



# Why is Research Challenging?

It requires many skills in different domains

- **Cognitive - Thinking Skills**

- Information Processing
- Problem Solving

- **Affective – Attitudes and Feelings**

- Confidence
- Curiosity
- Enthusiasm

- **Psychomotor – manual or physical skills**

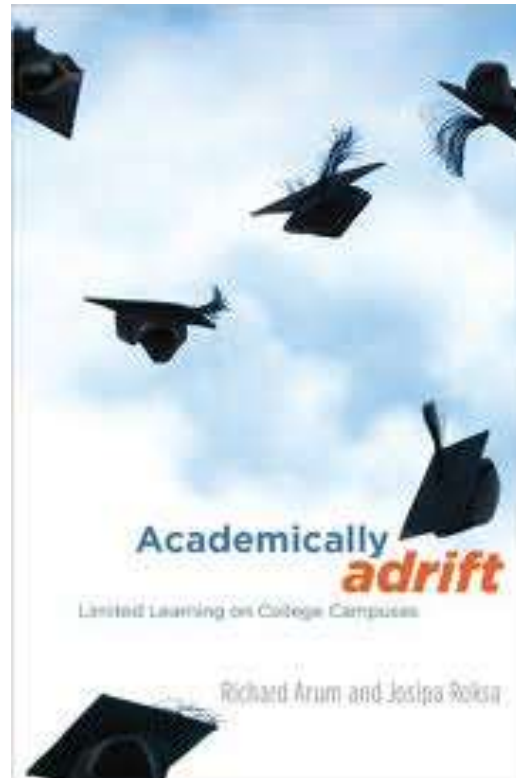
- Performing Laboratory Procedures
- Handling Instruments

# Cognitive Skills Needed for Research\*

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

\*From survey of LSU research mentors, March 2008

# But many students have not developed these abilities



Arum, Richard and Roksa, Josipa. 2011. *Academically Adrift: Limited Learning on College Campuses*. Chicago: University of Chicago Press.

# But they *can develop* them if we...

- Teach students *how* to learn



- Help them develop the right mindset

# Metacognition: The Key to Improving Cognitive Skills

The ability to:

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

# Why haven't most students developed metacognitive skills?



# According to data from the entering class of 2011...\*

- *It wasn't necessary in high school*
  - 60.5% of 2011 (down from 63% in 2010) entering first year students spent less than six hours per week doing homework in 12<sup>th</sup> 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 results*



*productive behavior* → *desired results*

# 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

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- **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

# 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

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**Anticipatory set CAN interfere!**

**Let's look at the car on the next slide...**

**Is this a 2-door or 4-door car?**



Dana, *first year physics student*

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



**Problem:** Memorizing formulas and using  
[www.cramster.com](http://www.cramster.com)

**Solution:** Solve problems with no external  
aids and test mastery of concepts

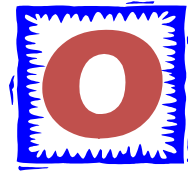
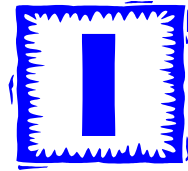


# Why the Fast and Dramatic Increase?

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**

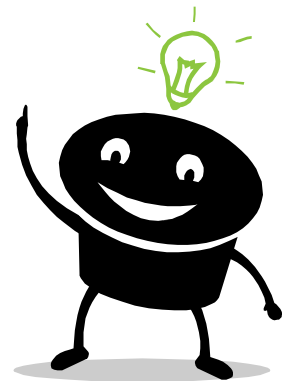
**Valentine's Day**

**Quarter Hour**

**NOW, how many words or phrases  
do you remember?**

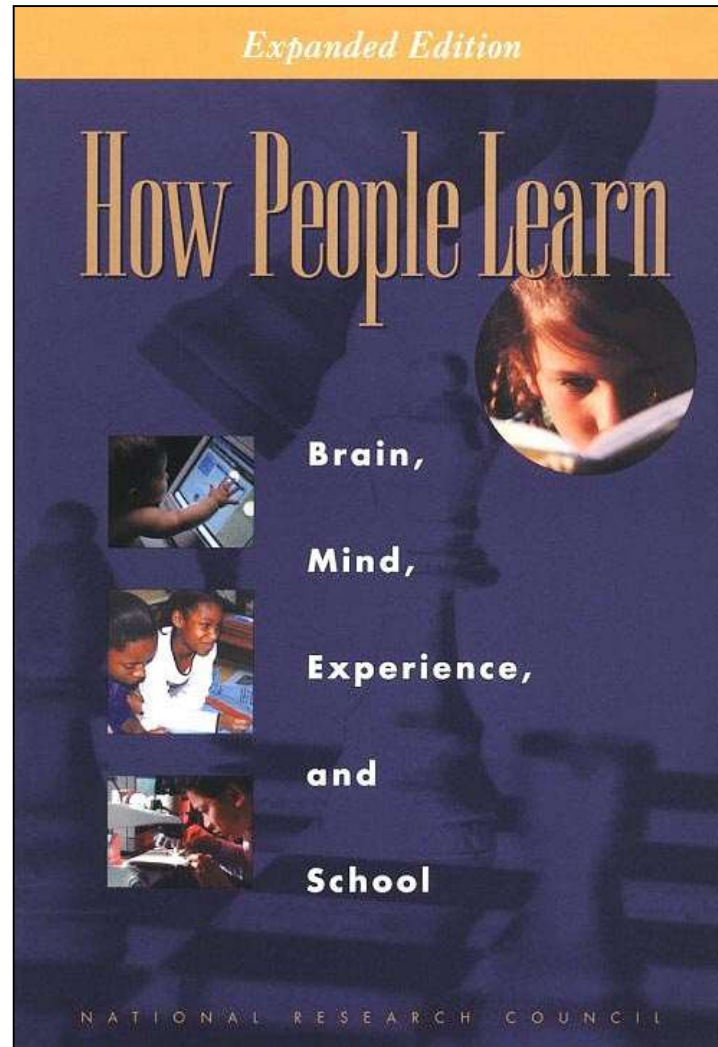
**What were two major *differences* between the two attempts?**

