Evaluating Student Use of Metacognitive Learning Strategies in General Chemistry

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Summary

- Many students struggle in introductory STEM courses because the do not use appropriate learning strategies.
- An in-class intervention can increase metacognitive knowledge.
- This investigation evaluates student use of these strategies.
- A strong awareness of the metacognitive best-practices is noted for students at all levels of achievement.
- Different perspectives and practices are correlated with success in the class.
- These findings have pedagogical implications.

Context

Greater emphasis is now being given to improving students' knowledge of science content by allocating more attention to metacognition, epistemology, and student beliefs and attitudes (Seethaler, 2015).

The Learner...

Metacognitive knowledge.

- Differentiate between concepts mastered and those requiring further study.
- Understand strategies for learning.
- Knows how, and when, to use different strategies.

Motivation

- Has high self-efficacy and is interested in learning.
- Learns autonomously, has self-accountability.

Behavior

- Optimizes study environment.
- Employs appropriate learning strategies, and adjusts approach as needed, based on feedback.

Self-Regulated Learning

In response to metacognitive awareness of a gap between performance and goals, and driven by self-efficacy and the will to improve, the learner implements intentional changes in learning strategies.

Feedback

Action

Strategies
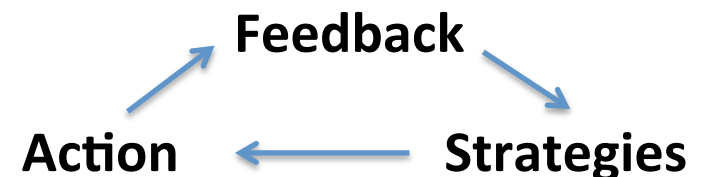
Metacognitive Knowledge

Add metacognition to existing course elements
o Practice tests & score prediction (Casselman & Atwood)
o Practice tests & mental effort (Holme)
o Enhanced answers keys & reflection (Sabel)

Add new course elements
o Videos, e.g. "How to Get the Most out of Studying" (used by Cardinale)

Surveys of metacognitive strategies
(Stanton; Sebesta; Bunce); M-ASSISST (Bunce)

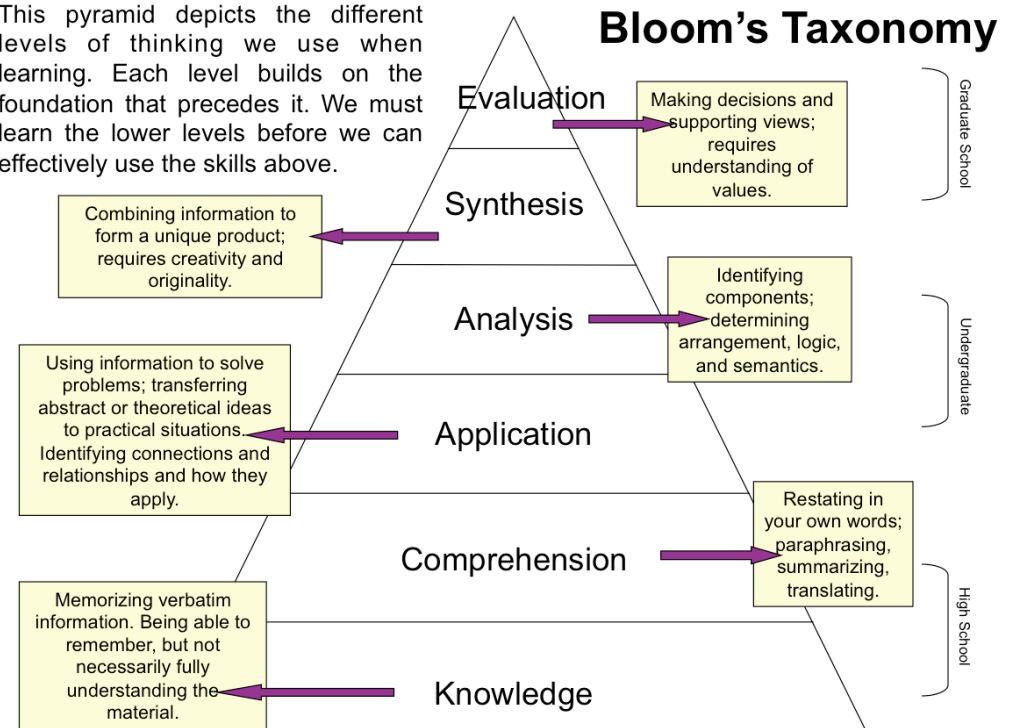| Successful, improving students	Less successful, declining students
Use specific strategies	Fail to implement plan
Deep, meaningful strategies	Surface, superficial strategies
Favor independent resources, like practice tests.	Seek personal help, like tutors

Nearly all students are willing to take a different approach to studying
...but far fewer follow through on their plan.

