

# Metacognition: The Best Tool to Improve Learning!



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**Director Emerita, Center for Academic Success, LSU**  
**AAAS, ACS, CLADEA Fellow**



## Mission Statement

To be a great Catholic university dedicated to **providing students with *excellent teaching and learning*** in the Franciscan and liberal arts tradition.

## Vision Statement

To **provide an education distinguished in its ability to prepare transformative leaders** for service to the world.

# **Tools for *Teaching* & Community Day**

# Metacognition Empowers Students Maximally Make Use of the Tools Provided

Metacognition is the ability to:

- think about your own thinking
- be consciously aware of yourself as a problem solver
- monitor, plan, and control your mental processing (e.g. “Am I *understanding* this material, or just *memorizing* it?”)
- accurately judge your level of learning
- know what you know and what you don’t know

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

# What is “Metacognitive Equity”?

- **Educational Equity\***

reducing the discrepancy in educational outcomes between low-income versus high-income students and minority versus majority students (closing the gap)

- ***Metacognitive Equity***

reducing the discrepancy in metacognition (*thinking strategies*) between low-income versus high-income, minority versus majority, and well prepared versus underprepared students

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\*<https://www.kaganonline.com/grants/Excellence&Equity.pdf>

# Why is there a metacognitive equity gap?

- Children from low-income families enter high school with average literacy skills five years behind those of high-income students
- Economically disadvantaged students have less access to mentors who will model metacognitive thinking skills
- Students from minority and low-income backgrounds less likely to be encouraged to persist through challenges

# Why don't many students already have metacognitive knowledge?



**It wasn't necessary before**

# Data from UCLA Higher Education Research Institute (HERI)

## First Year Student Survey – 2010 - 2019

|      | % spending at least<br>6 hrs/wk on homework | % with an<br>A average |
|------|---|------------------------|
| 2010 | 37.3  | 48.4                   |
| 2011 | 39.5  | 49.7                   |
| 2012 | 38.4  | 49.5                   |
| 2013 | 41.4  | 52.8                   |
| 2014 | 42.9  | 53.1                   |
| 2015 | 44.8  | 58.7                   |
| 2016 | 44.0  | 55.1                   |
| 2017 | 44.1  | 51.5                   |
| 2018 | 42.3  | 57.6                   |
| 2019 | 43.3  | 59.3                   |

# How do you think most students would answer the following?

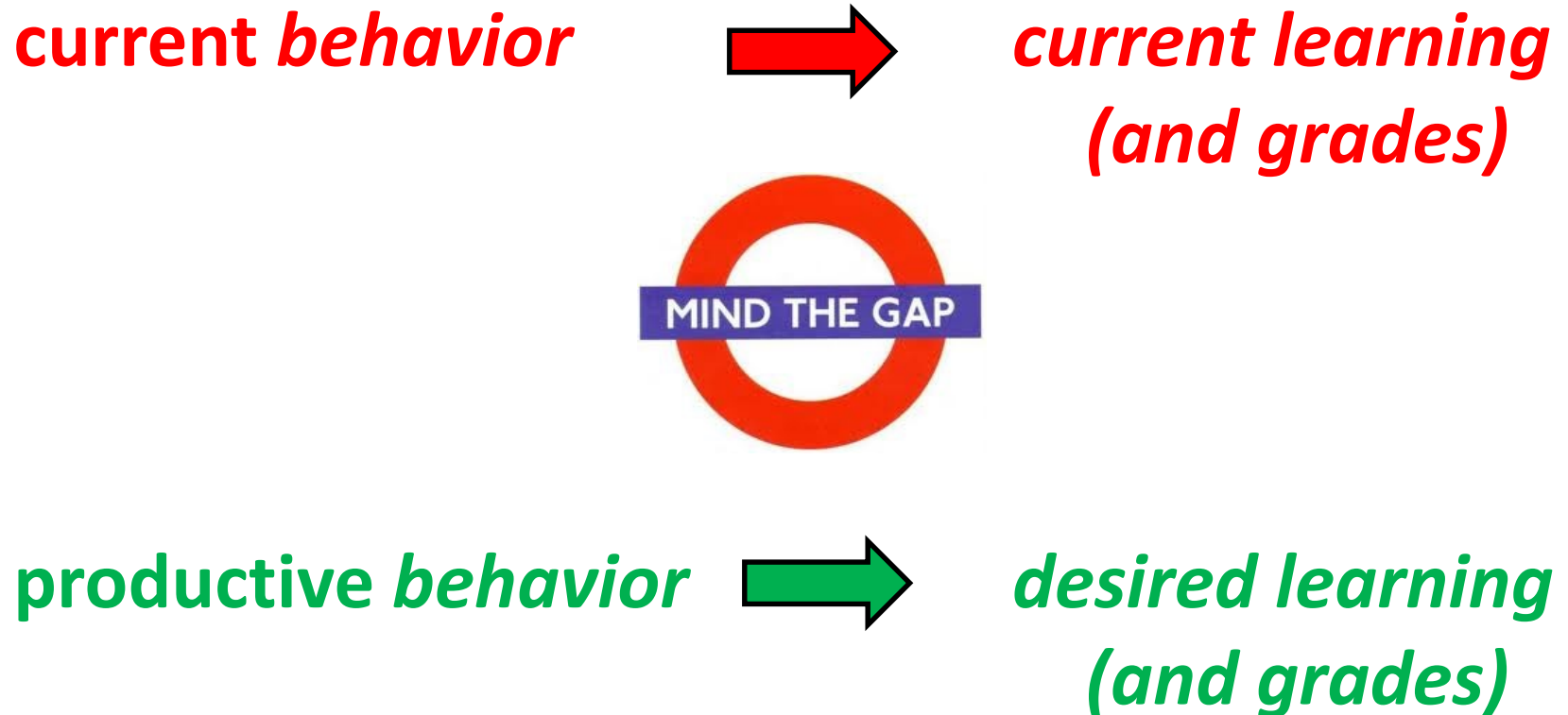
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- What did most of your teachers in high school do the *day before the test*?
  - What did they *do* during this activity?
  - What grade would you have made on the test if you had gone to class *only* on the day before the test?
-