- 1. We knew what the task was**
- 2. We knew how the information was organized**





# Excellent Resource



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

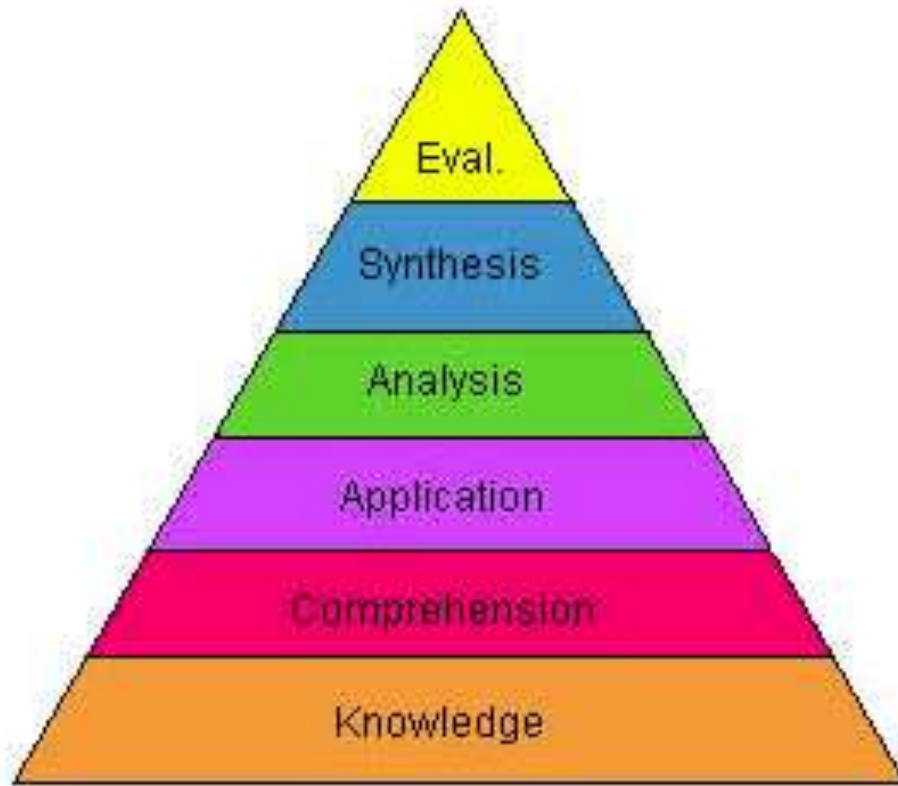
- Active learning is more lasting than passive learning
  - Passive learning is an oxymoron\*
- Thinking about thinking is important
  - Metacognition\*\*
- The level at which learning occurs is important
  - Bloom's Taxonomy\*\*\*

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

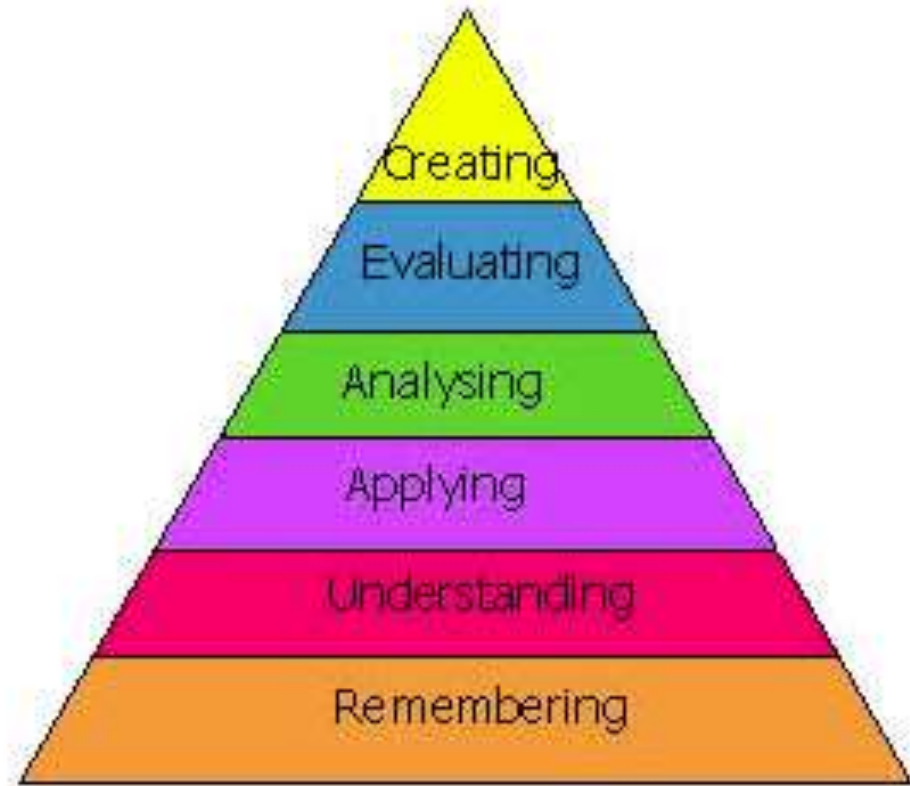
\*\* Flavell, John, "Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry." *American Psychologist*, Vol 34(10), Oct 1979, 906-911.