McGuire's Approach

- Improve student metacognitive knowledge and convince them to adopt a growth mindset and employ evidence based learning strategies.

- Use an in-class presentation to demonstrate how learning strategies that "worked" in high school are not sufficient in college.

Student Data
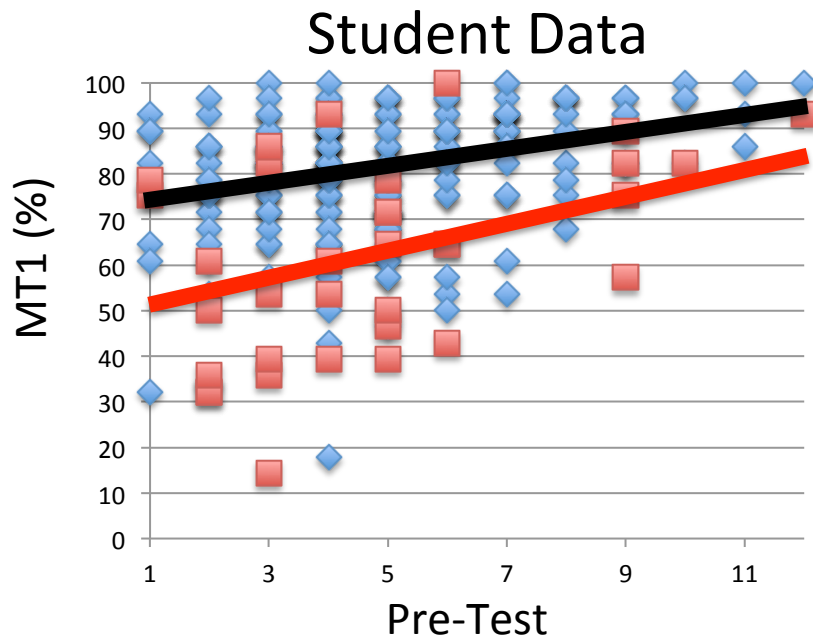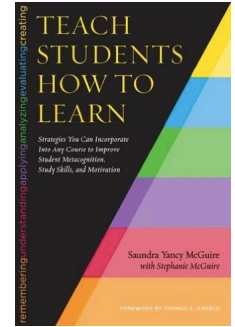
This pyramid depicts the different levels of thinking we use when learning. Each level builds on the foundation that precedes it. We must learn the lower levels before we can effectively use the skills above.

Bloom's Taxonomy

Making decisions and supporting views; requires understanding of values.

Combining information to form a unique product; requires creativity and originality.

Identifying components; determining arrangement, logic, and semantics.

Using information to solve problems; transferring abstract or theoretical ideas to practical situations. Identifying connections and relationships and how they apply.

Restating in your own words; paraphrasing, summarizing, translating.

Memorizing verbatim information. Being able to remember, but not necessarily fully understanding the material.

Evaluation

Synthesis

Analysis

Application

Comprehension

Knowledge

Graduate School

Undergraduate

High School

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Students Need a Plan for Success

|	Before Class	Class	After Class	Preparing for Exams
Best	Active reading, Take notes, Sample problems.	Treat class as a self-test. Address weaknesses	Reach mastery. Teach the material.	Work with classmates, write and share exam questions.
Better	Active reading	Mental Review. Coordinate class notes & book.	Review first, then use homework a self-test	Consolidate and review notes. Use practice test as self-test.
Good	Preview and map material	Identify Objectives & Problem-solving strategies	Identify and learn from mistakes	Use practice tests to identify objectives, learn from mistakes
Typical	Nothing	Attend every class	Complete homework (the last day)	Read class slides, Look at homework problems.

	Pre-class questions as homework	Frequent in-class questions & discussions	Post-class homework that includes earlier material, prompting recall of information.	Multiple timed practice exams with feedback
Best	Active reading, Take notes, Sample problems.	Treat class as a self-test. Address weaknesses	Reach mastery. Teach the material.	Work with classmates, write and share exam questions.
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	Before Class	Class	After Class	Preparing for Exams

The Class Format Can Support the Best Practices

In-Class Survey & After Intervention.

