students how to learn

Project seeks to retain deaf, hard-of-hearing and first-generation STEM majors

Oct. 18, 2013
by Susan Gawlowicz
Follow Susan Gawlowicz on Twitter
Follow RITNEWS on Twitter

Like 1 Tweet 3 +1 1 Share 5

Scott Franklin

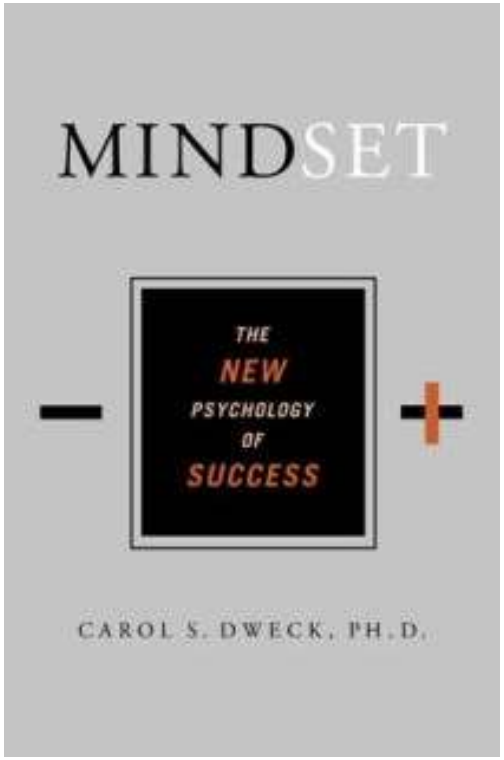
Starting college on the right foot—and in the right frame of mind—can make the difference between completing a bachelor's degree and dropping out in the first or second year of school.

Rochester Institute of Technology is launching a $900,000 National Science Foundation-funded program to improve the retention of deaf, hard-of-hearing and first-generation undergraduates majoring in science, engineering and computer science. Between five and 10 percent of RIT's students are deaf or hard of hearing. Many attend the National Technical Institute for the Deaf or receive support services—such as interpreting and notetaking—from NTID while enrolled in one of RIT's other eight colleges.

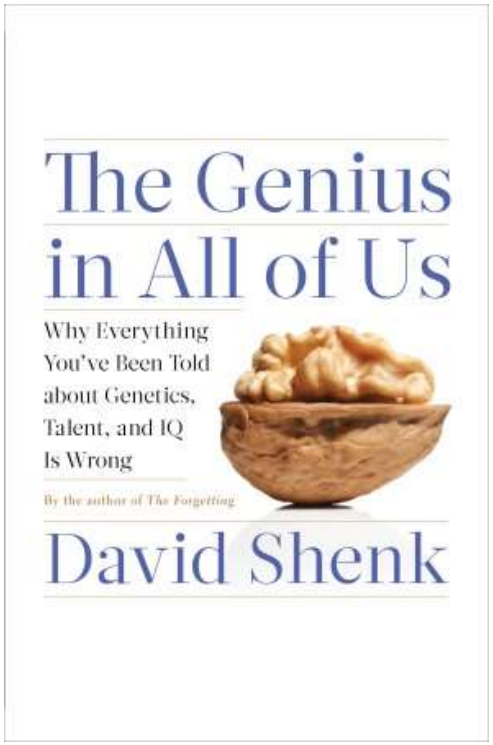
RIT's Project IMPRESS (Integrating Metacognitive Processes and Research to Ensure Student Success) seeks to teach students self-reflection and self-assessment skills—key components of metacognition, or thinking about how one thinks and learns.

"We know that all students—not just our target population—overestimate their understanding," says Scott Franklin, professor in RIT's School of Physics and Astronomy. "Helping students see reflection, assessment and metacognition as a fundamental part of how they learn can make a huge impact on their success."

Help Students Develop the Right Mindset



Dweck, Carol, 2006. *Mindset: The New Psychology of Success.* New York: Random House Publishing



Shenk, David, 2010. *The Genius in All of Us: Why Everything You've Been Told About Genetics, Talent, and IQ Is Wrong. New York: Doubleday*

*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

Dweck, Carol (2006) *Mindset: The New Psychology of Success.* New York: Random House Publishing

Responses to *Many* Situations are Based on Mindset

	Fixed Intelligence Mindset Response	Growth Intelligence Mindset Response
Challenges	*Avoid*	*Embrace*
Obstacles	*Give up easily*	*Persist*
Tasks requiring effort	*Fruitless to Try*	*Path to mastery*
Criticism	*Ignore it*	*Learn from it*
Success of Others	*Threatening*	*Inspirational*

