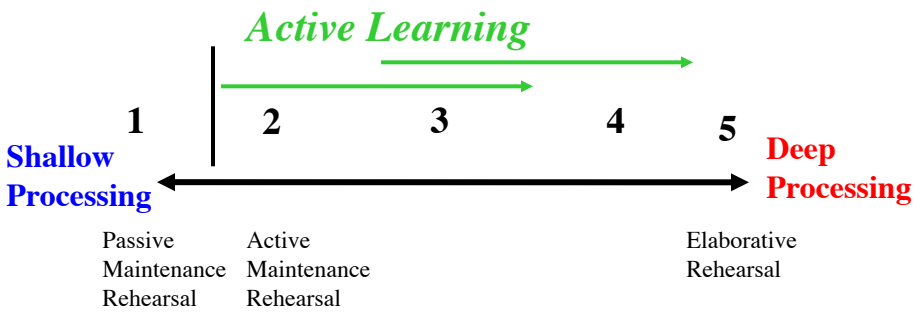
Encoding & Retrieval

Active Learning for Classroom Instruction & Assessment



Types of Mnemonics

- **Peg Method** -- *memorize a series of pegs* (e.g. "One is a Bun")
- **Method of Loci** -- *remember various "drops" in a familiar place* (e.g. Chaucer sitting on the sofa)
- **Link Method** -- *when remembering lists form an image for each item and picture them interacting*

Types of Mnemonics cont.

- **Stories** -- *develop a story containing all of the to be remembered information*
- **First Letter Method** -- *create a word from the first letters of words* (e.g. HOMES for the Great Lakes)
- **Keyword** -- *taking part of the keyword and pairing it with an image* (e.g. a gust of wind blowing through a horse's mane to remember Augusta)

Memory is Reconstructive!!

- **Eyewitness accounts flawed**
- **"Flashbulb" memories have inaccuracies**
- **We fill in the gaps to make sense**

Metacognition

- Executive processes; oversees the memory system
- Is rather late developing
- Can be improved through direct instruction & modeling
- Is largely independent of general ability

Metacognition

Knowledge of Cognition

Declarative
Knowledge of memory limitations

Procedural
Knowledge about Strategies

Conditional
Knowledge about When and Why to use Strategies

Regulation of Cognition

Planning
Setting goals, Activating Background Knowledge, Budgeting Time

Monitoring
Observation of Performance

Evaluation
Reevaluating Goals, Revising Predictions

Examples of Metacognition

- Knowing how well you are doing on your educational psychology test
- Predicting how difficult a chemistry project will be
- Understanding how much you know about former presidents
- Knowing what information is important to take away from class lecture
- Knowing how well you understand the directions for setting up a wireless printer

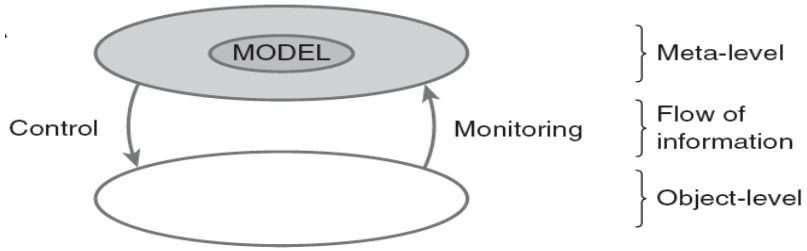
Examples of Metacognition cont.

- Choosing one strategy over another when playing a board game
- Knowing if you have studied enough for the history exam
- Understanding and utilizing strategies that will make you a better setter in volleyball -- example
- Knowing when your performance on the trumpet was up to par
- Knowing which Trivial Pursuit categories you are strong and weak at