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

# Bloom's Taxonomy



Old Version

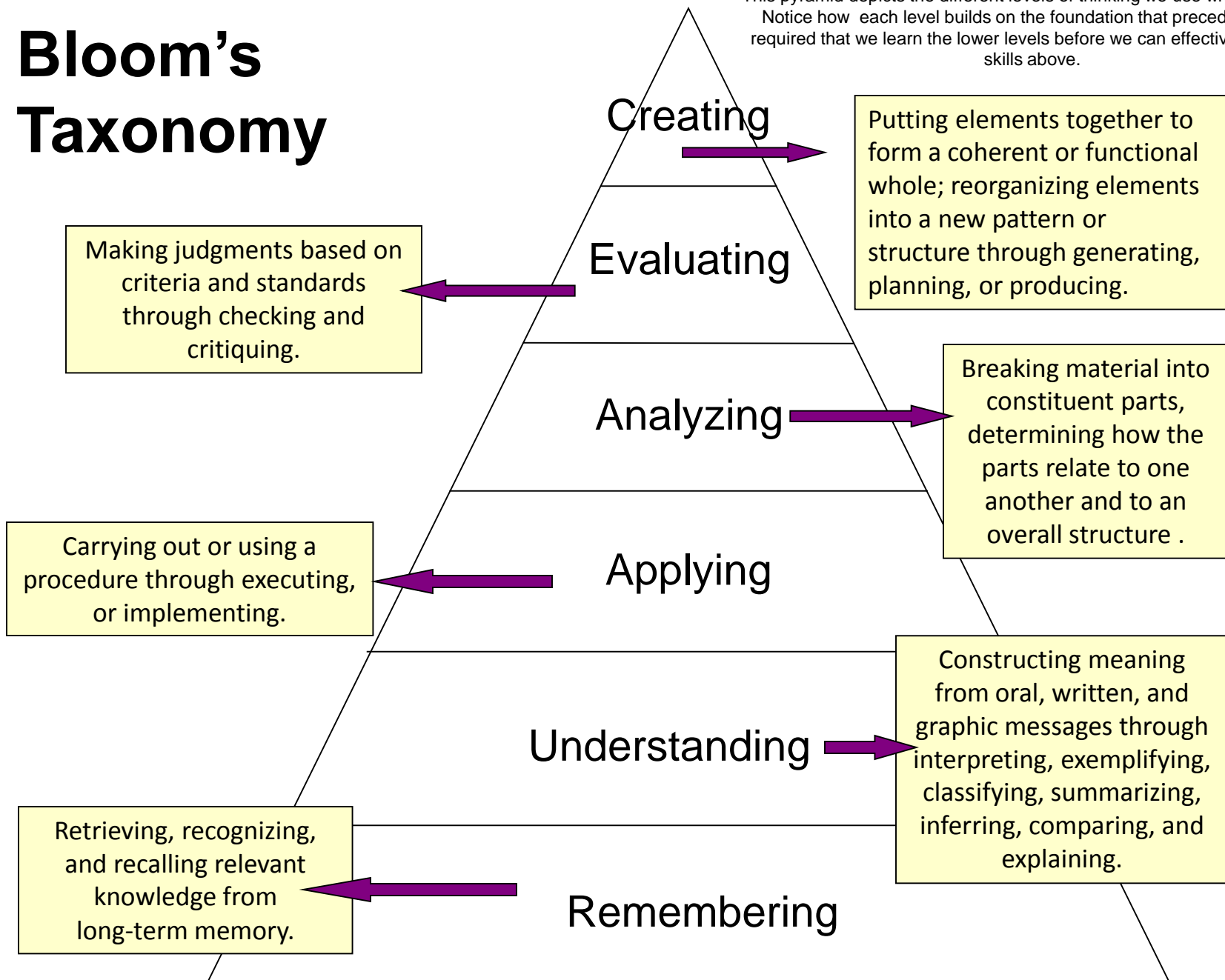


New Version

Anderson & Krathwohl, 2001

# 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.



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