"I think the information on metacognitive learning strategies will help me learn in this class." **99% strongly agree or agree.**

"This is the only class that has encouraged me to strive to be the best I can be. No other professor or TA has ever told me that I can do well in their class. This is also the only class that has given 'study' tips."
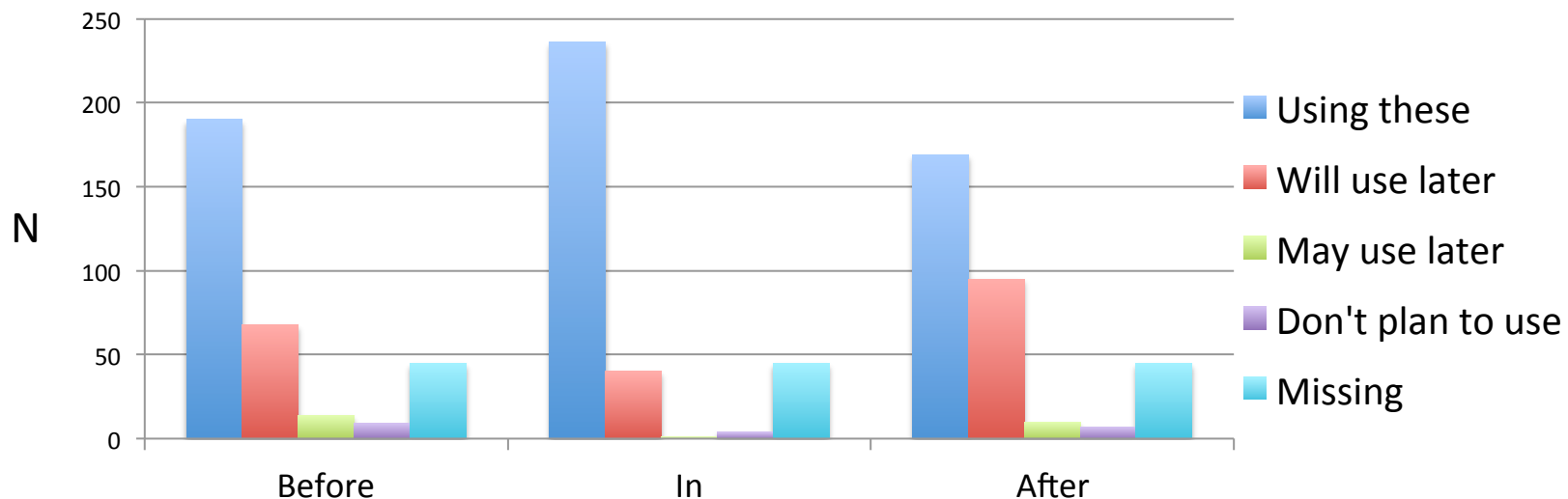
The intervention leads to a growth mindset and the intention to use metacognitive learning strategies before, in, and after class.

Nearly all students are willing to take a different approach to studying ...but far fewer follow through on their plan.

Motivated Strategies for Learning Questionnaire MSLQ Pintrich, 1991. Data from Yu & Pearson

- ## Motivation
  - Value component: Intrinsic, extrinsic, inherent in the task.
  - Expectancy component: Control of learning, self-efficacy, test anxiety.

- ## Resource Management
  - Time & study environment, effort, peer learning, help seeking.

- ## **Cognitive & Metacognitive Learning Strategies**

Variable	Example	# items	Correlation with course grade
Rehearsal	Rereading class notes.	4	0.00
Organization	Make simple charts, figures.	4	0.07
Elaboration	Write brief summaries	6	**0.14****
Metacognition	Ask myself questions.	12	**0.23****

**p<0.01

Open-Response Prompt

As we reach the end of the semester, your approach for learning and studying General Chemistry has probably settled into a routine.

Describe your practices in four paragraphs. In each paragraph, describe 1) what you do, 2) how/if you changed during the semester, and 3) how the class be structured to better address your learning in this area.
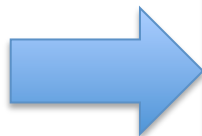
Course Structure & Practices

- Before class learning. → Textbook & active reading, pre-class homework.