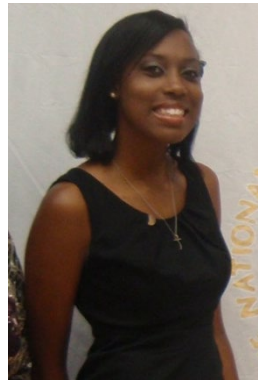


# Faculty Must Help Students Make the Transition

Help students identify and close “the gap”



# Metacognition Was Dana's Key to Academic Success



Dana, *first year physics student*  
80, 54, 91, 97, 90 (final)

Before Metacognition: Memorizing formulas and  
using online homework programs

After Metacognition: Solving problems with no  
external aids and testing mastery of concepts

Dana Lewis, MS in Medical Physics, 2015  
Univ of Texas Graduate School  
of Biomedical Sciences at Houston  
Thesis research at UT MD Anderson Cancer Center



Practicing Medical Physicist as of 8/28/2016  
when she completed her residency!

# Effective Homework Strategy

- **Study material first**, 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



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

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\* Developing an anticipatory set

# A Reading Strategy that Works: SQ5R

- **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)

# 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

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

# 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 Power of Teaching to Learn: What Happened When Ty Taught His Betta Fish



- First encounter on September 17, 2018
- Email on October 25, 2018

Bio Exam Grades: 66, 98, 90; Final Grade B

Chem Exam Grades: 62, 83; Final Grade B

# Impact of Teaching to Learn

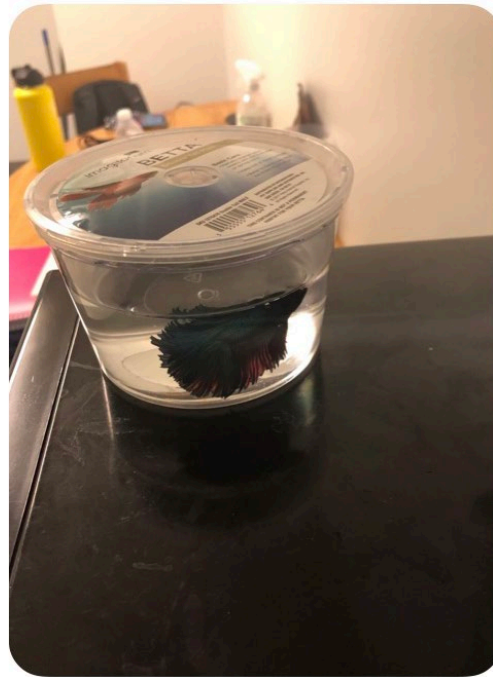
Ty, LSU First Year Student

Email Received on October 26, 2018

I attended more of the Supplemental Instruction (SI) sessions and the exam reviews. Before the exam reviews and SI Sessions I would try to answer as many of the questions as possible to see about where I was in terms of grasping the information, then at the exam reviews/SI sessions I would know what I needed to understand. Next after the reviews/SI sessions **I would go to my room and “teach” the materials to my betta fish. The material I couldn’t explain, I would study more. I would continue that cycle until I could explain everything in my notes....**

# **Betta fish purchased on September 21, 2019 by Howard University Bison STEM Scholars**

Sat, Sep 21, 12:34 PM

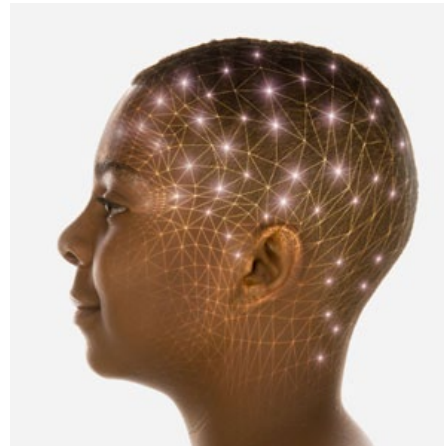


Look what you inspired!!

**March 6, 2021 Update:  
Sully is still alive and living with Makayla!**

# Why Is Fast and Dramatic Improvement Possible?

It's all about the *strategies*, and getting *them* to *engage their brains*!