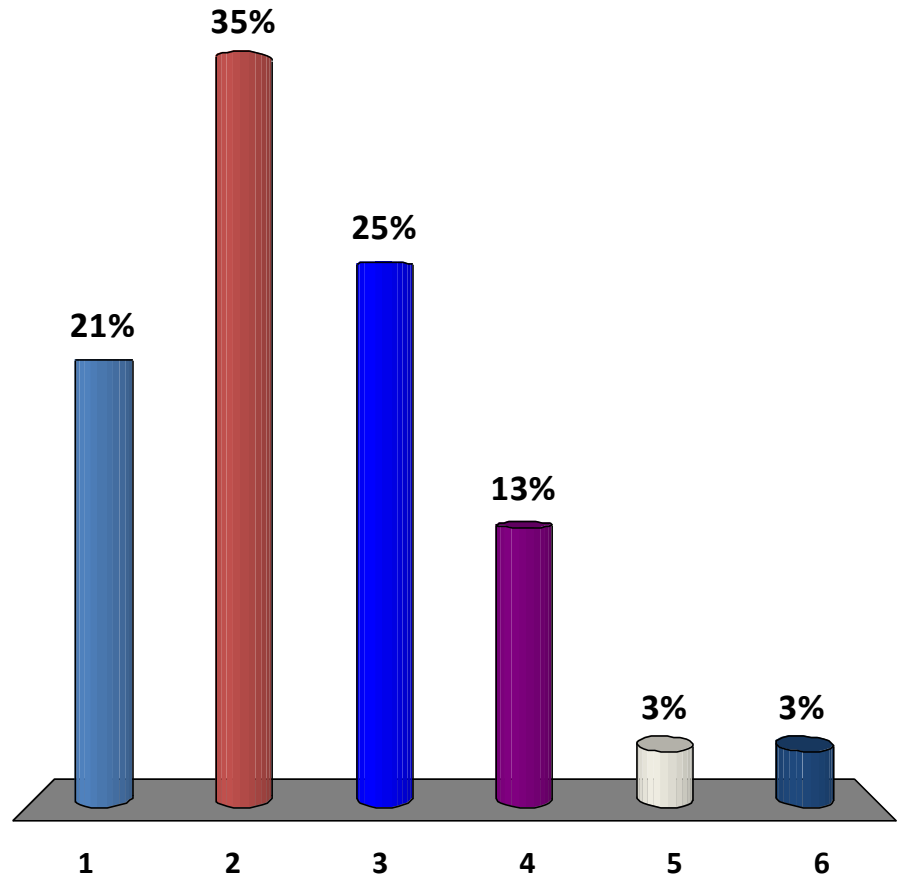
**They GET it!**



## *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?**

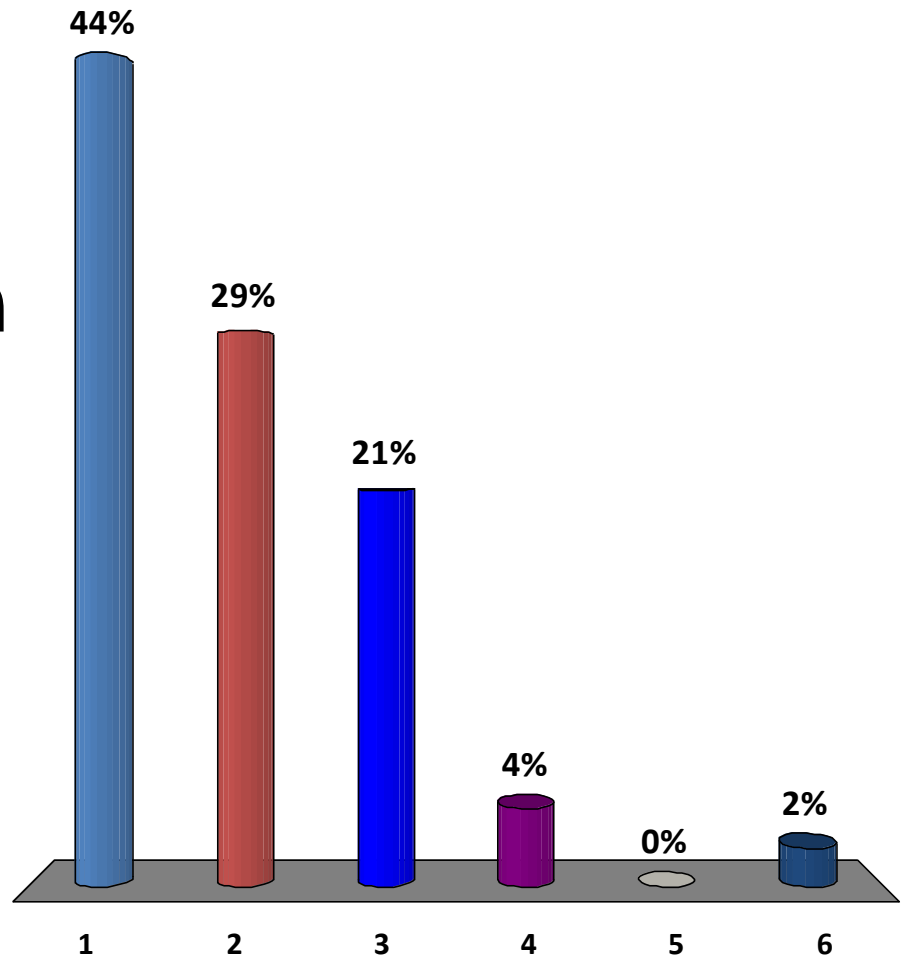
1. Knowledge
2. Comprehension
3. Application
4. Analysis
5. Synthesis
6. Evaluation



