

# ...Speed Networking...

You have:

- 1 MINUTE each to explain what you will be teaching at St. Olaf *and* your research area
- 2 MINUTES to ask questions/talk. Try to find an area where your professional lives at St. Olaf might intersect
- Then move one chair clockwise and start again...

# How Learning Works: Seven Research-Based Principles

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# Quick Problem to Solve

There are 26 sheep and 10 goats on a ship. How old is the captain?

Adults: Unsolvable  
5th graders: Over 75% attempted to provide a numerical answer.

After giving the answer “36” one student explained “Well, you need to add or subtract or multiply in problems like this, and this one seemed to work best if I add.”

(Bransford & Stein, '93)

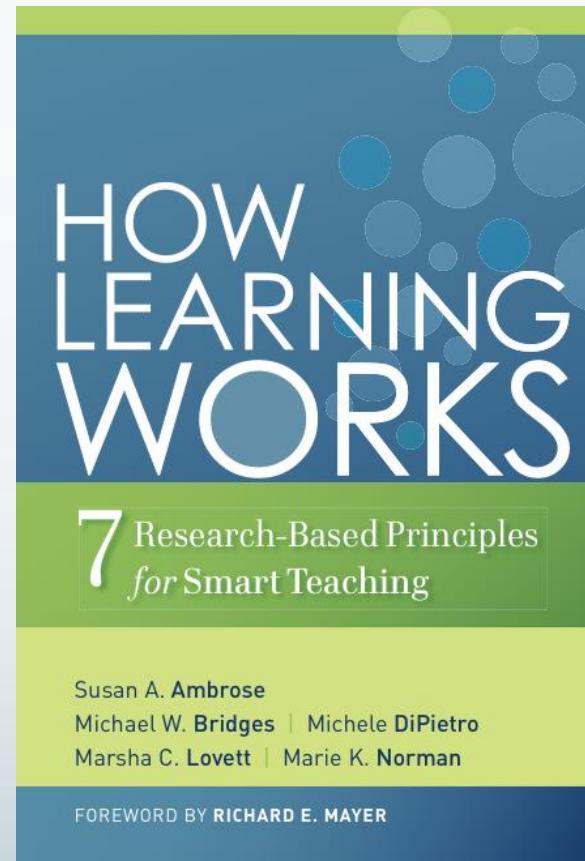
# **The Moral:**

We must really understand how students  
*process what we teach them!!*

# How Learning Works: Seven Research-Based Principles

Synthesis of 50 years of research

- Constant determinants of learning
- Principles apply cross-culturally
  - Translations to Mandarin, Korean and (forthcoming) Japanese



# Objectives

Following this workshop, you should be better able to consider pedagogical strategies to support learning based on the seven principles.

# What is Learning?

One definition:

**“Learning is a *process* that leads to change, which occurs as a result of experience and increases the potential for improved performance and future learning.”**

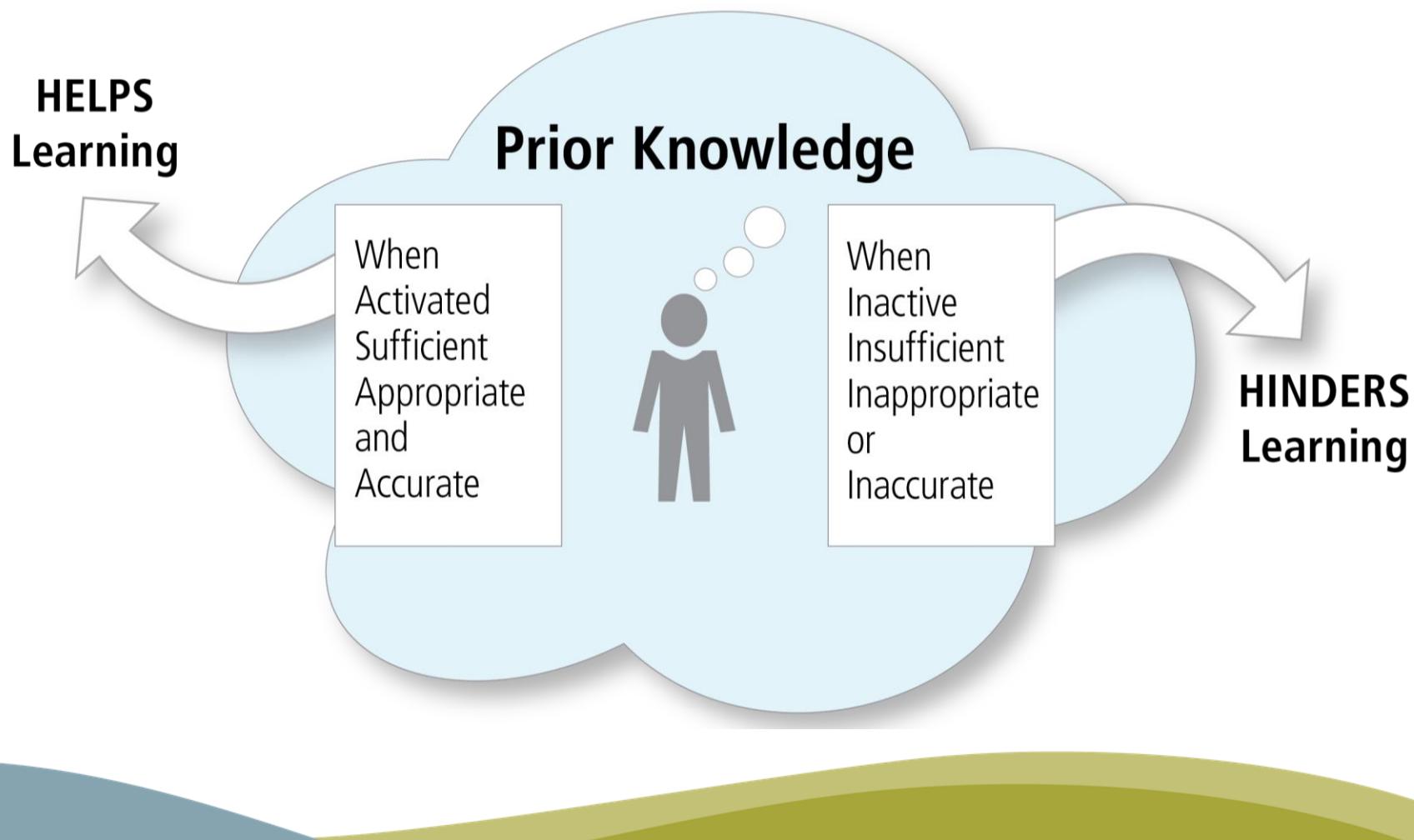
# 7 Learning Principles

1. Students' **prior knowledge** can help or hinder learning.
2. How students **organize knowledge** influences how they learn and apply what they know.
3. Students' **motivation** determines, directs, and sustains what they do to learn.
4. To develop **mastery**, students must acquire component skills, practice integrating them, and know when to apply what they have learned.
5. Goal-directed **practice** coupled with targeted **feedback** enhances the quality of students' learning.
6. Students' current level of **development** interacts with the social, emotional, and intellectual **climate** of the course to impact learning.
7. To become **self-directed** learners, students must learn to monitor and adjust their approaches to learning.

“I consider that a man's brain originally is like a little empty attic, and you have to stock it with such furniture as you choose.”  
(Sherlock Holmes, *A Study in Scarlet*)

**FALSE**

# 1. Prior Knowledge can help or hinder learning



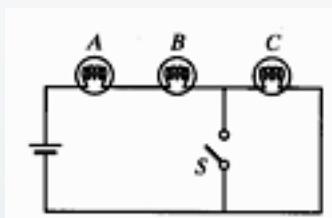
# Prior knowledge can hinder learning

If it is:

- Inappropriate
- Insufficient
- Inaccurate

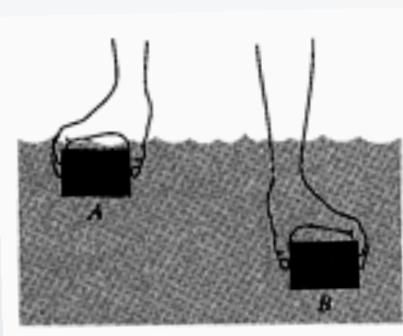
# Some examples of inaccurate prior knowledge (*misperceptions*)

When the switch S is closed, do the following increase, decrease, or stay the same?