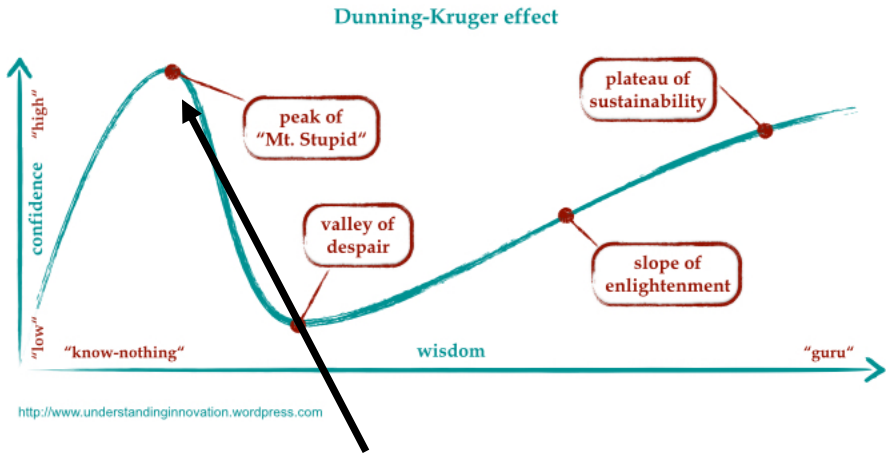
"Having knowledge is only part of effective learning. It also is important to use one's knowledge strategically and to understand the strengths and limitations of one's knowledge."

(Bruning, Schraw, Ronning, 1999; p. 102)

The "Knowing" and "Adjusting" Processes:



Adapted from Nelson & Narens (1990)



"Unskilled and Unaware"

Metacognitive Readers

- **Readers Low in Metacognitive Abilities:**
  - **Lack awareness of process**
  - **Unconsciously incompetent**
  - **"Don't know that they don't know"**
- **Readers High in Metacognitive Abilities:**
  - **Realize there is a problem with reading**
  - **Don't know how to fix the problem**
  - **Consciously incompetent**
  - **"Know they don't know, but…"**

Questions regarding calibration

Calibration is the degree to which one can match their *perception* of their performance with their *actual* level of performance.

Calibration is one measure of metacognitive monitoring accuracy

Is calibration related to performance?
Does prior knowledge improve calibration?
Can training and/or feedback improve calibration?

Is calibration related to performance?

TABLE 2. Correlations Among Grade Point Average (GPA), Test Score, and Local Monitoring Accuracy

Test	1	2	3	4	5	6	7	8	9
1 GPA	—	.59**	–.76**	.67**	–.68**	.50**	–.44*	.64**	–.63**
2 Test 1 score		—	–.79**	.59**	–.62**	.63**	–.36**	.64**	–.58**
3 Test 1 accuracy				–.63**	.77**	–.60**	.46*	–.69**	.61**
4 Test 2 score				—	–.80**	.40*	–.32	.69**	–.52**
5 Test 2 accuracy					—	–.54**	.48*	–.74**	.69**
6 Test 3 score						—	–.64**	.70**	–.53**
7 Test 3 accuracy								–.36	.59**
8 Test 4 score								—	–.63**
9 Final exam accuracy									

*$p < .05$. **$p < .01$.

Nietfeld, J. L., Cao, L., & Osborne, J. W. (2005). Metacognitive monitoring accuracy and student performance in the classroom. *Journal of Experimental Education, 74*(1), 7-28.

Does prior knowledge improve calibration?

Design:

- **3 Groups with varied math background**
  - **Low Knowledge N=31**
  - **Mid Knowledge N=34**
  - **High Knowledge N=28**
- **Completed a test of math probability and general intelligence**
- **Provided monitoring judgments for each item**
- **The High Knowledge group significantly outperformed the other two groups *and* made significantly more accurate monitoring judgments**
- **No differences were found in general ability between the 3 groups**

Nietfeld, J. L., & Schraw, G. (2002). The role of knowledge and strategy training on metacognitive monitoring. *The Journal of Educational Research, 95*, 131-142.

Can strategy training improve calibration?

How many ways can a jury of 4 women and 3 men be chosen from 5 women and 5 men?

A. 20
B. 30
C. 40
D. 50

0%_____100%
Accurate Accurate

Can training and/or feedback improve calibration?

Monitoring accuracy on math probability problems by college students – Session 1=pretest, Session 2=after training (for Training group only), Session 3=after one week. Lower numbers equal higher accuracy.