## *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?**

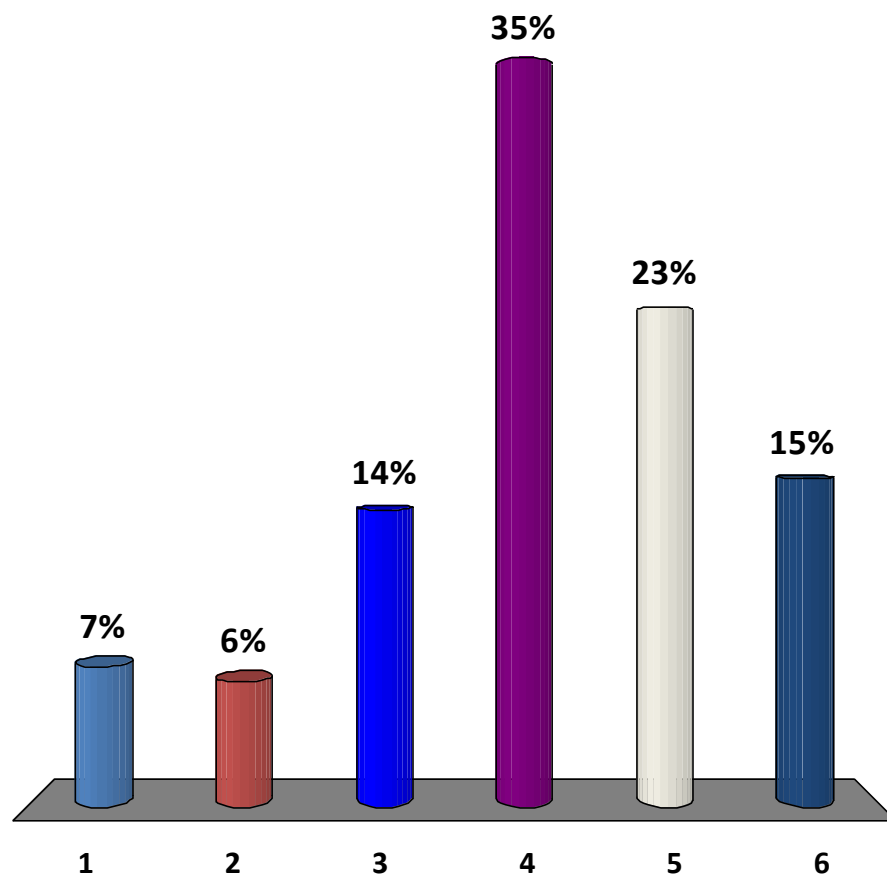
- 1. Knowledge**
- 2. Comprehension**
- 3. Application**
- 4. Analysis**
- 5. Synthesis**
- 6. Evaluation**