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

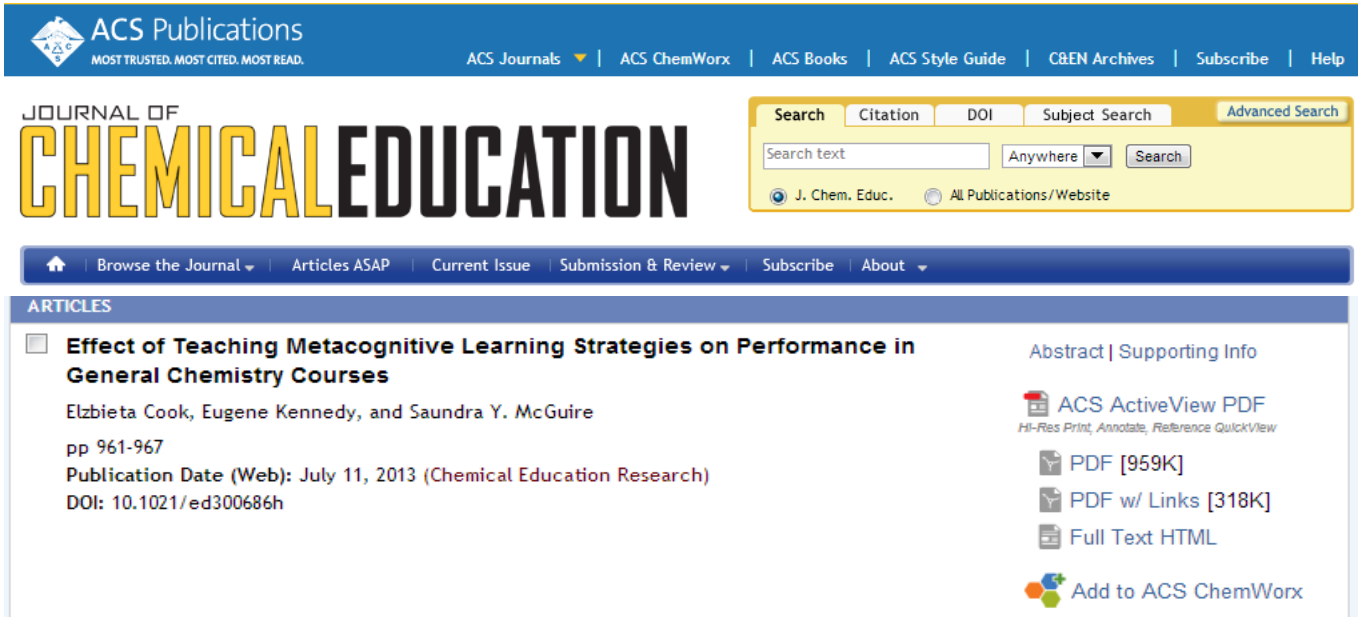
Semester GPA: 3.8

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

	Attended	Absent
Exam 1 Avg.:	71.65%	70.45%
Exam 2 Avg.:	77.18%	68.90%
Final course Avg*.:	81.60%	70.43%
Final Course Grade:	**B**	**C**

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 Zhao[1], Jeffrey Wardeska[1], Saundra McGuire[2], Elzbieta Cook[2]

[1]Department of Chemistry, East Tennessee State University

[2]Department of Chemistry, Louisiana State University

*Accepted for publication April 2013

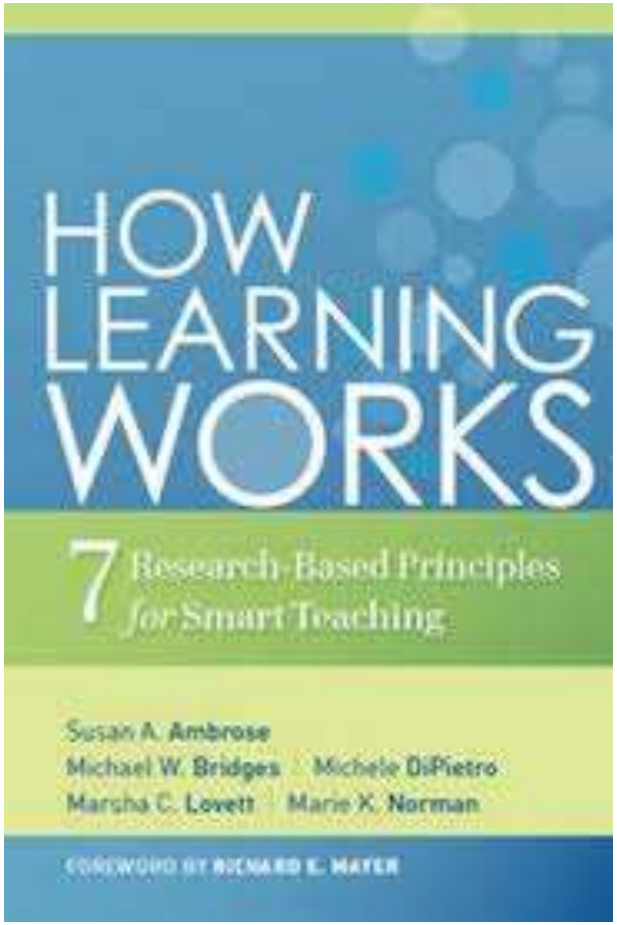
Motivation

"Motivation refers to the ***personal investment*** an individual has ***in reaching a desired state or outcome***.

(Ambrose et. al, 68)

"In the academy, the term 'motivating' means ***stimulating interest in a subject*** and, therefore, the ***desire to learn it***."