- a) The intensity of A & B
- b) The intensity of C
- c) The current drawn from the battery
- d) The voltage drop across each bulb
- e) The power dissipated in the circuit

Bricks A & B are identical. The force needed to hold B in place (deeper than A) is



- a) Larger than
- b) The same as
- c) Smaller than  
the force required to hold A in place

**What are some  
misconceptions students  
have in your field?**

# Some other misconceptions....

**Science:** Seasons happens because the earth orbits the sun elliptically (Schneps and Sadler, 1988)

**Statistics:** Association implies causation

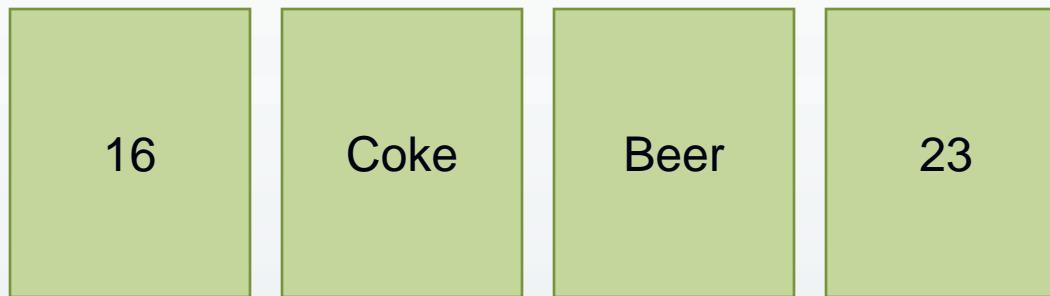
**Psychology/Neuroscience:** People use only 10% of their brains

# But even if prior knowledge is correct...



- Each card has a letter on one side and a number on the other.
- Rule: If a card has a vowel on one side, it must have an even number on the other side.
- Questions: What is the minimum number of cards that must be turned over to check whether this rule is being followed? Which cards are they? (Wason 1966, 1977)

# Reasoning *Using* Prior Knowledge



- Each card represents a student at a bar. The age of each student is on one side and what she is drinking is on the other.
- Rule: If a person is drinking a beer, then she is over 21
- Question: Which card(s) must be turned over to check whether everyone's behavior is legal? (Griggs & Cox, 1982)

# The moral

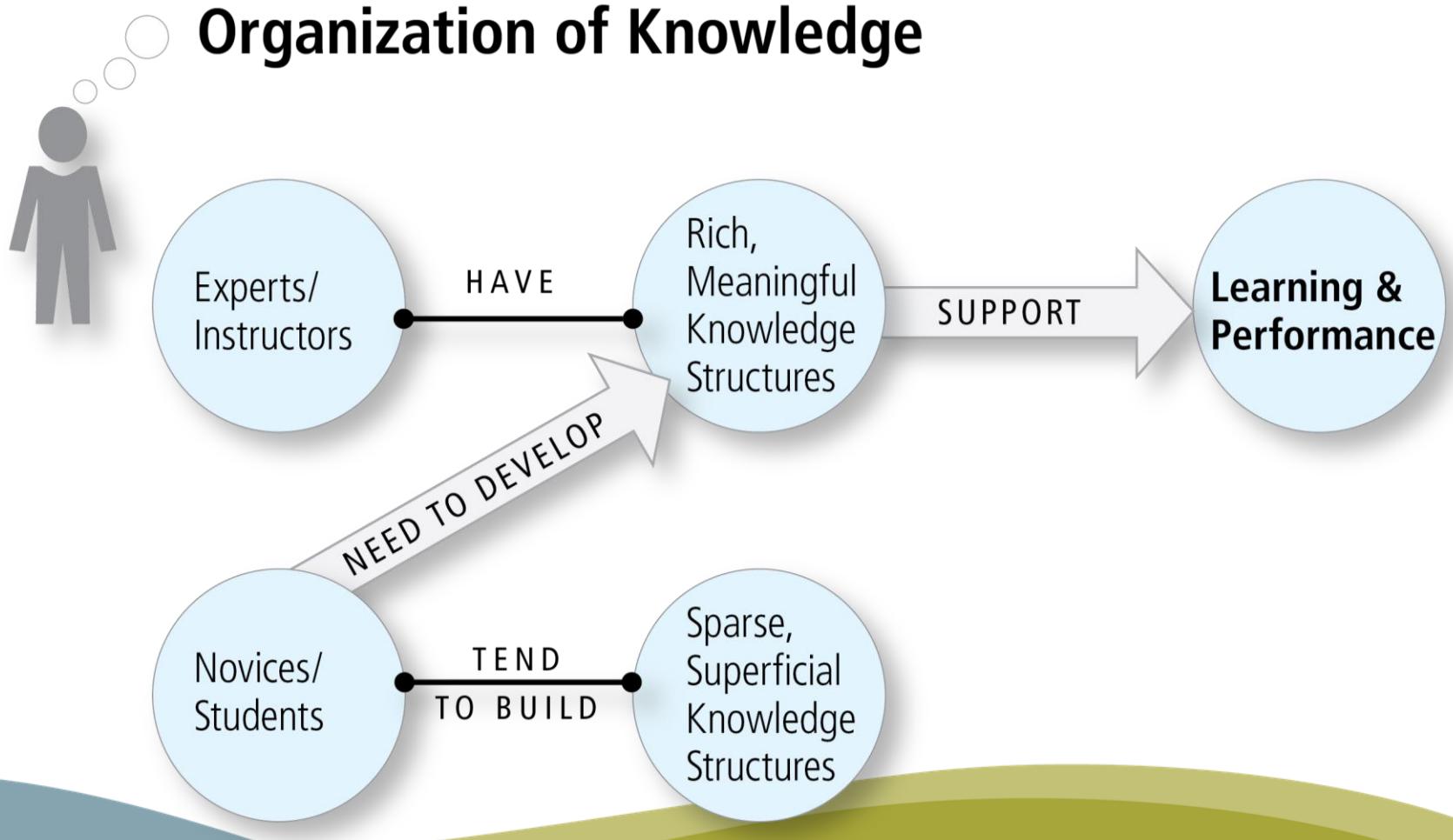
- Prior knowledge lies *inert* most of the time
- Prior knowledge must be *activated* to be useful

# What we owe our students

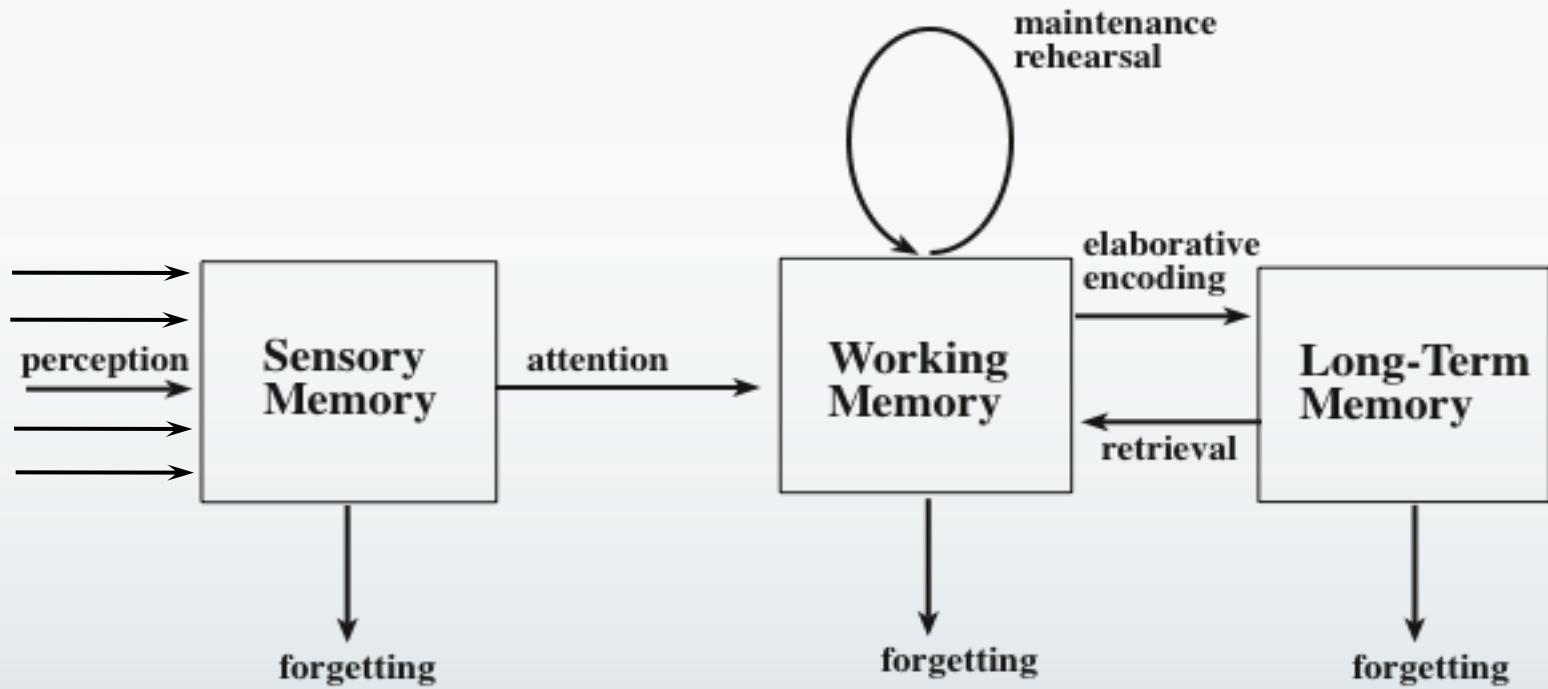
Learning environments that:

- Value and engage what students bring to the table
- Actively confront and challenge misconceptions

## 2. How students organize knowledge influences how they learn and apply what they know



# How is information processed?



(Atkinson and Shiffrin 1968; Baddeley, 1986)

Memorize the following list:

**TSXCOBCAFTNB**

Try again:

**FOXABCTNTCBS**

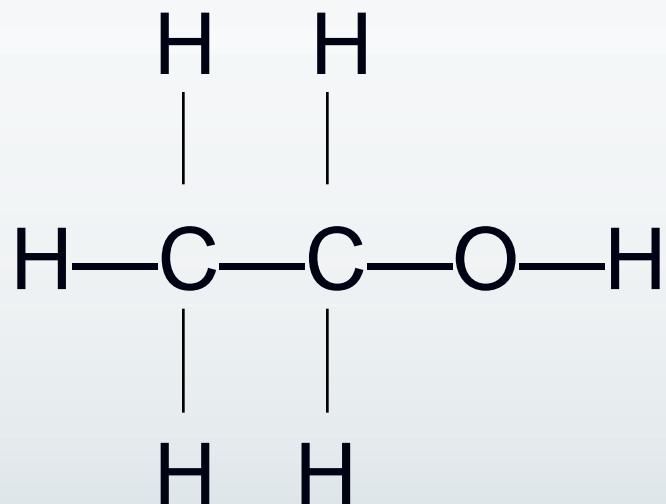
# A Statistics Example

Memorize the following formula:

$$f(x) = \frac{1}{\sqrt{2\pi \cdot 5}} e^{-\frac{1}{2} \frac{(x-10)^2}{5}}$$

# A Chemistry Example

Memorize the following formula:



# Knowledge Organization

We all “chunk” knowledge and organize it by connecting new information to existing knowledge

The same knowledge can be organized in multiple ways

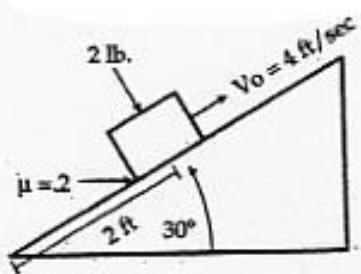
Experts have mental structures very different from novices/students

# How Novices & Experts Differ

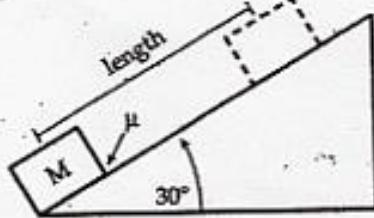
(Chi, Feltovich & Glaser, 1981)

## Novices' Groupings

Problem 23



Problem 35

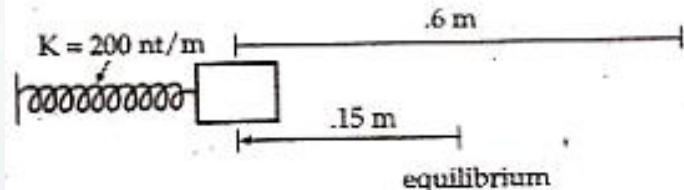


Novice 1: "These deal with blocks on an inclined plane"

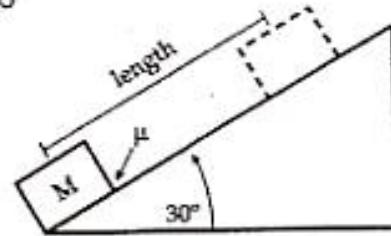
Novice 6: "Blocks on inclined planes with angles"

## Experts' Groupings

Problem 21



Problem 35



Expert 2: "Conservation of Energy"

Expert 4: "These can be done from Energy considerations"

# How Novices & Experts Differ

- Experts have a higher density of connections
- Experts' structures rely on deep underlying principles
- Experts have more flexible structures

These features affect memory, meaning-making, and transfer.

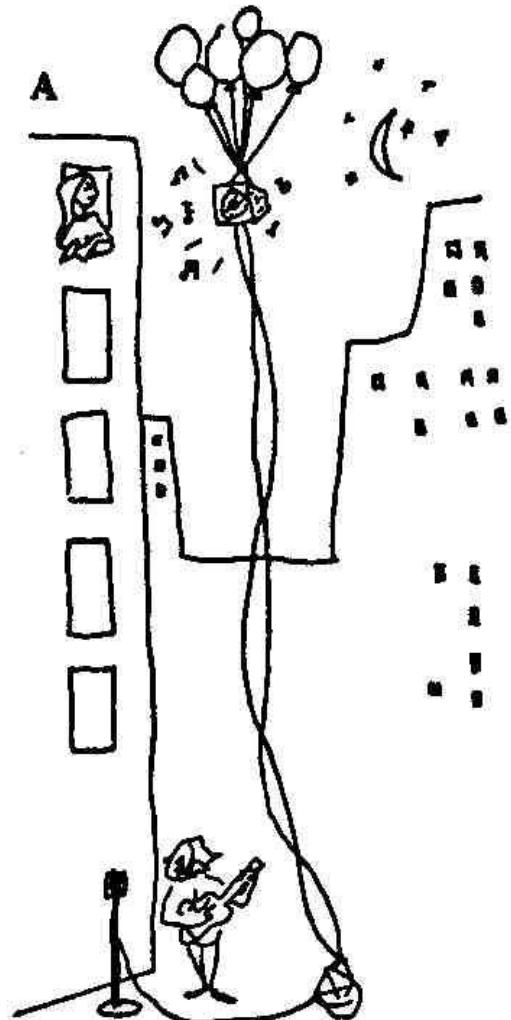
# An Example...

If the balloons popped, the sound wouldn't be able to carry since everything would be too far away from the correct floor. A closed window would also prevent the sound from carrying, since most buildings tend to be well insulated. Since the whole operation depends on a steady flow of electricity, a break in the middle of the wire would also cause problems. Of course, the fellow could shout, but the human voice is not loud enough to carry that far. An additional problem is that a string could break on the instrument. Then there could be no accompaniment to the message. It is clear that the best situation would involve less distance. Then there would be fewer potential problems. With face to face contact, the least number of things could go wrong. (p. 719)