## *How students answered (in 2008)*

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

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

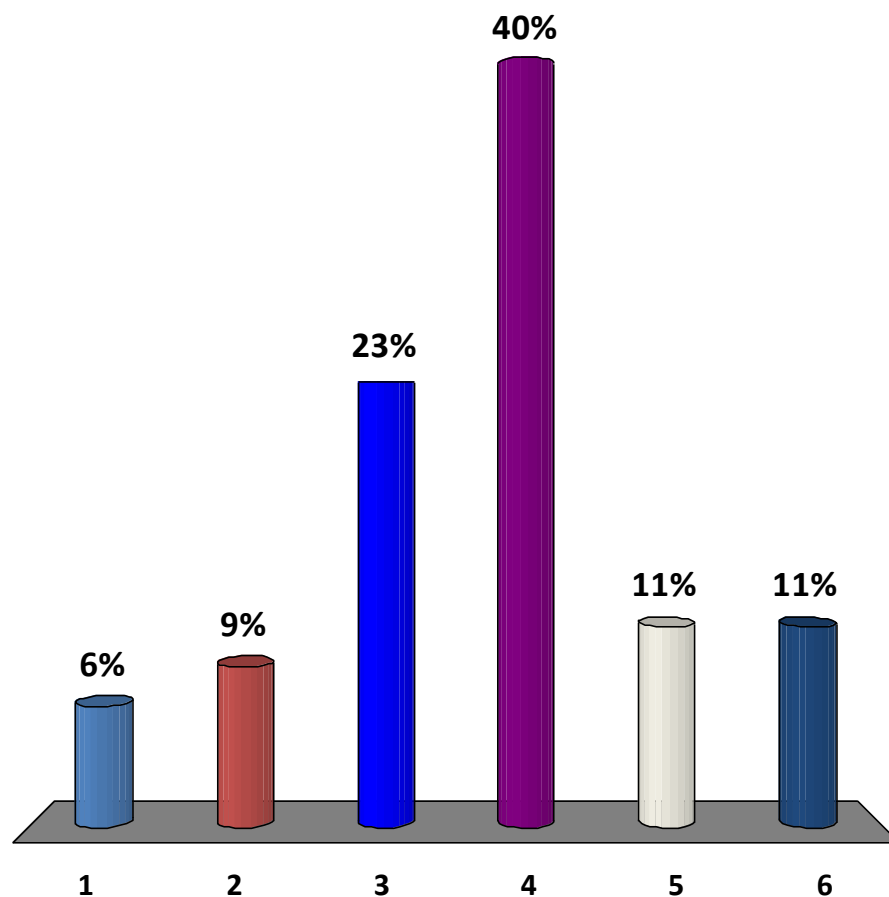




## *How students answered (in 2013)*

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

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



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

## Teach them the Study Cycle\*



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

## 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

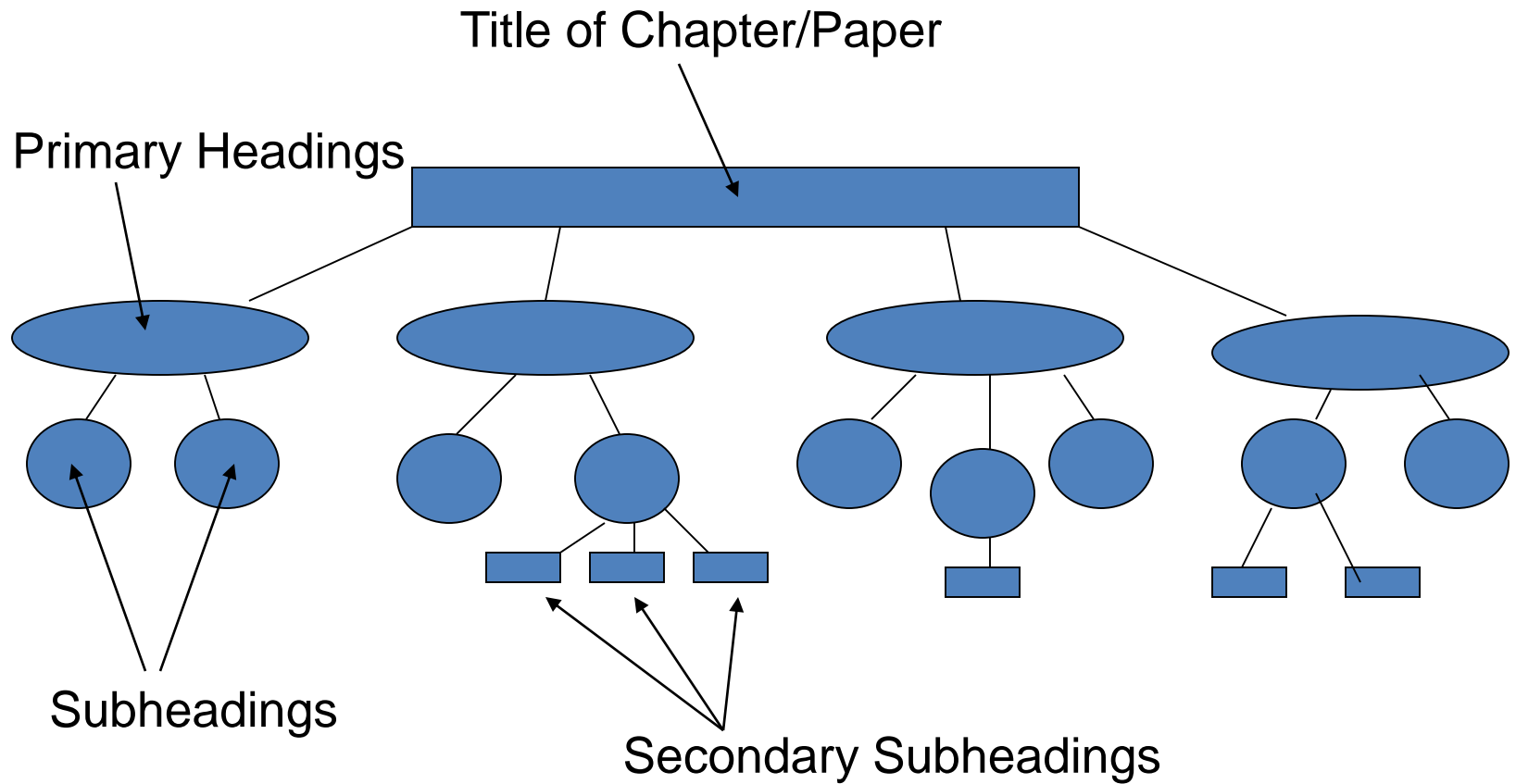
1	<b>Set a Goal</b>	1-2 min	<b>Decide what you want to accomplish in your study session</b>
2	<b>Study with Focus</b>	30-50 min	<b>Interact with material</b> - organize, concept map, summarize, process, re-read, fill-in notes, reflect, etc.
3	<b>Reward Yourself</b>	10-15 min	<b>Take a break</b> – call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