Table 3.—Means and Standard Deviations for Experiment 2

Group	Raven test performance		Probability performance		Probability confidence		Probability bias		Probability accuracy		Self-efficacy	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Training												
Session 1	.64	.23	.58	.12	.70	.13	.14	.15	.37	.09	35.02	8.79
Session 2			.68	.13	.79	.12	.10	.15	.29	.08	33.88	9.01
Session 3			.62	.10	.78	.13	.16	.15	.35	.08	34.07	8.82
Control												
Session 1	.69	.23	.59	.15	.66	.17	.10	.14	.32	.10	36.61	8.93
Session 2			.58	.15	.69	.16	.11	.14	.34	.08	35.79	8.63
Session 3			.60	.09	.69	.16	.09	.16	.36	.08	36.81	9.96

Note. Performance, confidence, and accuracy ranged from 0 to 1. Bias ranged from –1 to 1.

Nietfeld, J. L., & Schraw, G. (2002). The role of knowledge and strategy training on metacognitive monitoring. *The Journal of Educational Research, 95*, 131-142.

Can training and/or feedback improve calibration?

No change in monitoring accuracy (calibration) in the absence of training or feedback.

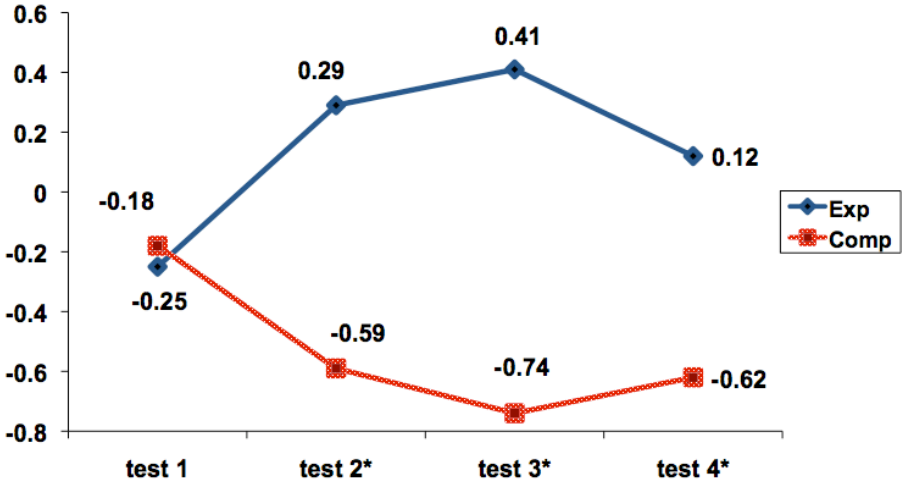
TABLE 1. Means and Standard Deviations of Monitoring Accuracy, Bias, and Confidence, by Test

			Monitoring accuracy								
	Score		Local		Global		Bias		Confidence		
Item	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*n*
Test 1	.78	.13	.29	.11	.13	.10	–.03	.11	.75	.13	27
Test 2	.81	.09	.29	.10	.13	.12	–.05	.12	.76	.13	27
Test 3	.76	.13	.35	.12	.26	.18	–.07	.19	.68	.18	27
Final	.81	.12	.28	.11	.11	.11	–.02	.17	.78	.16	26
GPA	3.35	.41									27

Note. GPA = grade point average.

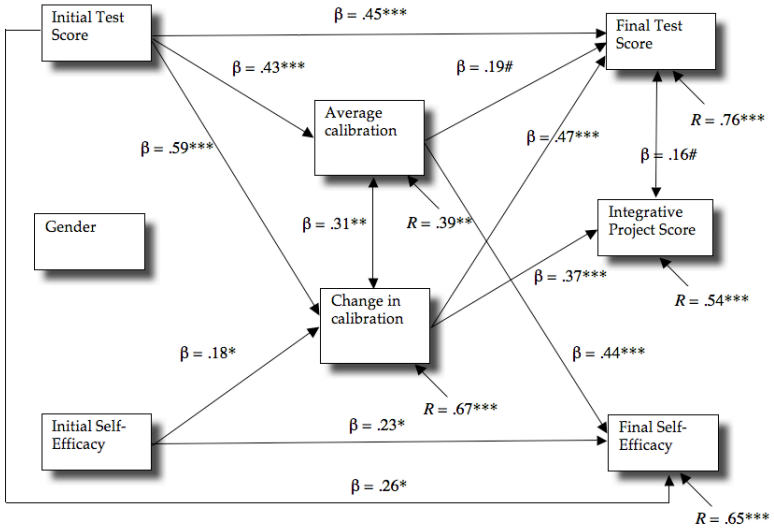
Nietfeld, J. L., Cao, L., & Osborne, J. W. (2005). Metacognitive monitoring accuracy and student performance in the classroom. *Journal of Experimental Education, 74*(1), 7-28.