# Try now ☺

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*Bransford & Johnson, 1972*

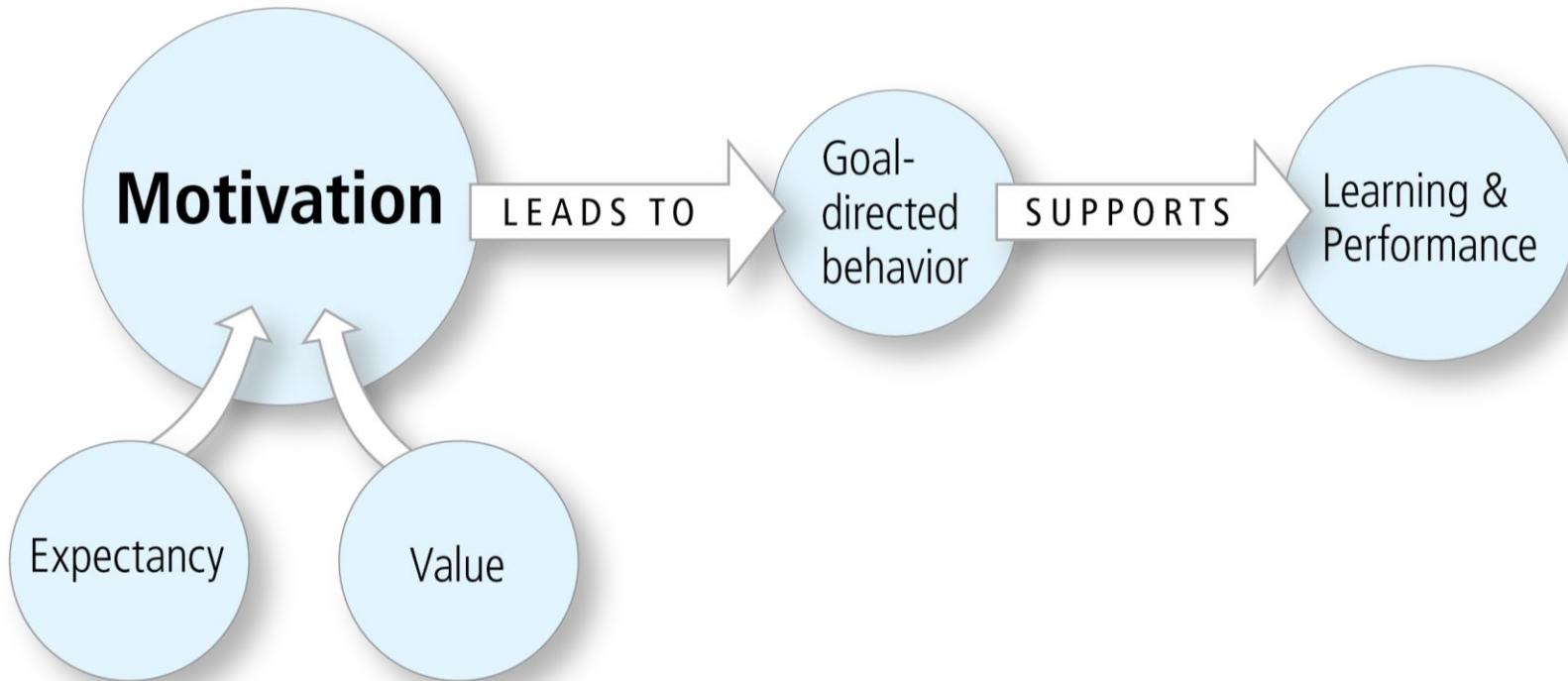


# What we owe our students

Learning environments that not only transmit knowledge, but

- Help students organize their knowledge in productive ways
- Actively monitor students' construction and transfer of knowledge

### 3. Students' *motivation* determines, directs, and sustains what they do to learn



# Goals/Value

- If students cannot find any value in what we are offering them, they won't find motivation to do it
- Students value multiple goals
- Some goals are in competition

**What do students value in  
*your* field?**

# Goals/Value

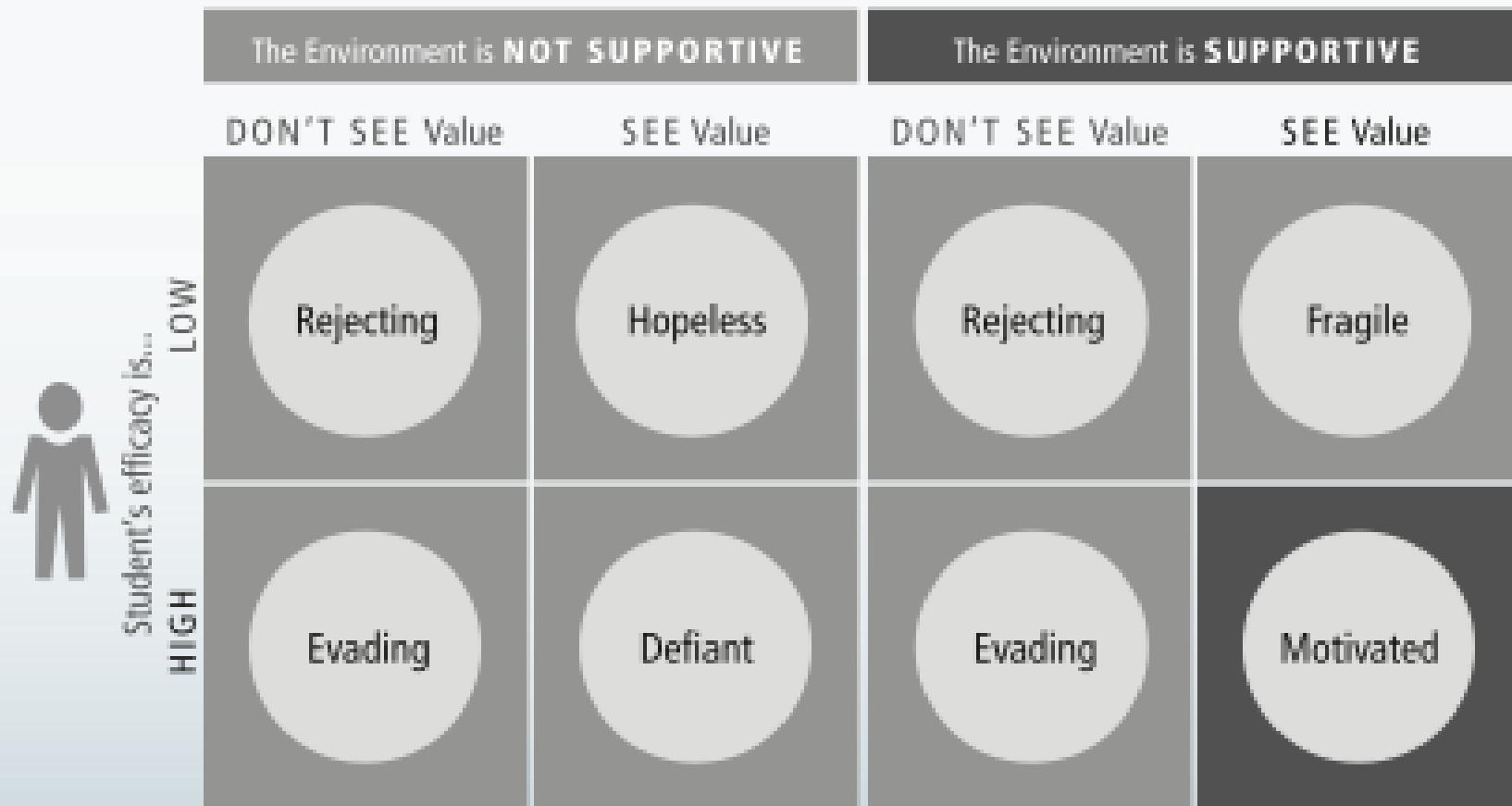
- Rewards & Punishments
- Learning
- Competence
- Performance approach/avoid
- Social
- Affective
- Purpose/Integrity/Authenticity

# **Expectancy: expectation of a successful outcome**

Three main components of this positive expectation:

- (1) **Outcome expectancy:** beliefs that certain behaviors are causally connected to desired outcomes
- (2) **Efficacy expectancy:** that one has the ability to do the work necessary to succeed (*self-efficacy*)  
e.g., You “have it” or you don’t vs. the mind is like a muscle; I’m no good at math vs. I lack experience in math
- (3) **Environmental expectancy:** that the environment will be supportive of one’s efforts.  
e.g., Perceptions of: Instructor’s fairness; Feasibility of the task; Instructor’s approachability/helpfulness; Team members’ ability and effort

# Effects of Value, Self-efficacy, & Environment on Motivation

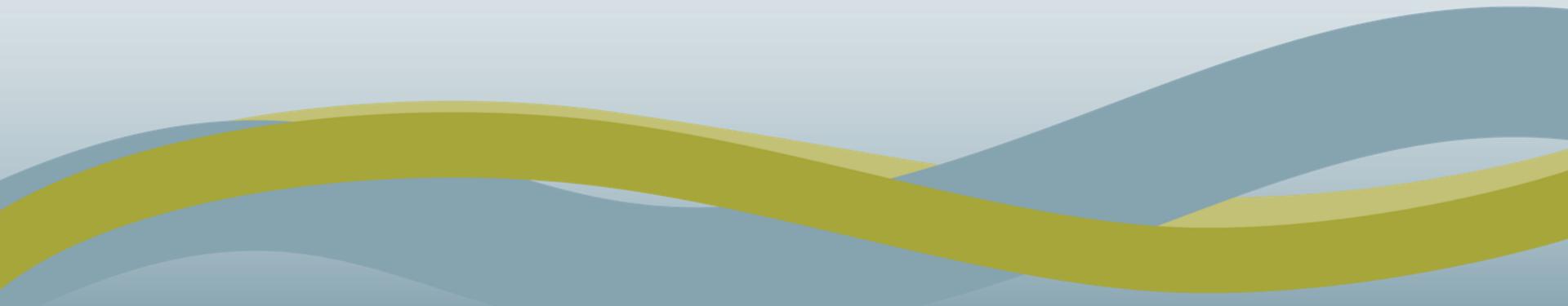


# What we owe our students

Learning environments that:

- Stay up-to-date with what students value
- Engage multiple goals
- Build self-efficacy
- Are responsive and helpful