# Finding Numbers in Sequential Order



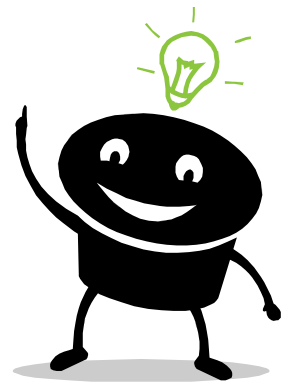
**How many can you find in  
15 seconds?**

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|    |    |    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|----|----|
| 76 | 4  | 48 | 28 | 64 | 5  | 77 | 33 | 53 | 45 |
| 56 | 32 | 16 | 44 | 72 | 17 | 37 | 69 | 29 | 1  |
| 20 | 36 | 8  | 24 | 52 | 21 | 61 | 13 | 57 | 49 |
| 68 | 60 | 12 | 80 | 40 | 9  | 41 | 65 | 25 | 73 |
| 3  | 67 | 47 | 79 | 23 | 70 | 22 | 38 | 14 | 54 |
| 19 | 31 | 55 | 51 | 71 | 6  | 62 | 2  | 46 | 50 |
| 59 | 7  | 63 | 27 | 39 | 74 | 10 | 42 | 66 | 26 |
| 35 | 75 | 15 | 43 | 11 | 78 | 18 | 34 | 30 | 58 |

**What was the major difference  
between the first attempt  
and the second attempt?**

**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\*\*\*

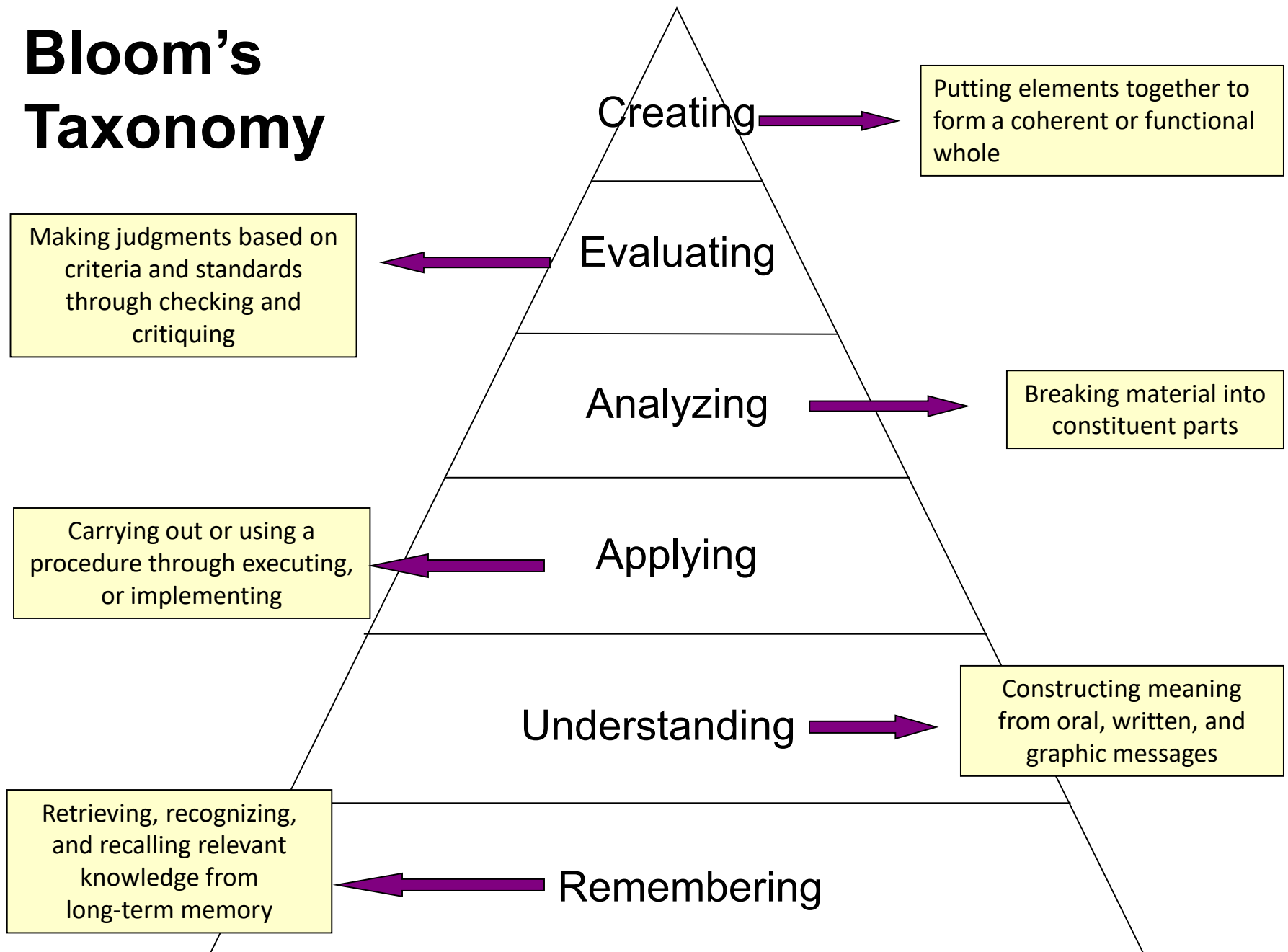
\*Cross, Patricia, "Opening Windows on Learning" League for Innovation in the Community College, June 1998, p. 21.