Can monitoring training and/or feedback improve classroom performance?



Nietfeld, J. L., Cao, L., & Osborne, J. W. (2006). The effect of distributed monitoring exercises and feedback on performance and monitoring accuracy. *Metacognition and Learning, 2*, 159-179.

Can training and/or feedback improve calibration?



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Give metacognitive strategy instruction a chance to "sink in" . . .

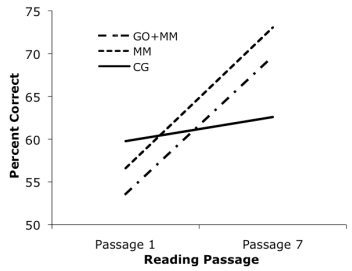
Study in how 5th graders comprehend expository science text

Comprehension Score Change over Time, Controlling for Prior Knowledge

In 4 conditions:

1) Graphic organizer + Metacognitive instruction
2) Metacognitive instruction
3) Graphic organizer instru
4) Traditional instruction

After 6 weeks an effect is found



Hoffmann, K. F. (2010)

Using strategy instruction and confidence judgments to improve metacognitive monitoring skills

Condition	Gates-MacGinitie Tests	Gates Confidence Judgments	Practice Passages	Prompted Self-Monitoring	Monitoring Accuracy Training
1 Control	*		*		
2 NI	*	*			
3 CMT	*	*	*	*	
4 CMT+MAT	*	*	*	*	*

CMT = Comprehension Monitoring Training
MAT = Monitoring Accuracy Training

Sessions every day for 2 weeks with 5th graders

Spider Specialties

Read the following paragraph carefully, then answer the questions.

Some spider webs are simply a tangle of silk threads that run in various directions between supports such as walls or furniture. Other webs, called orb webs, are made up of silk threads that form an intricate geometric pattern. Such webs can be over two feet wide. Some spiders create wide flat webs with a funnel shape in the center. The spider hides inside the funnel until an insect lands on the flat part of the web. The spider then runs from the funnel to grab the insect. Sheet webs are flat sheets of web that hang below crisscrossed threads of silk. When an insect flies into the crisscrossed threads, it falls onto the sheet of silk and the spider traps it.

Self-Monitoring Statements

a. This text makes sense to me and I understand it well.

Strongly Agree *Agree* *Disagree* *Strongly Disagree*

b. I am using fix-up strategies while reading this selection.

Strongly Agree *Agree* *Disagree* *Strongly Disagree*

c. I am confident that I could explain the main idea(s) of this text to someone else.

Strongly Agree *Agree* *Disagree* *Strongly Disagree*

Comprehension Questions "Spider Specialties"

1. In the selection, the word *intricate* means
   A. Shape
   B. Design
   C. Complicated
   D. Simple

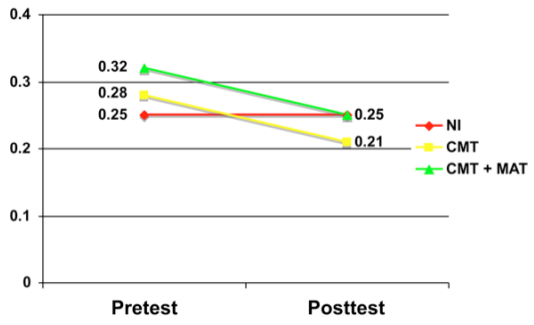
0% Accurate _____ 100% Accurate

2. What is the main idea of this selection?
   A. Spiders are intelligent animals.
   B. There are many different kinds of spider webs.
   C. Spiders eat man types of insects.
   D. Spiders are excellent hunters.