- In-Class. → Note taking by hand, group discussion, identify problem-solving strategies.
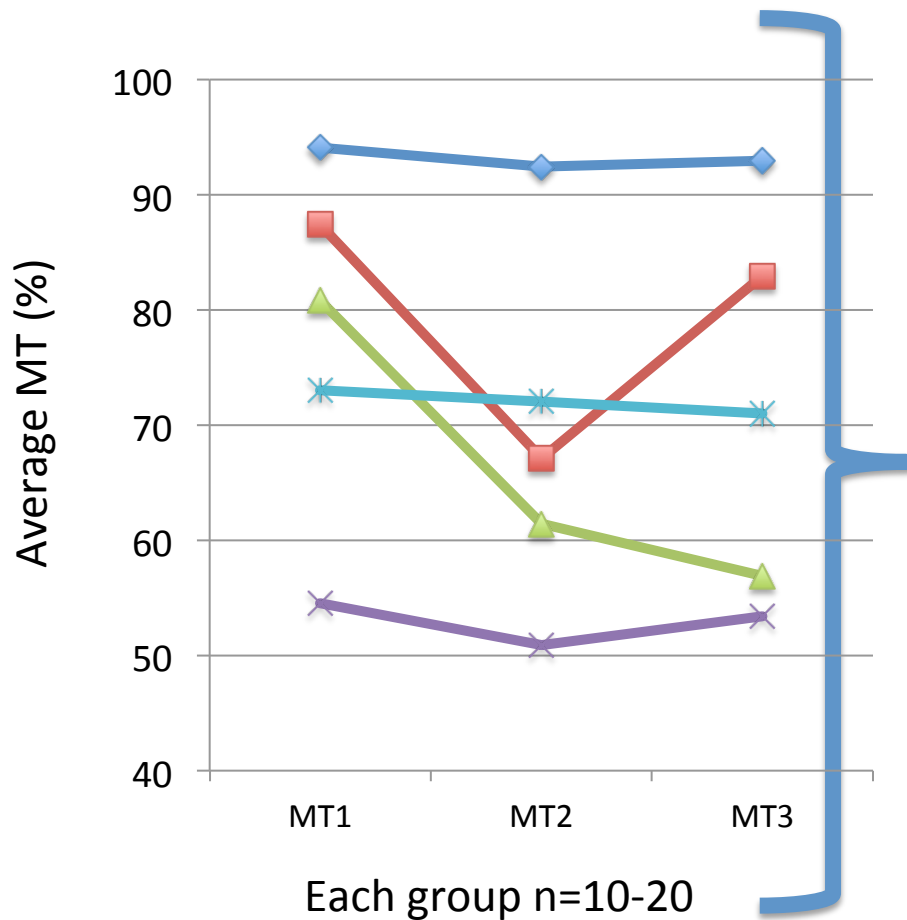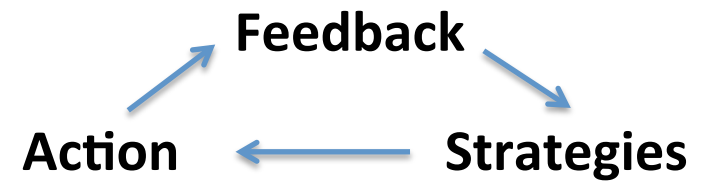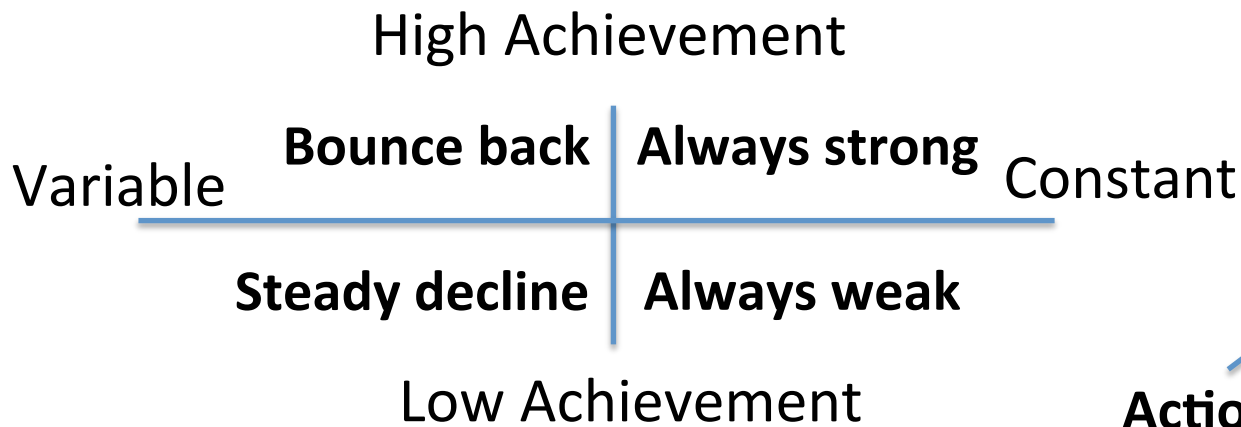
- After class/homework. → Recall/review info., return to textbook, consolidate info., HW as a self-test.