\*\* 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



**When we teach students  
about Bloom's Taxonomy...**

**They GET it!**

## *How do you think students answered?*

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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

## *How do you think students answered?*

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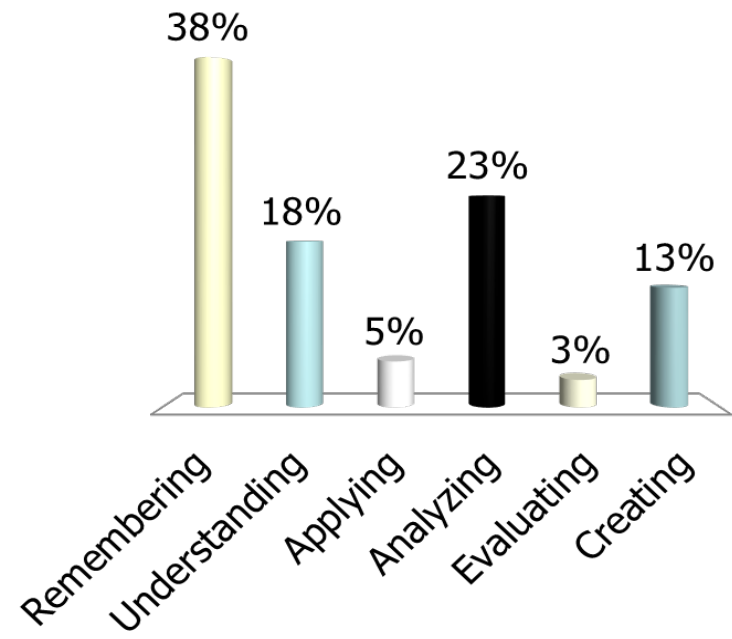
At what level of Bloom's do you think you'll need to operate to make A's in college courses?

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

## *How students answered (in 2018)*

At what level of Bloom's do you think you'll need to operate to make A's and B's in high school?

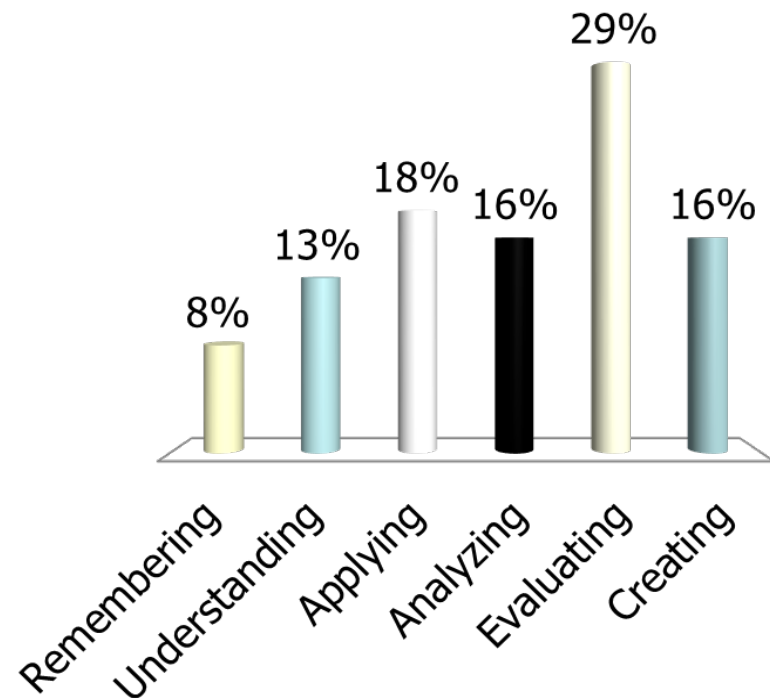
1. Remembering
2. Understanding
3. Applying
4. Analyzing
5. Evaluating
6. Creating



## *How students answered (in 2018)*

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



## Teach them the Study Cycle\*

*\*adapted from Frank Christ's PLRS system*

## 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?

## Focused 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  |



# ***Brea Manuel, BS in Chemistry, 2018***

***Entered PhD Program at  
Emory University on Full Fellowship in Fall 2018  
Became a PhD Candidate in Spring 2020!!!***



**The intense (focused) study sessions helped me most.** I actually got A+ on 3 out of 4 of my finals using that method of studying. It's important to use it everyday before finals week, and I think it would really benefit students during finals week.

**Manuel, B.A.,** Karloff, D.B. Recruit and retain a diverse workforce. *Nat Rev Chem* (2020). <https://doi.org/10.1038/s41570-020-0214-z>

Thermoreversible Control of Nucleic Acid Structure and Function with Glyoxal Caging  
Steve D. Knutson, Aimee A. Sanford, Colin S. Swenson, Megan M. Korn, **Brea A. Manuel,**  
and Jennifer M. Heemstra\**J. Am. Chem. Soc.* 2020, 142, 41, 17766–17781  
<https://doi.org/10.1021/jacs.0c08996>

# Sharing Bloom's and The Study Cycle Improved Learning

Dr. Kelter:

After the ND-Gateway workshop this August, I shared Dr. McGuire's presentation with several of my colleagues and students in the ABEN department.