0% Accurate _____ 100% Accurate

3. What is the purpose of the funnel shape in the center of wide flat webs?
   A. to keep the spider from scaring away possible meals
   B. to trap insects inside
   C. to make the webs pretty
   D. to hide insects

0% Accurate _____ 100% Accurate



Pretest calibration bias		Posttest calibration bias	
M	SD	*M*	SD
0.03	(0.14)	0.03	(0.14)
−0.04	(0.12)	0.01	(0.16)
0.01	(0.17)	0.14	(0.12)
0.00	(0.14)	0.06	(0.15)

CMT + MAT

CMT

Huff, J. D., & Nietfeld, J. L. (2009). Using strategy instruction and confidence judgments to improve metacognitive monitoring skills. *Metacognition and Learning*, *4*, 161-176.

Description of Written Response Categories.

Category	Definition	Example
Externally-focused thoughts	Thoughts not directly related to the task	"Is there spit on my face?"; "My mind wonders,"; "I may think about school or a friend."
Planning	Thoughts related to pre-race preparations	"First I start warming up, usually to fast music, for it gets me pumped up to run."
Information Management Strategy (IMS)	Thoughts that reflect strategies that the runner employs during the competition	"Usually, I am thinking about dividing the race up into smaller parts, for instance, four 200s because it's easier to get through."
Monitoring	Thoughts runners have about their energy level, pain tolerance, or form	"I am thinking about how much I have left."
Debugging	Thoughts that reflect changes in strategies or adjustments during the race	"If it is not going well I am trying trying to fight negative feedback from my body and mind."
Evaluation	Thoughts that reflect back on a race	"I sometimes think that I am running hard and then when I finish I know that I could have gone harder."

Nietfeld, J. L. (2003). An examination of metacognitive strategy use and monitoring skills by competitive middle distance runners. *The Journal of Applied Sport Psychology, 15*, 307-320.

External thoughts represented only 12% of the total recorded. In contrast, 41% of the responses were information management strategies, 42% of the responses involved monitoring, and more broadly, ***88% of the responses were internally-focused and metacognitive in nature***.

Runners missed their target mile time by an average of 9 seconds

The relationship between the Racing the Mile Questionnaire and the mile performance task ($r = -.44$). This correlation indicates that ***participants who report being more strategic when preparing for and racing a mile also show a tendency to be more accurate at monitoring their pace on a performance task*** (low scores on the performance task represent more accurate monitoring).

4. Do you make adjustments in your running during the race?
5. Do you visualize and/or meditate about the race after you run?
6. If you are not racing well after a half-mile do you just finish without changing anything about your performance?
7. Do you make changes in your racing after watching highly successful runners?
8. Do you have a race plan when you are on the starting line?
9. Does the type and amount of training you do affect the way you race?
10. Do you adjust your pace to fit the race and the other runners?

Nietfeld, J. L. (2003). An examination of metacognitive strategy use and monitoring skills by competitive middle distance runners. *The Journal of Applied Sport Psychology, 15*, 307-320.

Research Team

Interdisciplinary Coordination

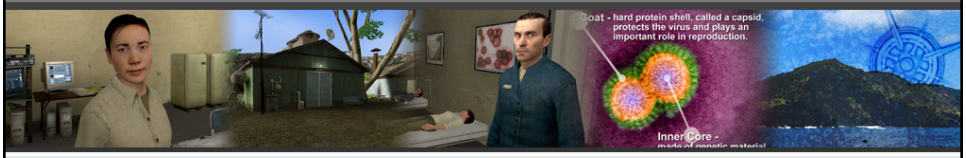
- Computer Science
- Educational Psychology
- Curriculum & Instruction
- K-12 students and teachers

Infrastructure

- Computational: Game Technology
- Personnel: Graphic Design & Animation

Supported by the National Science Foundation under grants REC-0632450 and REC-0534458

Crystal Island – Outbreak



Crystal Island – Uncharted Discovery

Crystal Island: Uncharted Discovery

Overall Problem: Establishing Village Life

Quest 1: Landform Identification	Quest 2: Map Navigation	Quest 3: Modeling
Level 1	**Level 1**	**Level 1**
The geographer asks the student to label three landforms (waterfall, dam, plateau).	The student is asked to navigate to three locations on the island using map coordinates and to pick up a flag at each location. The student can only carry three flags at a time. Flags can be picked up and dropped anywhere. Decoy flags are also present.	The student is asked to match a photo of the island with a model meant to represent that part of the island.
Level 2	**Level 2**	**Level 2**
The geographer asks the student to photograph three landforms (lake, delta, and tributary) that are identified on her blackboard by definition only. For example, the student would have to know that "a stream or river that flows into another river" is a tributary.	The student is asked to navigate to three locations on the island using compass points, map coordinates, and a map scale. The student must then take a picture of an animal at each location. Decoy animals are also present.	The student is asked to create a virtual model of the village. The cartographer gives the student an app for the virtual tablet that allows the student to arrange the hut models into the correct configuration.