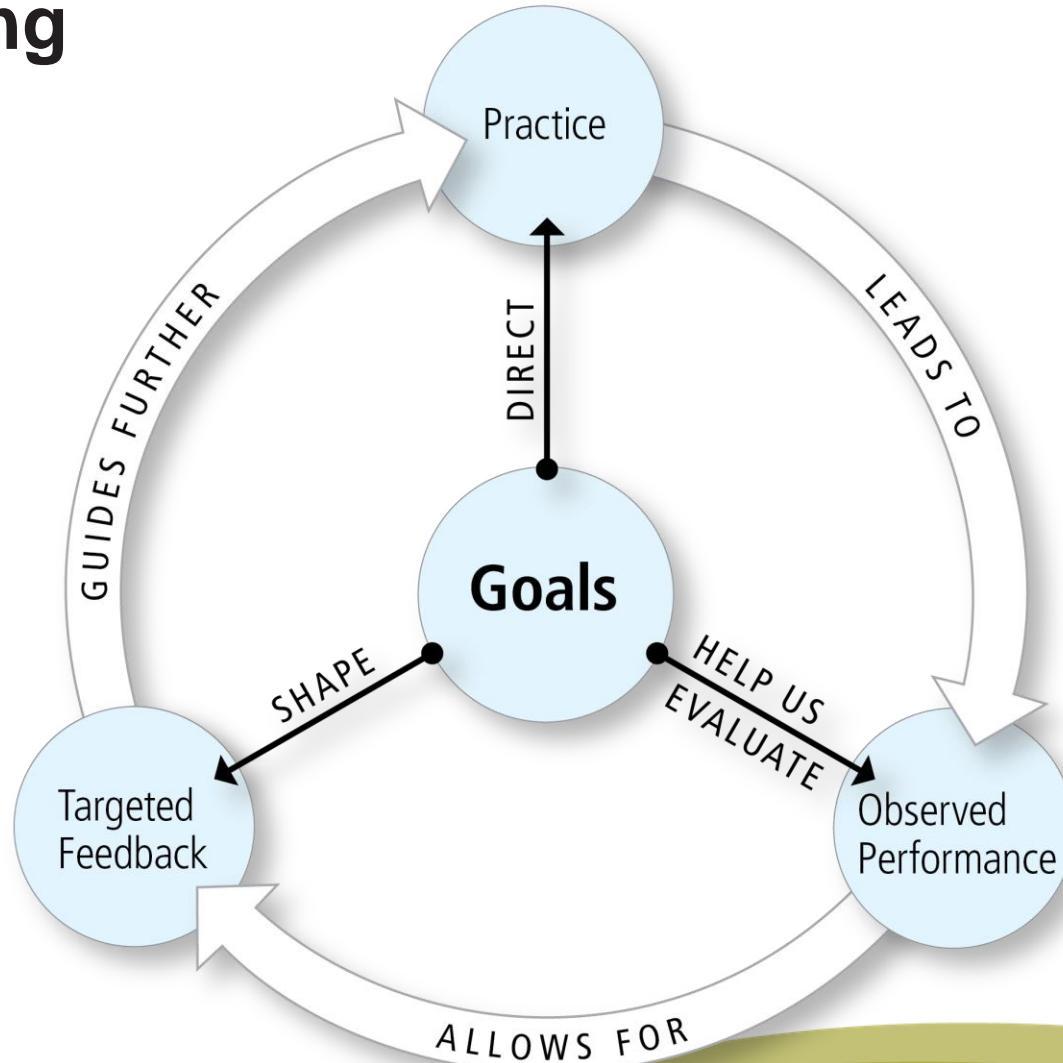
The next two  
principles pertain to  
learning *skills*



**4. To develop mastery, students must acquire component skills, practice integrating them, and know when to apply what they have learned**



## 5. Goal-directed *practice* coupled with targeted *feedback* enhances the quality of students' learning



“It’s not teaching that causes learning. Attempts by the learner to perform cause learning, dependent upon the quality of feedback and opportunities to use it.” -- Grant Wiggins

### Goals

- Explicit
- Before the performance

### Practice

- Scaffolded
- Zone of Proximal Development  
(Vygotsky 1978)

### Feedback

- Frequent
- Timely
- Constructive

# An important caveat

The Stroop Effect (1935)

|      |        |        |
|------|--------|--------|
| XXXX | RED    | YELLOW |
| XXXX | YELLOW | RED    |
| XXXX | BLUE   | GREEN  |
| XXXX | GREEN  | BLUE   |
| XXXX | RED    | YELLOW |
| XXXX | GREEN  | BLUE   |
| XXXX | BLUE   | RED    |

# An Example – Learning to Drive

Initially

- students rely on very general rules and problem-solving skills, e.g. following a step-by-step example, matching variables in equations
- working memory load is very high
- performance is very slow, tedious and error-prone

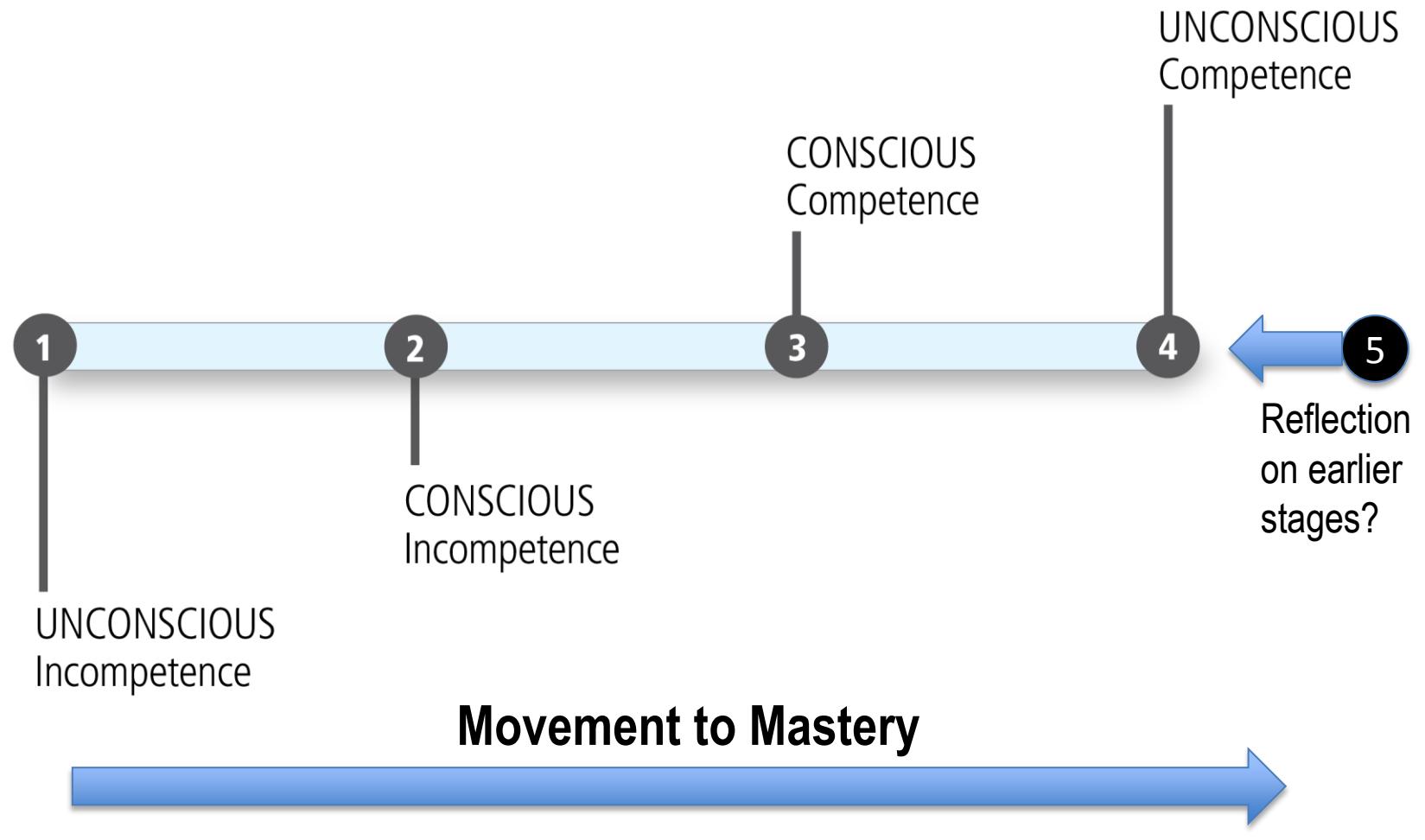
With some practice:

- very general rules are instantiated with discipline-specific details to make new, more efficient productions
- performance becomes faster
- many errors are detected and eliminated with feedback

With a great deal of practice:

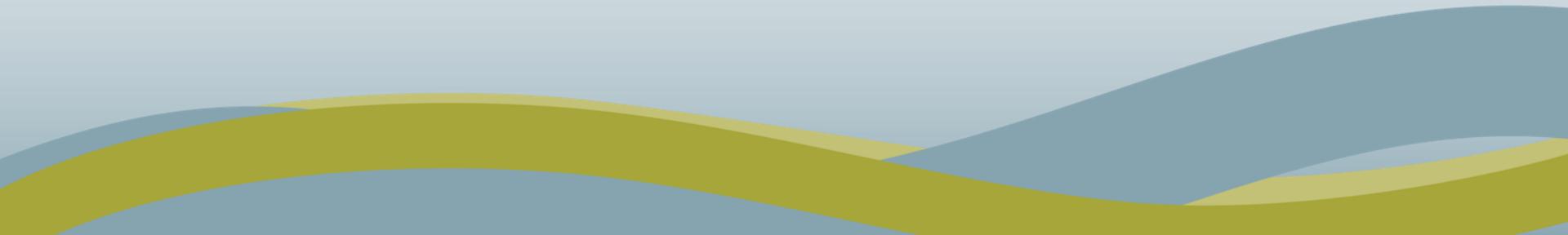
- related steps are compiled and “automatized” by collapsing steps
- less attention is needed to perform
- performance continues to speed up
- experts may lose the ability to verbalize all steps

# The Expert Blindsight



Sprague and Stuart (2000)

Where are *your* expert  
blindspots?



# What we owe our students

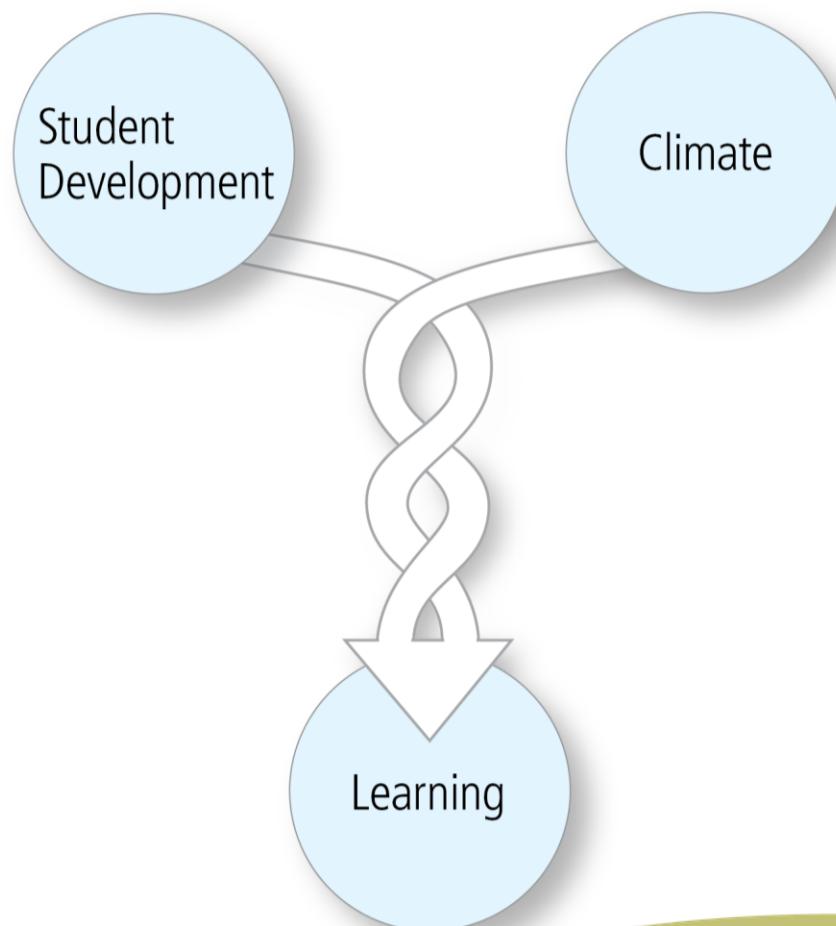
Learning environments where educators

- Actively hunt down their expert blindspots

Learning environments that:

- Emphasize both individual skills and their integration
- Explicitly teach for transfer
- Provide multiple opportunities for authentic practice
  - Oriented toward clear goals
  - Coupled with targeted feedback

## 6. Students' current level of *development* interacts with the social, emotional, and intellectual *climate* of the course to impact learning



# Developmental Theories

- Describe how our views of certain concepts (e.g., knowledge, morality, culture, identity) evolve over time from unsophisticated positions to ones that embrace complexity
- Development is described as a response to intellectual, social, or emotional challenges, where students begin to question values and assumptions inculcated by parents and society, and start to develop their own
- Development can be described in stages
- It describes students in the aggregate, not individually
- Development is not always forward

# Intellectual Development

## I. Dualism/Received/Absolute Knowledge

- Knowledge: viewed as received Truth
- What matters: facts—things are right or wrong
- Teacher: has the answers
- Learning: Memorizing notes for tests, getting the A is what counts

Frustration: Why won't the teacher answer my questions?

# Intellectual Development

## II. Transitional Knowledge

- Knowledge: partially certain, partially uncertain
- What matters: facts—things are right or wrong
- Teacher: has the answers
- Learning: Memorizing notes for tests, getting the A is what counts

Frustration: Why won't the teacher answer my questions?

# Intellectual Development

## III. Multiplicity/Subjective/Independent Knowledge

- Knowledge: a matter of opinion
- Teacher: not the authority—just another opinion
- Learning: a purely personal exercise

Frustration: How can the teacher evaluate my work?

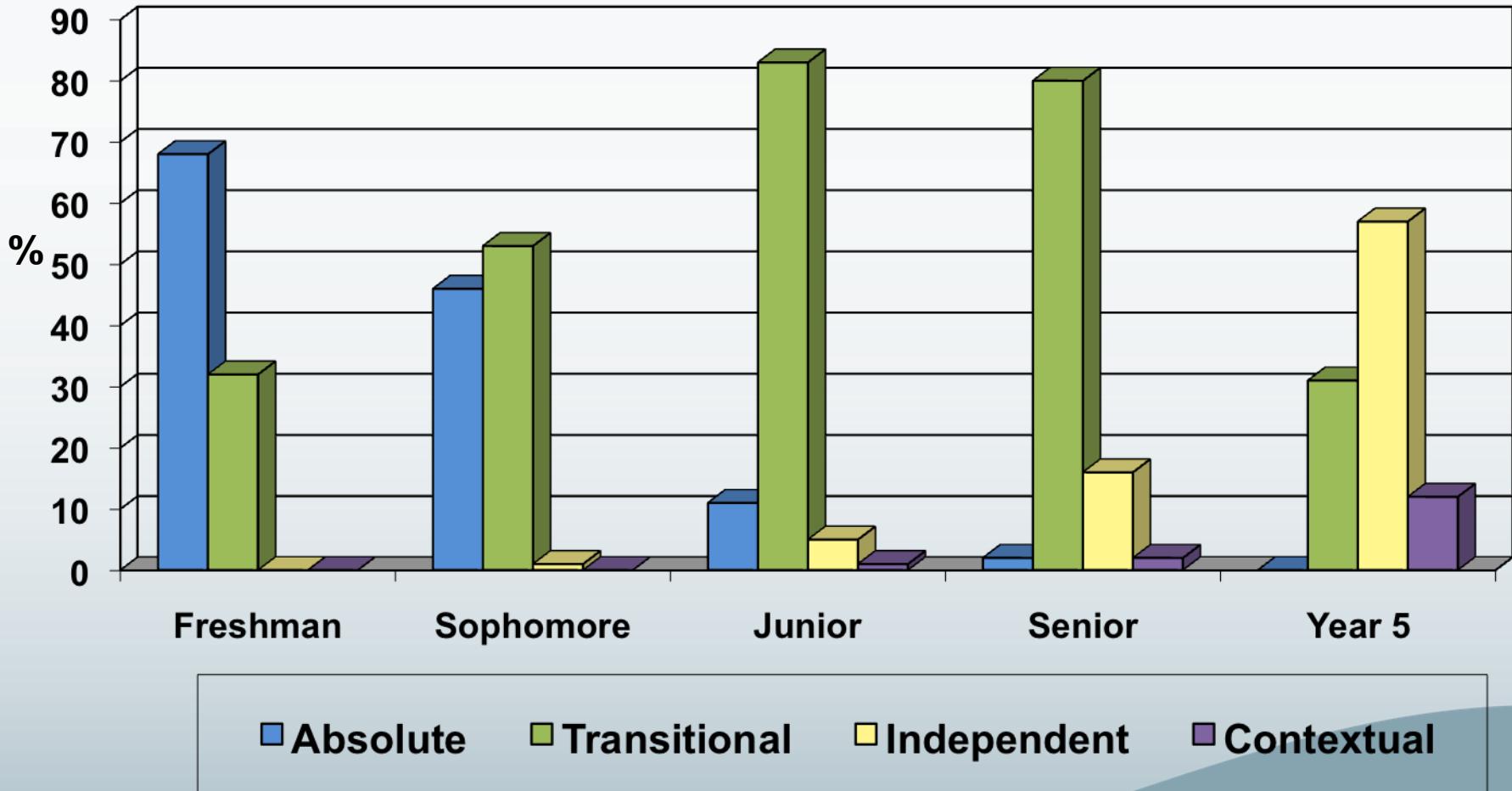
# Intellectual Development

## IV. Relativism/Procedural/Contextual Knowledge

- Knowledge: based on evidence
- What matters: supporting your argument with reasons
- Teacher: Conversation partner, acts as a guide, shows the direction
- Learning: depends on the context—what we “know” is colored by perspectives and assumptions

Questions asked: What are more sources of information?