- Exam preparation. → Summarize info., authentic use of practice tests, address weaknesses, teach the material.
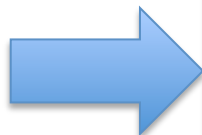
High Achievement

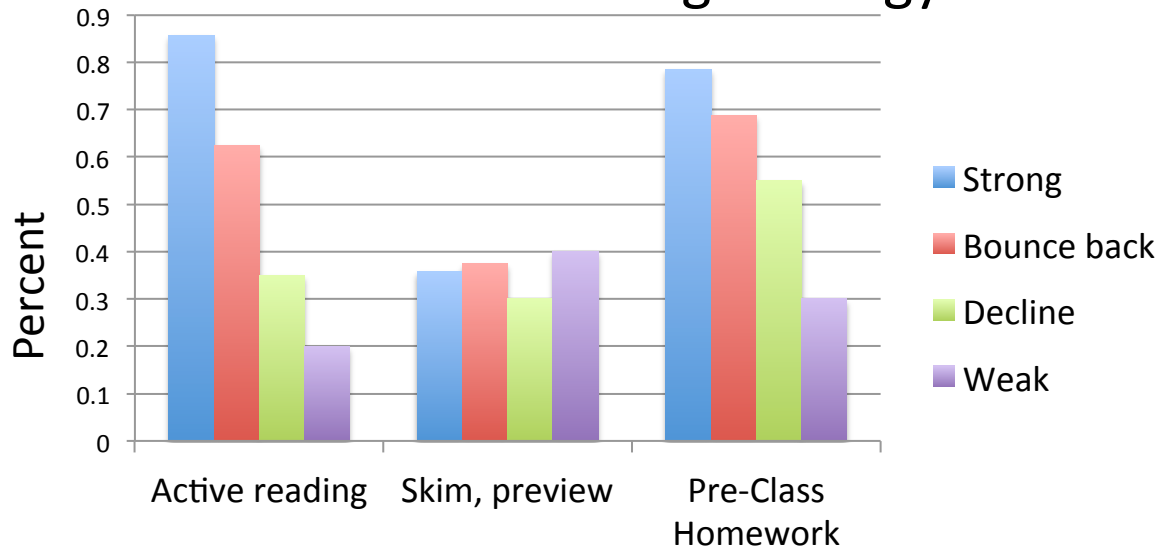|		
Variable	**Bounce back**	**Always strong**	Constant
	Steady decline	**Always weak**	

Low Achievement

Feedback

Action ← Strategies

Course Structure & Practices
Textbook & active reading, pre-class homework.

Note taking by hand, group discussion, identify problem-solving strategies.
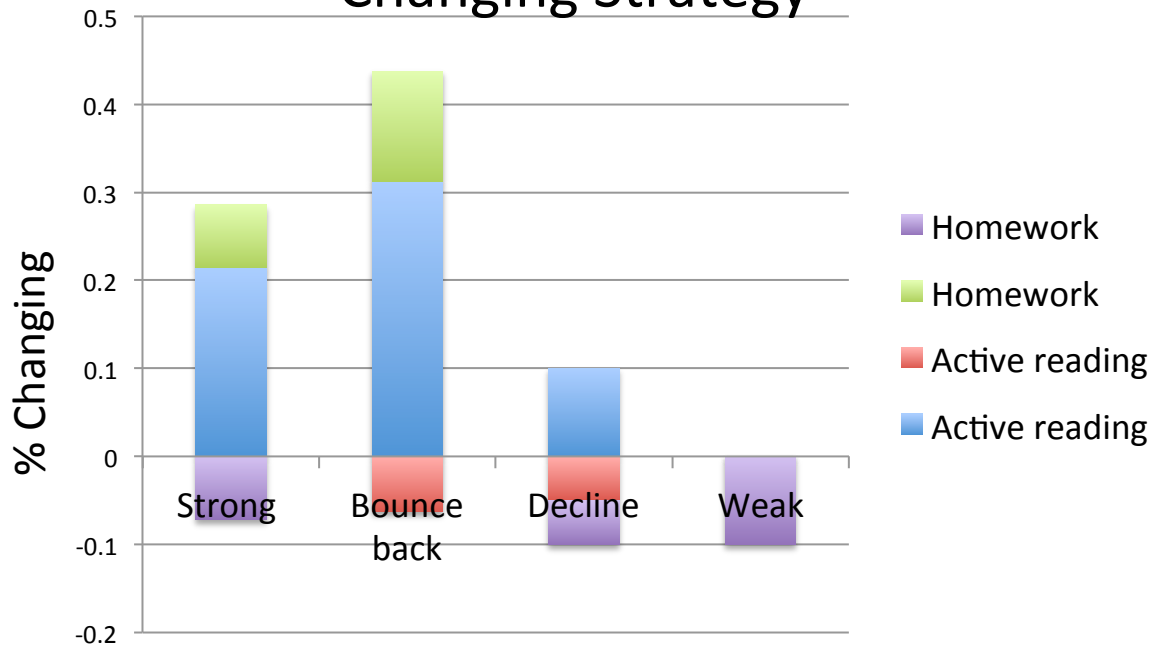
Recall/review info., return to textbook, consolidate info., HW as a self-test.