(Nilson, 57)



Ambrose, S.A., Bridges, M.W., DiPietro, M., Lovett, M.C., Norman, M.K. (2010) ***How Learning Works: Seven Research-Based Principles for Smart Teaching.*** **San Francisco, CA: Jossey Bass.**

Three Important Levers that Influence Motivation

- ***Value*** **– the importance of a goal (attainment, intrinsic, instrumental)**
- ***Supportive Nature of the Environment*** **– the instructor is approachable, support is available from peers and others**
- ***Efficacy Expectancies*** **– the belief that one is capable of identifying, organizing, initiating, and executing a course of action that will bring about a desired outcome**

Ambrose et al., 80

Sharing Strategies that Have Worked for Others Can Be Very Motivational

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

Top 5 Reasons Folks 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 an EE 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 whether they were using or not using the strategies. The average scores of the different groups on the first two exams are shown below.

Reported Use of Strategies	Exam 1	Exam 2
Did not use the strategies	58	54
Used metacognitive strategies	95	80

Changes Faculty Have Made that *Improved* Learning and Performance

- **Provide learning strategies information to students after Test 1, and tell them about mindset**

  (Psychology Professor at Southern Crescent Technical College, 2013)
- **Increase the frequency of tests from three per semester to biweekly** *(Mathematics Professor at Miles College, 2013)*
- **Have students determine their learning style and write reflection on how they will use the information** *(Entomology Professor at LSU, 2009)*
- **Present one 50 minute session on metacognition, Bloom's Taxonomy, and the Study Cycle** *(Chemistry Professor at Middle Tennessee State University, 2012)*
- **Teach students how to read** *(Chemistry Professor at LSU, 2004)*

LSU Analytical Chemistry Graduate Student's Cumulative Exam Record

2004 – 2005	
9/04	Failed
10/04	Failed
11/04	Failed
12/04	Failed
1/05	Passed
2/05	Failed
3/05	Failed
4/05	Failed

Began work with CAS and the Writing Center in October 2005

2005 – 2006	
10/05	Passed
11/05	Failed
12/05	Passed best in group
1/06	Passed
2/06	Passed
3/06	Failed
4/06	Passed last one!
5/06	N/A

Dr. Algernon Kelley, December 2009

... 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

From a Xavier University student to Dr. Kelley in Fall 2011

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

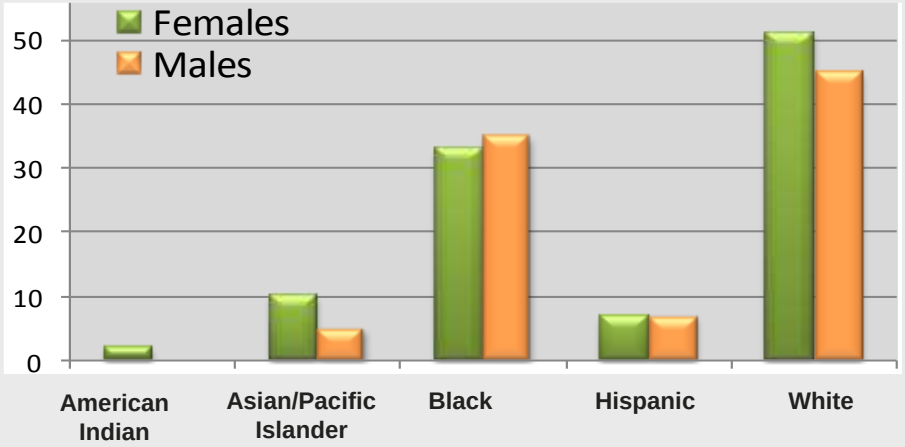
Hey Dr. Kelley! **I have increased my Bio exam grade from a 76% to a 91.5% using your system. Ever since I started your study cycle program, my grades have significantly improved. I have honestly gained a sense of hope and confidence here at Xavier. My family and I are really grateful that you have taken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

Knowledge of Metacognition Greatly Increases URM Student Success

- They are less likely to have been cognitively challenged in high school
- They are less likely to be encouraged to stick with it
- They are more likely to experience the impact of a paradigm shift

LA-STEM SCHOLARS

Percentage of total Scholars Served by Ethnicity &Gender: 2003-2011



SIX-YEAR GRADUATION RATES IN STEM

	*LA-STEM Research Scholars Program	Highly Selective Institutions	Louisiana State University	Selective Institutions	Moderately Selective Institutions
All	92.3%	51.8%	33.8%	37.4%	25.3%
Male	94.9%	52.8%	38.1%	38.1%	25.7%
Female	90.2%	49.8%	28.2%	36.0%	24.7%
Black	92.3%	34.4%	28.4%	26.7%	12.2%

Teaching and Learning Strategies That Work

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

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AMERICAN
Scientist

September-October 2010
Volume 98, Number 5

MARGINALIA

Learning and Teaching Strategies

Roald Hoffmann and Saundra Y. McGuire

Conclusion

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
- encouraging students to *persist in the face of initial failure*
- *encouraging 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

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*Excellent student reference

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