One ABEN student was struggling in his classes. I asked how he studied, and found he didn't have good study habits. I **shared the PPT with him on August 21, 2018, and also emphasized the content in slide 32 (Bloom's Taxonomy) and slide 45 (Study Cycle).** He wrote me an email today (September 7, 2018) and said:

**"I actually am applying myself and changed my study and planning habits and it seems to be paying off already. I scored 114% on the first and only graded homework assignment so far and took the first exam on Wednesday and got 100%."**

I also applied the suggestion in Slide 14 to my class, and **invited students to co-teach some lectures with me.** They did a fantastic job by adding much more content and real world experience to the class. This is truly a wonderful experience for me because **I saw that students poured their passion and talent into the lecture.**

Please extend my appreciation to Dr. McGuire.

Thanks,

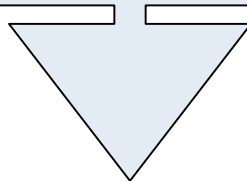
Xinhua Jia, Ph.D., P.E. Associate Professor, Agricultural and Biosystems Engineering  
North Dakota State University

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%   |
| <b>Final Course Grade:</b> | <b>B</b> | <b>C</b> |

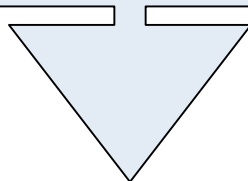


**The one 50-min presentation on study and learning strategies was followed by an improvement of one full letter grade**

**\*Cook, E.; Kennedy, E.; McGuire, S. Y. *J. Chem. Educ.*, 2013, 90 (8), 961–967**

# Performance in Gen Chem 1202 Sp 2013 Based on One Learning Strategies Session

|                            | Attended | Absent   |
|----------------------------|----------|----------|
| Exam 1 Avg:                | 71.33%   | 69.27%   |
| Homework Total:            | 169.8    | 119.1    |
| Final course Avg*:         | 82.36%   | 67.71%   |
| <b>Final Course Grade:</b> | <b>B</b> | <b>D</b> |

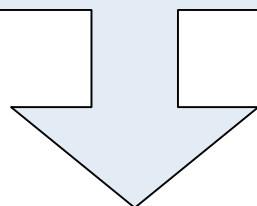


The students who attended the 50-min presentation on learning strategies finished the course two letter grades higher than those who were absent.

The homework total difference was most notable.

# Performance in Gen Chem 1202 Sp 2015 Based on One Learning Strategies Session

|                            | Attended | Absent   |
|----------------------------|----------|----------|
| Exam 1, 2, 3 Avg:          | 68.14%   | 69.67%   |
| Exam 4 Avg:                | 83.45%   | 75.91%   |
| Final Exam Avg:            | 80.98%   | 75.24%   |
| Final course Avg*:         | 84.90%   | 78.83%   |
| <b>Final Course Grade:</b> | <b>B</b> | <b>C</b> |

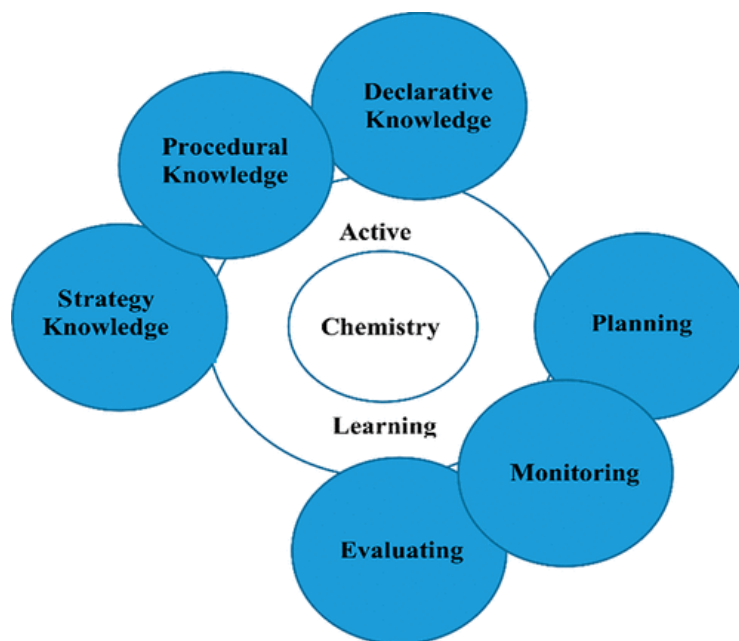


**The 50-min presentation on study and learning strategies  
*after exam 3* was followed by an improvement of one letter grade**

# Metacognition Enhances Efficacy of Active Learning

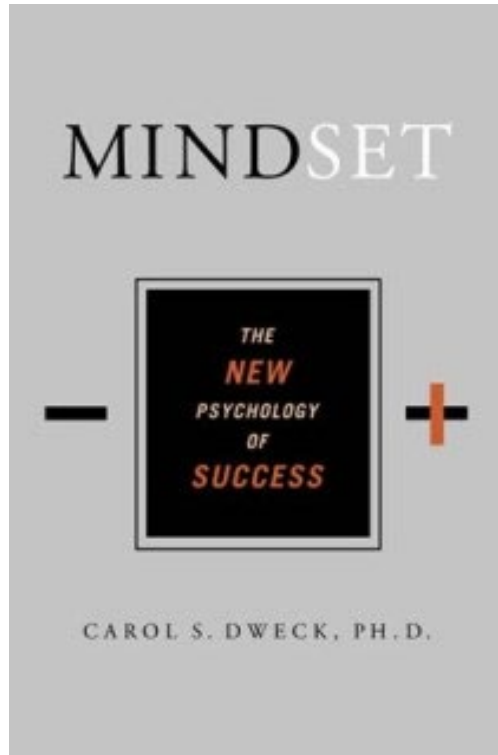
## Metacognition and Active Learning Combination Reveals Better Performance on Cognitively Demanding General Chemistry Concepts than Active Learning Alone