# Intellectual Development by Year



# Classroom Climate

Students work out these developmental challenges in the context of the classroom environment.

Perceptions of a “chilly” climate affect student learning, critical thinking, and preparation for a career (Pascarella et al. 1997; Whitt et al 1999).

Climate is best understood as a continuum:



DeSurra & Church (1994)

# What factors contribute to climate?

- Content
- Interactions
  - ✓ Faculty-student and student-student
    - e.g., stereotype threat
- Tone
  - ✓ Syllabus study—punishing vs. encouraging (Ishiyama and Hartlaub 2002)
    - *Punishing*: “If for some substantial reason you cannot turn in your papers or take an exam at the scheduled time you must contact me prior to the due date, or test date, or you will be graded down 20%”
    - *Rewarding*: “If for some substantial reason you cannot turn in your papers or take an exam at the scheduled time you should contact me prior to the due date, or test date, or you will only be eligible for 80% of the total points.”

# Results

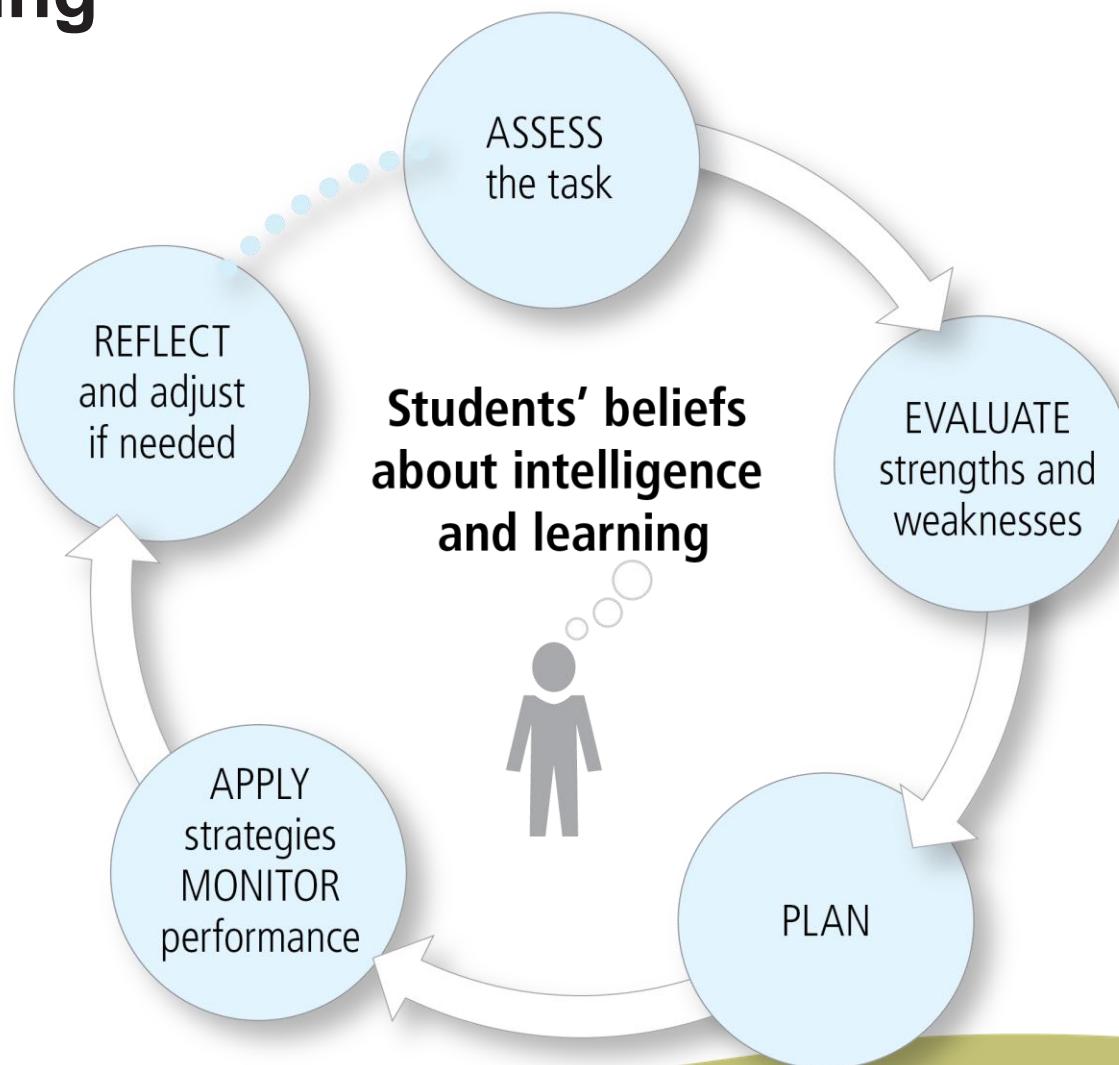
- Significant difference in perceived approachability ( $p=.04$ )
  - ✓ Instructor with punishing wording rated as less approachable
  - ✓ Students less likely to seek help from the punishing instructor
  - ✓ First & second year students most affected by wording

# What we owe our students

Learning environments that:

- Use the tools of the disciplines to engage and embrace complexity
- Are explicitly inclusive in methods and content