# Concept maps can develop ability to think critically



And there are many different forms  
of concept maps

# Chapter/Paper Map



# Compare and Contrast

**Thermodynamic Control**

**Kinetic Control**

**How are they similar?**

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**How are they different?**

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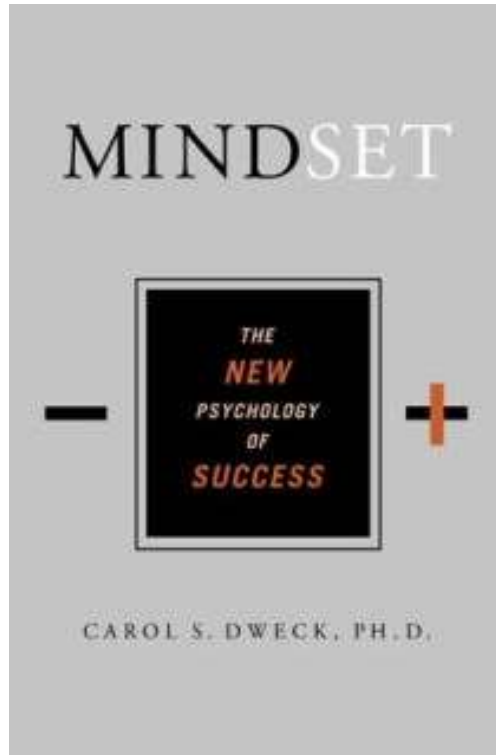
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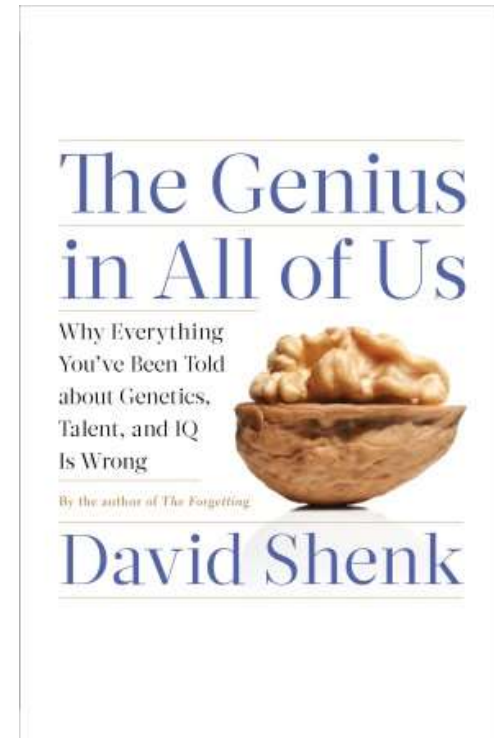
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# Help Students Develop the Right Mindset



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



# Responses to *Many* Situations are Based on Mindset

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

## *Email from a Spring 2011 Chem 1201 student*

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

April 6, 2011

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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

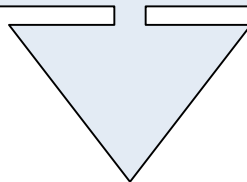
Semester GPA: 3.8

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:	<b>81.60%</b>	<b>70.43%</b>
<b>Final Course Grade:</b>	<b>B</b>	<b>C</b>



**The one 50-min presentation on study and learning strategies  
resulted in an improvement of one full letter grade!**



## ARTICLES

**Effect of Teaching Metacognitive Learning Strategies on Performance in General Chemistry Courses**

Elzbieta Cook, Eugene Kennedy, and Sandra Y. McGuire

pp 961-967

Publication Date (Web): July 11, 2013 (Chemical Education Research)

DOI: 10.1021/ed300686h

[Abstract](#) | [Supporting Info](#)

ACS ActiveView PDF  
Hi-Res Print, Annotate, Reference QuickView

PDF [959K]

PDF w/ Links [318K]

Full Text HTML

Add to ACS ChemWorx



## Metacognition: An Effective Tool to Promote Success in College Science Learning\*

Ninfeng Zhao<sup>1</sup>, Jeffrey Wardeska<sup>1</sup>, Sandra McGuire<sup>2</sup>, Elzbieta Cook<sup>2</sup>

<sup>1</sup>Department of Chemistry, East Tennessee State University

<sup>2</sup>Department of Chemistry, Louisiana State University

\*Accepted for publication April 2013



**Sharing Strategies that  
Have Worked for Others  
Can Be Very Motivational**

## Before and After

- Robert, freshman chemistry student  
42, 100, 100, 100 A in course
- Michael, senior pre-med organic student  
30, 28, 80, 91 B in course
- Miriam, freshman calculus student  
37.5, 83, 93 B in course
- Ifeanyi, sophomore thermodynamics student  
67, 54, 68, 95 B in course
- Terrence, junior Bio Engineering student  
GPA 1.67 cum, 3.54 (F 03), 3.8 (S 04)

# Top 5 Reasons Folks Did Not Do Well on Test 1 in General Chemistry\*

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

\*McGuire's Survey of General Chemistry Students



# Top 5 Reasons Students Made an A on Test 1:

- 1. Did preview-review for every class
- 2. Did a little of the homework at a time
- 3. Used the book and did the suggested problems
- 4. Made flashcards of the information to be memorized
- 5. Practiced explaining the information to others