Jacinta M. Mutambuki\*, Mwarumba Mwavita, Caroline Z. Muteti,  
Brooke I. Jacob, and Smita Mohanty

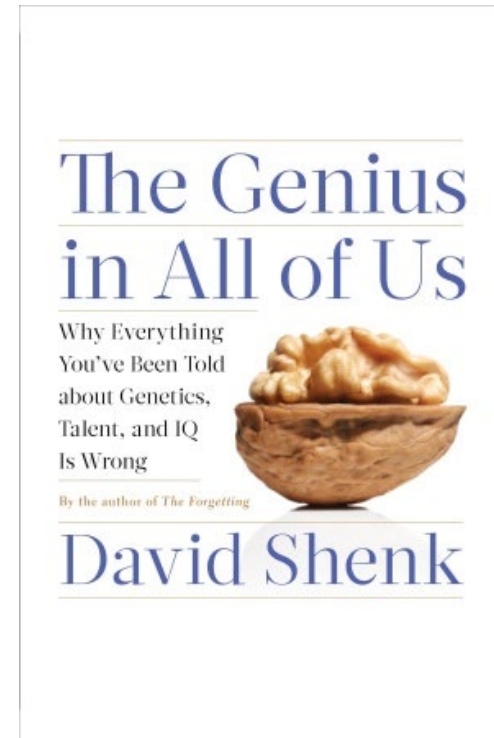


J. Chem. Educ. 2020, 97, 7, 1832–1840, Publication Date: June 25, 2020  
<https://doi.org/10.1021/acs.jchemed.0c00254>

# Mindset Matters!



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



# Two Different Mindsets About Intelligence

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- **Fixed Mindset**

Intelligence is static

You have a certain amount of it

- **Growth Mindset**

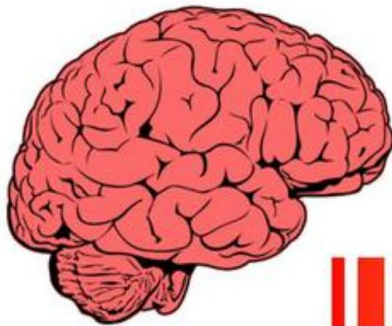
Intelligence can be developed

You can grow it with actions

# Responses to *Many* Situations are Based on Mindset

## A Mindset Shift

### Fixed



- Avoid challenges
- Give up easily
- See effort as pointless
- Ignore useful negative feedback
- Feel threatened by the success of others

### Growth



- Embrace challenges
- Persist in the face of setbacks
- See efforts as a path to mastery
- Learn from criticism
- Feel lessons and inspiration in the successes of others.



Consider where you would place yourself currently. Now think about what you can do to release your growth mindset.

# Which mindset about intelligence do you think *most students* have?

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1. Fixed
2. Growth

**Which mindset about student intelligence  
do you think *most faculty* have?**

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1. Fixed
2. Growth

## *Email from a General Chemistry Student with a Fixed Mindset*

“...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

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“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

## Study links faculty attitudes on intelligence to student success in STEM, with large impact on minority student success

Submitted by Scott Jaschik on February 18, 2019 - 3:00am

A new study suggests that faculty members' attitudes about intelligence can have a major impact on the success of students in science, mathematics and technology courses. Students see more achievement when their instructors believe in a "growth mind-set" about intelligence than they do learning from those who believe intelligence is fixed. The impact was found across all student groups but was most pronounced among minority students.