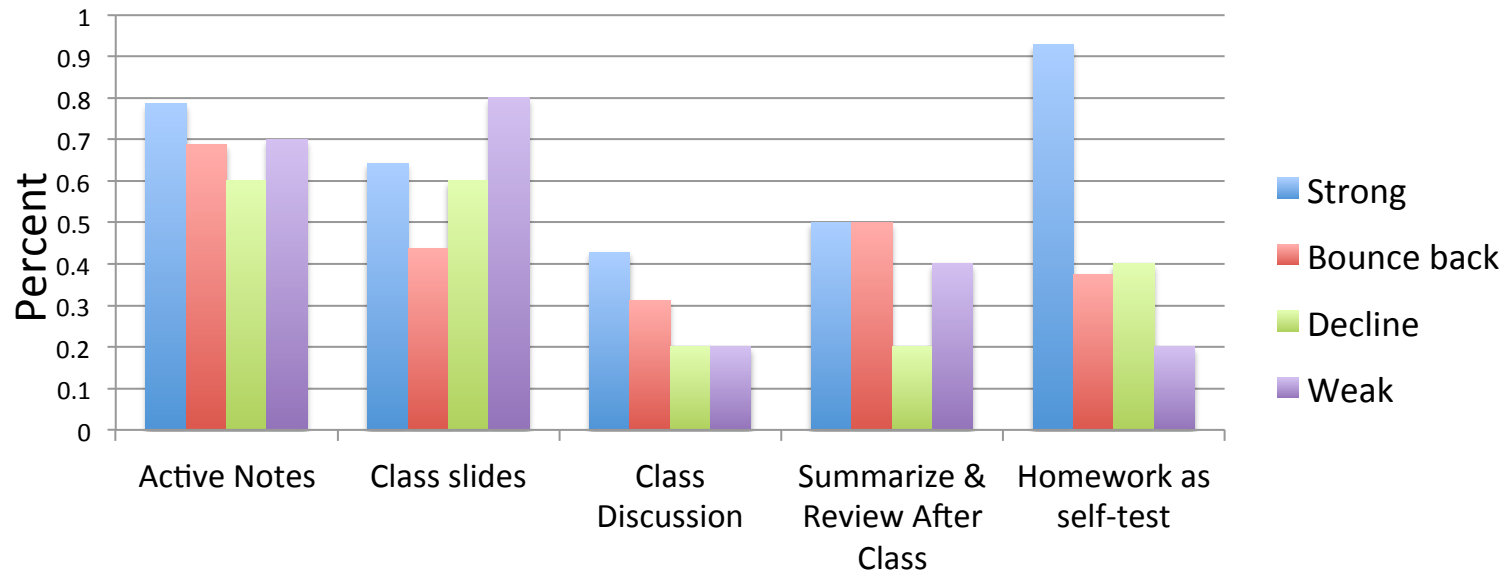Summarize info., authentic use of practice tests, address weaknesses, teach the material.

Average MT (%)

100
90
80
70
60
50
40

MT1   MT2   MT3

Each group n=10-20

Pre-Class Learning Strategy

Percent

| | Active reading | Skim, preview | Pre-Class Homework |

Legend:
- Strong (blue)
- Bounce back (red)
- Decline (green)
- Weak (purple)

Changing Strategy

% Changing

| Strong | Bounce back | Decline | Weak |

Legend:
- Homework (purple)
- Homework (green)
- Active reading (red)
- Active reading (blue)

In-Class, Post-Class