## 7. To become self-directed learners, students must learn to monitor and adjust their approaches to learning

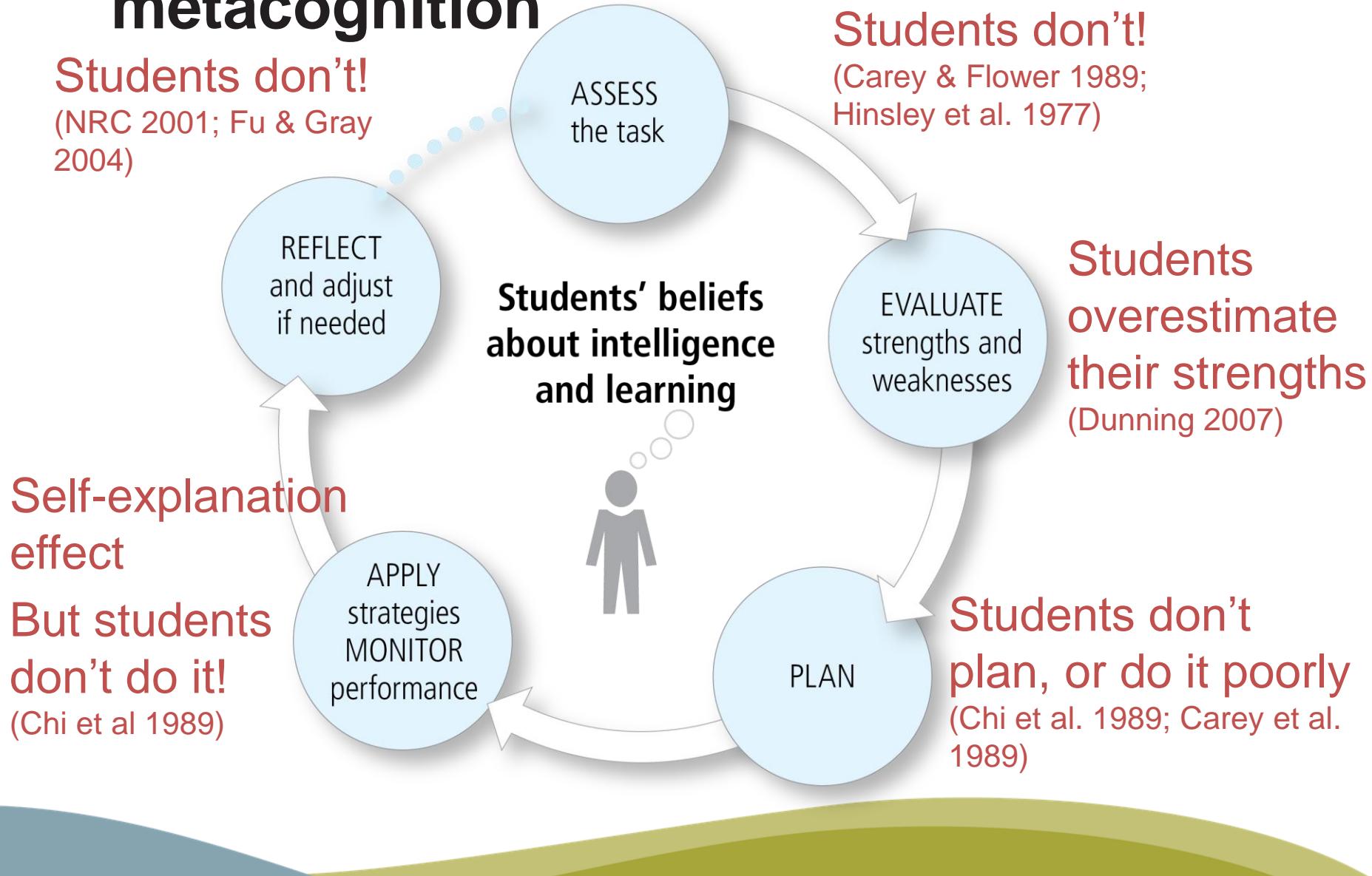


# Metacognition: Definitions

“Metacognition refers to one’s knowledge concerning one’s own cognitive processes or anything related to them, e.g., the learning-relevant properties of information or data. For example, I am engaging in metacognition if I notice that I am having more trouble learning A than B; if it strikes me that I should double check C before accepting it as fact.”—J. H. Flavell (1976, p. 232).

“The process of reflecting and directing one’s own thinking.”—National Research Council (2001, p. 78).

# Evidence from research on metacognition



# Research on beliefs about learning

- Quick<-----> Gradual
  - Intelligence <-----> Intelligence  
as Entity Incremental
- 

Beliefs about learning influence effort, persistence, learning and performance (Schommer, 1994; Henderson & Dweck, 1990)

# Metacognition can be taught

- ✓ Early research found it was EXTREMELY hard
- ✓ More recent research is a little more optimistic

In particular:

- Students can be taught to monitor their strategies, with greater learning gains as a result (Bielaczyc et al., 1995; Chi et al., 1994; Palinscar & Brown, 1984)
- Students can be taught more productive beliefs about learning and the brain (Aronson et al., 2002)

## What we owe our students

Learning environments that foster:

- metacognitive awareness
- a lifelong learning disposition

# Teaching strategies

2 in particular:

- Guided self-assessment (Appendix A):
- Exam Wrappers (Appendix F):

<http://www.cmu.edu/teaching/designteach/teach/examwrappers/>

**Two über-strategies:**

- Modeling Your Metacognitive Processes
- Scaffold Students' Metacognitive Processes

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# References

- Ambrose, S., Bridges, M., DiPietro, M., Lovett, M., and Norman, M. (2010) *How Learning Works: 7 Principles for Smart Teaching*. Jossey-Bass.
- Aronson, J. , Fried, C. & Good, C. (2002). Reducing the effects of stereotype threat on African-American college students by shaping theories of intelligence. *Journal of Experimental Social Psychology*. 38, 113-125.
- Bandura, A. (1997) *Self-efficacy: The exercise of control*. Freeman.
- Baxter-Magolda, M. B. (1992). *Knowing and reasoning in college: Gender related patterns in students' intellectual development*. Jossey-Bass.
- Belenky, M. F., Clinchy, B. M., Goldberg, N. R., and Tarule, J. M. (1986). *Women's ways of knowing: The development of self, voice and mind*. Basic Books.
- Bennett, M. (1993) Towards a Developmental Model of Intercultural Sensitivity. In R. M. Paige,(ed.) *Education for the Intercultural Experience*. Intercultural Press.
- Bransford, J., & Johnson, M. (1972) Contextual prerequisites for understanding: Some investigations of comprehension and recall.

Carey, L., & Flower, L. (1989) Foundations for creativity in the writing process: Rhetorical representations of ill-defined problems. (Technical report No. 32) Center for the Study of Writing at University of California at Berkeley and Carnegie Mellon University.

Carey, L., Flower, L., Hayes, J. R., Shriver, K., & Haas, C. (1989) Differences in writers' initial task representations. (Technical report No. 34) Center for the Study of Writing at University of California at Berkeley and Carnegie Mellon University.

Chi, M., Bassok, M., Lewis, M., Reimann, P., & Glaser, R. (1989) Self-Explanations: How students study and use examples in learning to solve problems. *Cognitive Science*, 13, 145-182.

Chi, M., Feltovich, P., and Glaser, R. (1981) Categorization and representation of Physics problems by experts and novices. *Cognitive Science*, 5, 121-152.

Chi, M., de Leeuw, N., Chiu, M., & LaVancher, C. (1994). Eliciting self explanations improves understanding. *Cognitive Science*, 18, 439-477.

DeSurra, C. J., and Church, K. A. (1994). Unlocking the classroom closet: Privileging the marginalized voices of gay/lesbian college students, Paper presented at the Annual Meeting of the Speech Communication Association. New Orleans, LA.

Dunning, D. (2007) *Self-insight: Roadblocks and detours on the path to knowing thyself*. Taylor & Francis.

Ford, M. (1992) *Motivating humans: Goals, emotions, and personal agency beliefs*. Sage publications.

Fu, W. & Gray, W (2004) Resolving the paradox of the active user: Stable suboptimal performance in interactive tasks. *Cognitive Science*, 28(6), 901-935.

Gilligan, C. (1977) In a different voice: Women's conception of self and morality. *Harvard Educational Review*, 47, 481-517.

Griggs, R. A. and Cox, J. R. (1982). The elusive thematic-materials effect in Wason's selection task. *British Journal of Psychology*, 73, 407-420.

Hardiman, R., and Jackson, B. (1992) Racial identity development: Understanding racial dynamics in college classrooms and on campus. In M. Adams (ed.) *Promoting diversity in college classrooms: Innovative responses for the curriculum, faculty, and institutions*, 21–37. Jossey-Bass.

Henderson, V., & Dweck, C. (1990). Motivation and achievement. In S. Feldman & G. Elliott (Eds.). *At the threshold: The developing adolescent*. Harvard University Press.

Hinsley, D., Hayes, J. R., & Simon, H. A. (1977) From words to equations: Meaning and representation in algebra word problems. In M. Just and P. Carpenter (eds.) *Cognitive processes in comprehension*. Erlbaum

Kohlberg, L. (1976). Moral stages and moralization: The cognitive-developmental approach. In T. Lickona, (ed.) *Moral Development and Behavior: Theory, Research and Social Issues*. Rinehart and Winston.

Mazur, E. (1996) *Peer Instruction*. Addison Wesley.

National Research Council (2001) *Knowing what students know: The science and design of educational assessment*. National Academy

Pascarella, E. T., Whitt, E. J., Edison, M. I., Nora, A., Hagedorn, L. S., Yeager, P. M., & Terenzini, P. T. (1997) Women's perceptions of a "chilly climate" and their cognitive outcomes during the first year of college. *Journal of College Student Development*, 38(2), 109-124.

Perry, W. (1970), Forms of Intellectual and Ethical Development in the College Years: A Scheme. Holt, Rinehart, and Winston.

Schommer, M. (1994). An emerging conceptualization of epistemological beliefs and their role in learning. In K. Feldman & M. Paulsen (Eds.), *Teaching and learning in the college classroom* (2nd ed.) (pp. 173-183). Simon & Schuster.

Sprague, J., & Stewart, D. (2000) *The speaker's handbook*. Harcourt College Publishers.

Steele, C. & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans". *J Pers Soc Psychol* 69 (5): 797–811.

Stroop, J. R. (1935) Studies of interference in serial verbal reactions, *Journal of Experimental Psychology*, 18, 643-662.

Vroom, V. (1964) *Work and Motivation*. Wiley.

Vygotsky, L.S. (1978). *Mind and society: The development of higher psychological processes*. Harvard University Press.

Wason, P. C. (1966). "Reasoning". In Foss, B. M.. *New horizons in psychology*. Penguin.

Wason, P. C. (1977). "Self-contradictions." In P. N. Johnson-Laird & P. C. Wason (eds.) "Thinking: Readings in cognitive science." Cambridge University Press.

Whitt, E. J., Edison, M., Pascarella, E. T., Nora, A., & Terenzini, P. T. (1999). Women's perceptions of a "chilly" climate and cognitive outcomes in college: Additional evidence. *Journal of College Student Development*, 40, 163-177.