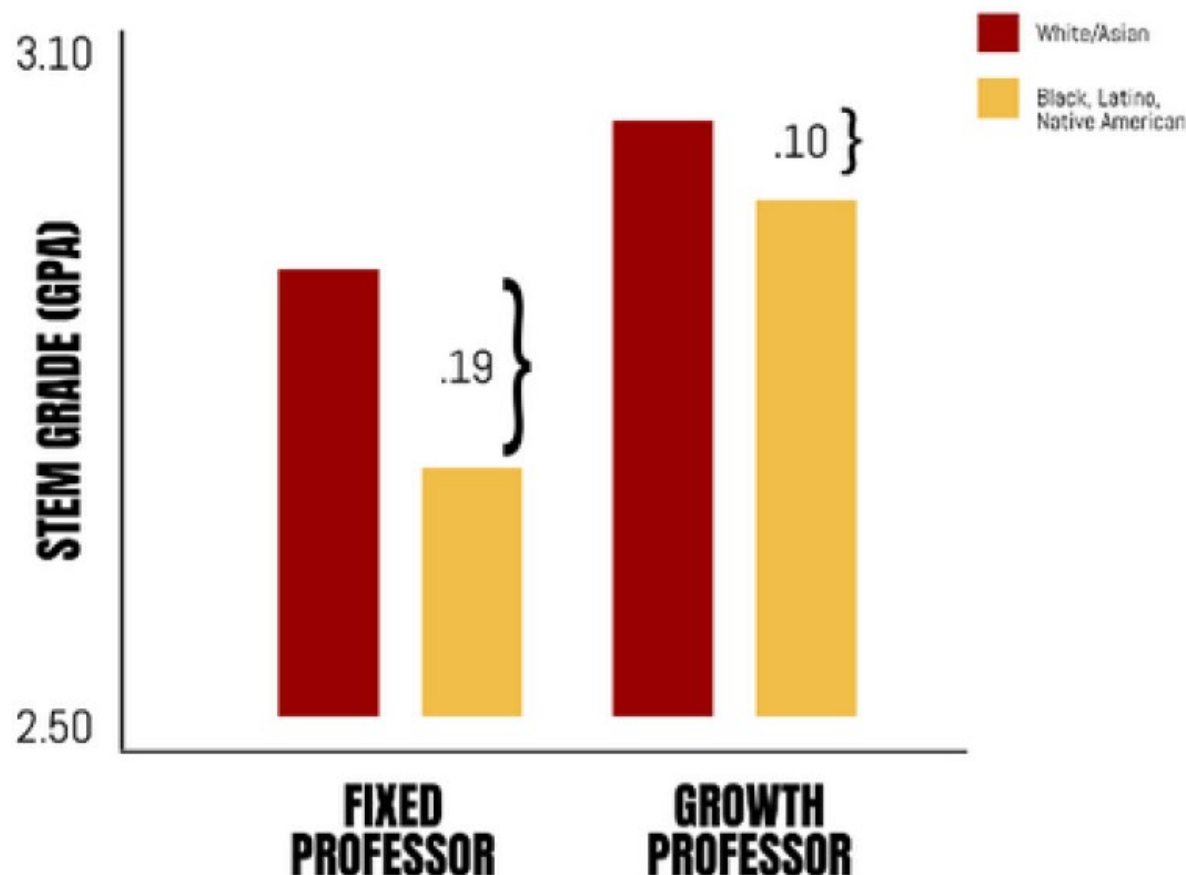
The study -- by brain science scholars at [Indiana University at Bloomington](#) <sup>[1]</sup> -- was published in the journal *[Science Advances](#)* <sup>[2]</sup> and presented last week at the annual meeting of the American Association for the Advancement of Science.

The researchers collected data on 150 faculty members in a range of STEM disciplines and 15,000 students over two years at a large public research university that is not identified. Faculty members were asked to respond to a general statement about intelligence along the lines of "To be honest, students have a certain amount of intelligence, and they really can't do much to change it."

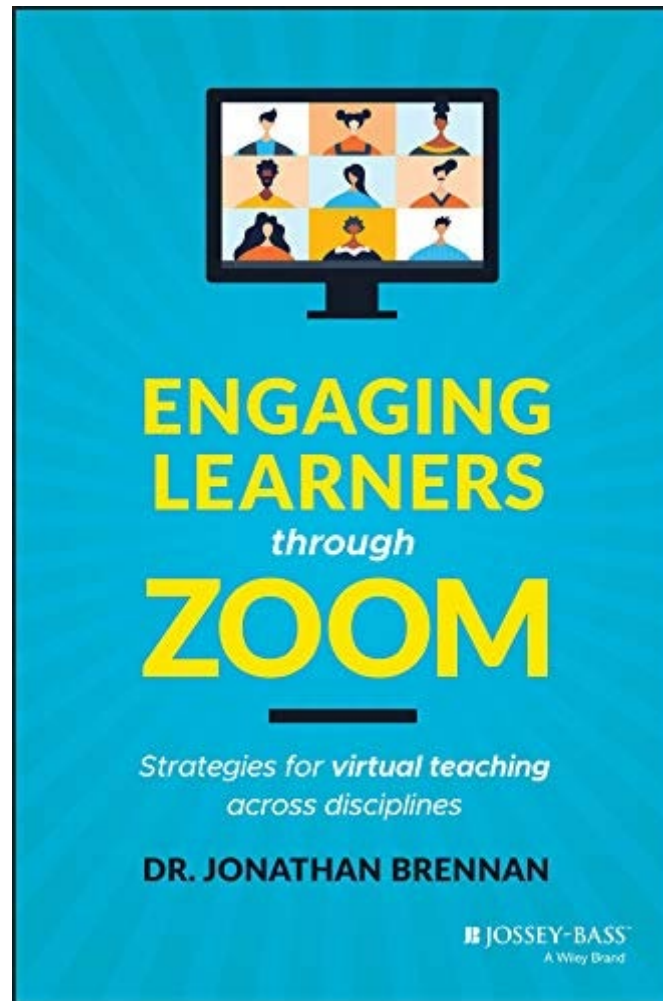
The study then looked at student performance in courses taught by those who agreed with that perspective and those who did not.

## The findings:

While all students perform better when STEM professors endorse a growth mindset belief, the racial achievement gap is almost halved when professors endorse a growth-mindset belief.