Modeling Quest: Level 1

What SRL variables predict performance in *Crystal Island – Uncharted Discovery* ?

If Calibration is replaced by response bias R^2 increases to .62

Note: Mastery Approach and Strategies Attribution were significant if using $p < .10$

Regression Results Predicting Efficiency in

CRYSTAL ISLAND - UNCHARTED DISCOVERY

Predictors	B	SE	β
Constant	2548.65	868.18	
Calibration	2504.64	465.14	.39***
Treasure Chest Time	2.85	.79	.25***
Interest	-379.37	115.05	-.24**
Luck Attribution	186.28	70.85	.19*
Mastery Approach	151.04	79.99	.16
Strategies Attribution	-191.25	105.60	-.14
Map Access	-22.87	19.41	-.09
Prior Knowledge	-34.52	30.26	-.09
Effort Attribution	-87.46	118.90	-.06
Performance Approach	-21.00	40.48	-.04
Science Self-Efficacy	91.88	200.69	.04
R^2		.521	

Note.

*$p < .05$, ** $p < .01$. *** $p < .001$.

Examples of Cognitive Strategies:

- Self-Checking
- Creating a productive physical environment
- Goal setting and planning
- Reviewing and organizing information after learning
- Summarizing during learning
- Seeking assistance
- Determining how much information to learn

Examples of Cognitive Strategies:

- Determining how new information relates to existing knowledge
- Determining how information will be used
- Identifying main ideas and important information
- Predicting
- Monitoring
- Reflecting on previous learning

3 Levels of Cognitive Study Strategies

- **Basic Study Strategies**
  - **Highlighting/Underlining/Note Taking**
  - **Don't take for granted that students know these!**
- **Comprehension Monitoring Strategies**
  - **Self-questioning/Summarizing**
  - **These are things you do "on-line" while learning**
- **Critical Thinking**
  - **Most important level--this is your goal!**
  - **What is critical thinking?**

Ten Essential Critical Thinking Skills

- **Distinguishing between verifiable facts and value claims**
- **Distinguishing between relevant and irrelevant information, claims, or reasons**
- **Determining the factual accuracy of a statement**
- **Determining the credibility of a source**
- **Identifying ambiguous claims or arguments**

Ten Essential Critical Thinking Skills cont.

- **Identifying unstated assumptions**
- **Detecting bias**
- **Identifying logical fallacies**
- **Recognizing logical inconsistencies in a line of reasoning**
- **Determining the strength of an argument or claim**

Taken from Beyer (1988)

A Good Strategy User . . .

- **Has a broad repertoire of strategies**
- **Metacognitive knowledge about why, when, and where to use strategies**
- **Has a broad knowledge base**
- **Ignores distractions**
- **Is automatic in the four components described above**

Pressley, Borkowski, and Schneider (1987)

Teaching Metacognitive Strategy Regulation

- Model strategies that cut across domains
- Encourage students to transfer strategies (eliminate inert knowledge)
- Demonstrate why some strategies are better than others
- Explain when and where a strategy will be used
- Use checklists to help monitor

Teaching Metacognitive Strategy Regulation *cont.*

- Ask students to look back on their performance and determine what they did well and not so well on
- Provide students with cues such as SQ4R (survey, question, read, reflect, recite, review)
- Encourage the use and practice of many different strategies
- **Strategies are most effective when integrated within the curriculum as opposed to being taught as a stand-alone unit**

Summary Recommendations from the Information Processing Model

- ☛Overlearn to the point of **automaticity**
- ☛Encourage **deeper processing**
- ☛Help guide **selective attention**
- ☛Remember that **meaning** drives learning & memory
- ☛Develop not only knowledge but **monitoring** ability
- ☛**Strategies** rule!