# 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.*

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

# Cognitive Skills Needed for Research\*

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

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\*From survey of LSU research mentors, March 2008

# Top 5 Reasons Students Flounder in Research Environments\*

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

\*McGuire's observations

# Top 5 Reasons Students Excel in Research Environments

- 1. Review and **master the basics**
- 2. **Understand how their project fits into the larger research picture** in their field
- 3. Operate at the **higher levels of Bloom's**
- 4. **Understand the "culture"** of the group and of the greater research community
- 5. Have a **growth intelligence mindset** and embrace challenges, expend effort, and persist through difficulties

# 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 with CAS and the Writing Center in	12/05	Passed best in group
12/04	Failed	October 2005	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.***



# Teaching and Learning Strategies That Work

*SCIENCE* , VOL 325

4 SEPTEMBER 2009

[www.sciencemag.org](http://www.sciencemag.org)

**ROALD HOFFMANN<sup>1\*</sup>**

**AND**

**SAUNDRA Y. MCGUIRE<sup>2</sup>**



**<sup>1</sup>Department of Chemistry and Chemical Biology, Cornell University, Baker Laboratory, Ithaca, NY 14853, USA.**

**<sup>2</sup>Center for Academic Success and Department of Chemistry, Louisiana State University, Baton Rouge, LA 70803, USA.**

AMERICAN  
**Scientist**

September-October 2010  
Volume 98, Number 5

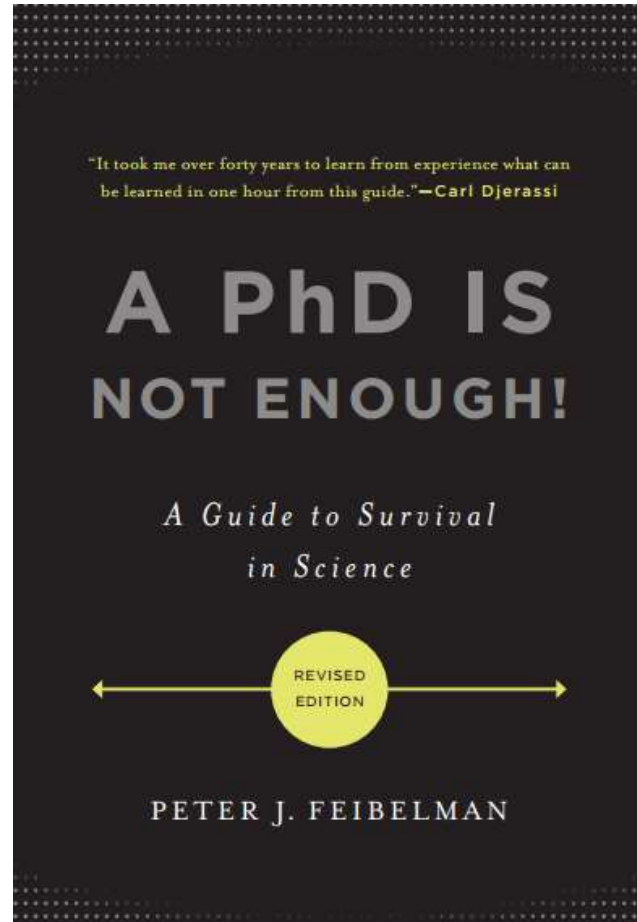


MARGINALIA

## **Learning and Teaching Strategies**

Roald Hoffmann and Sandra Y. McGuire

# Excellent Resource for Students



Feibelman, Peter J, 2011. *A PhD Is Not Enough!* New York: Basic Books

# ***We can* significantly increase students' preparation for research!**

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

# Special Note

Please visit the CAS website at [www.cas.lsu.edu](http://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](mailto:smcgui1@lsu.edu).

Have fun teaching your students powerful metacognitive strategies!

Sandra McGuire

# Useful Websites

- [www.cas.lsu.edu](http://www.cas.lsu.edu)
- [www.howtostudy.org](http://www.howtostudy.org)
- [www.vark-learn.com](http://www.vark-learn.com)
- [www.drearlbloch.com](http://www.drearlbloch.com)
- Searches on [www.google.com](http://www.google.com)

# Additional References

- Bransford, J.D., Brown, A.L., Cocking, R.R. (Eds.), 2000. *How people learn: Brain, Mind, Experience, and School*. Washington, DC: National Academy Press.
- Christ, F. L., 1997. *Seven Steps to Better Management of Your Study Time*. Clearwater, FL: H & H Publishing
- Cromley, Jennifer, 2000. *Learning to Think, Learning to Learn: What the Science of Thinking and Learning Has to Offer Adult Education*. Washington, DC: National Institute for Literacy.
- Ellis, David, 2006. *Becoming a Master Student\**. New York: Houghton-Mifflin.
- Hoffman, Roald and Sandra Y. McGuire. (2010). Learning and Teaching Strategies. *American Scientist* , vol. 98, pp. 378-382.
- Nilson, Linda, 2004. *Teaching at It's Best: A Research-Based Resource for College Instructors*. Bolton, MA: Anker Publishing Company.

\*Excellent student reference