# A Great Resource for Online Learning



*Brennan, J. (2021). Engaging Learners Through Zoom: Strategies for Virtual Teaching Across Disciplines. Sterling, VA: Stylus*



# LSU Analytical Chemistry Graduate Student's Cumulative Exam Record

| <u>2004 – 2005</u> |        |  | <u>2005 – 2006</u> |                      |
|--------------------|--------|--|--------------------|----------------------|
| 9/04               | Failed |  | 10/05              | Passed               |
| 10/04              | Failed |  | 11/05              | Failed               |
| 11/04              | Failed | Began work<br>with CAS and<br>the Writing<br>Center in<br>October 2005 | 12/05              | Passed best in group |
| 12/04              | Failed |  | 1/06               | Passed               |
| 1/05               | Passed |  | 2/06               | Passed               |
| 2/05               | Failed |  | 3/06               | Failed               |
| 3/05               | Failed |  | 4/06               | Passed last one!     |
| 4/05               | Failed |  | 5/06               | N/A                  |



**Dr. Algernon Kelley, December 2009**

## *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.*

# Conclusion

We *can* significantly increase student success by...

- teaching students *how* to learn
- making learning *visible*
- *not judging* student potential on initial performance
- encouraging students to *persist in the face of initial failure*
- encouraging the *use of metacognitive tools for deep and integrative learning*



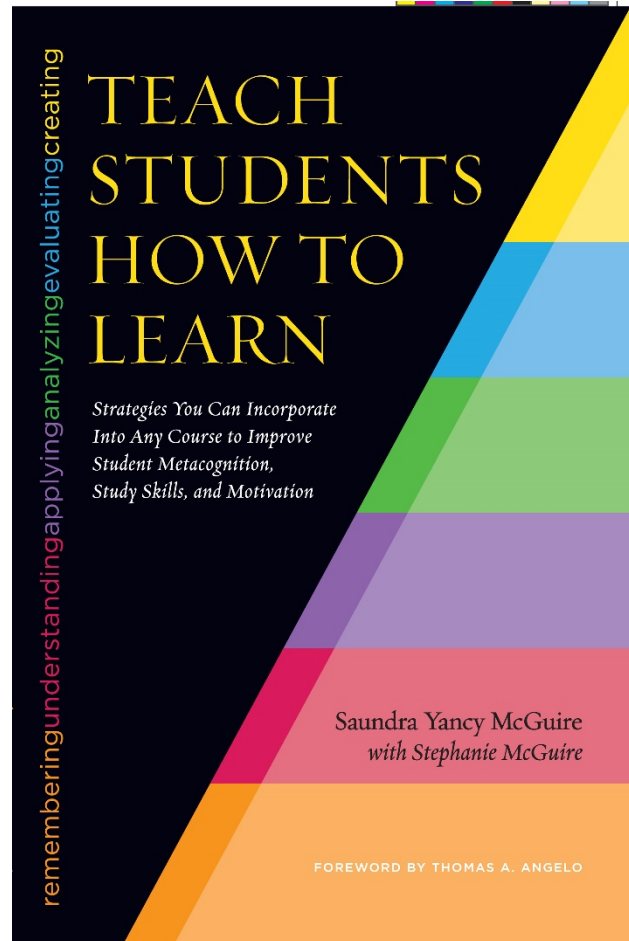


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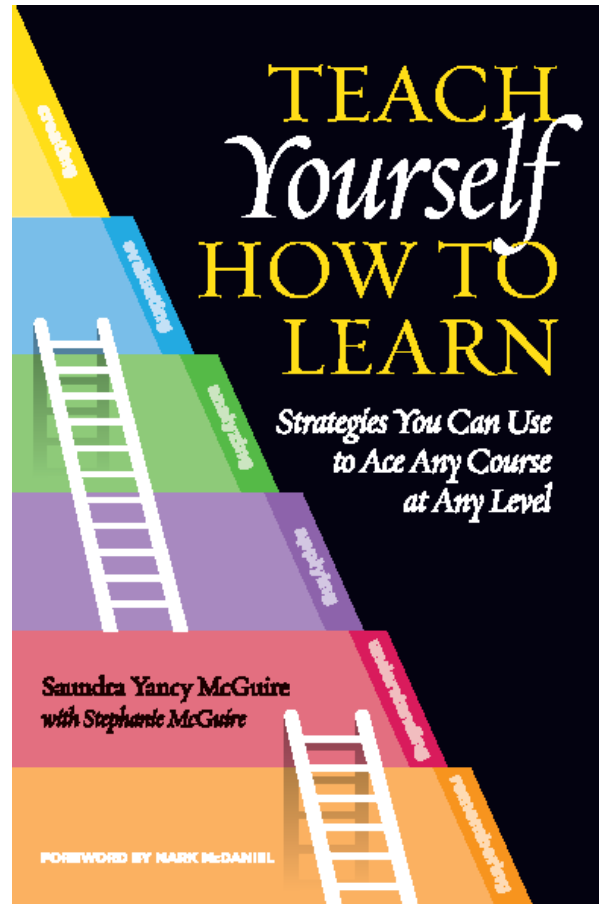
<http://academic.pg.cc.md.us/~wpeirce/MCCCTR/metacognition.htm>

# A Faculty Resource



**McGuire, S.Y. (2015). *Teach Students How to Learn: Strategies You Can Incorporate into Any Course to Improve Student Metacognition, Study Skills, and Motivation*. Sterling, VA: Stylus**

# The Book for Students



**McGuire, S.Y. (2018). *Teach Yourself How to Learn: Strategies You Can Use to Ace Any Course at Any Level*. Sterling, VA: Stylus**