

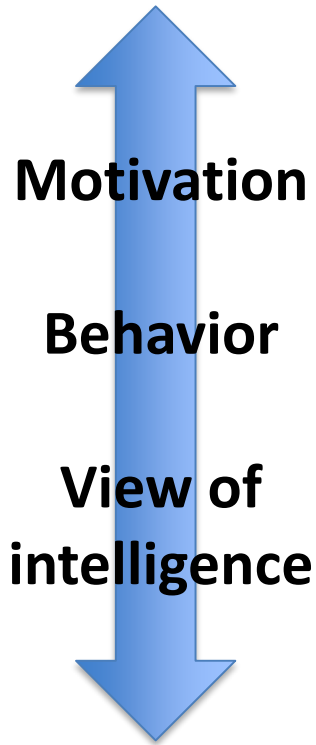
Promoting and evaluating student use of metacognitive learning strategies in general chemistry

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Many first-year students struggle with introductory STEM courses because their approaches for learning, which led to success in high school, are ill suited for college. An increasingly important objective has therefore been to structure introductory STEM courses to promote student metacognition. In this investigation, students' use and perspectives of learning strategies have been evaluated for large- enrollment general chemistry courses that were crafted to strongly support and promote student metacognition. Findings from these investigations will be shared, along with a discussion of strategies for better serving these first-year students.

Student Metacognition

- **Metacognitive knowledge:** Awareness of one's thinking, the ability to differentiate between concepts mastered and those requiring further study, and understand strategies for learning.



In some studies, **metacognitive knowledge** has been a **poor predictor** of **learning outcomes**...because simple knowing what we do not know does not guarantee that we will do anything about it (Dye and Stanton; Veenman).

- **Metacognitive regulation:** How we control our thinking, and the actions we take to learn. Ability to select appropriate learning strategies for a task, and modify approaches based on outcomes.

Student Metacognition

- **Metacognitive knowledge:** Awareness of one's thinking, the ability to differentiate between concepts mastered and those requiring further study, and understand strategies for learning.

Add metacognition to existing course elements

- Practice tests & score prediction (Casselman & Atwood)
- Practice tests & mental effort (Holme)
- Enhanced answers keys & reflection (Sabel)

Investigations

Add new course elements

- Videos, e.g. "How to Get the Most out of Studying"
(used by Cardinale)

Surveys of metacognitive strategies

(Stanton; Sebesta; Bunce); M-ASSISST (Bunce)

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Student Metacognition

- **Metacognitive knowledge:** Awareness of one's thinking, the ability to differentiate between concepts mastered and those requiring further study, and understand strategies for learning.

Metacognitive skills can be improved.

Successful, improving students

Use specific strategies

Less successful, declining students

Fail to implement plan

Findings

Deep, meaningful strategies

Surface, superficial strategies

Favor independent resources,
like practice tests.

Seek personal help,
like tutors

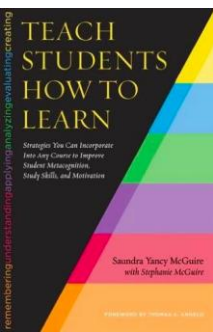
Nearly all students are willing to take a different approach to studying, but far fewer follow through on their plan. Ineffective strategies may be retained.

- **Metacognitive regulation:** How we control our thinking, and the actions we take to learn. Ability to select appropriate learning strategies for a task, and modify approaches based on outcomes.

In-Class Metacognition Session

“I can’t believe how poorly I did on the midterm. I never struggled on a test in high school, and this exam crushed me. I didn’t even recognize many of the questions. I am lost and don’t know what to do next. This makes me think I am just not good at Chemistry.”

-- Many freshmen in my office hours



JOURNAL OF
CHEMICAL EDUCATION

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

Elzbieta Cook,^{*,†} Eugene Kennedy,[‡] and Saundra Y. McGuire[†]

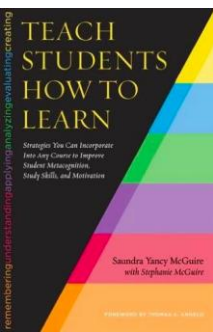
McGuire: Improving Metacognition

Knowledge

- Strategies for learning before, in, and after class.
- Self-testing.
- Deeper understanding & aiming for mastery, being able to teach others.

Regulation

- Growth vs. fixed mindset.
- Data driven, personal external outcome.
- Bloom's taxonomy and college courses.



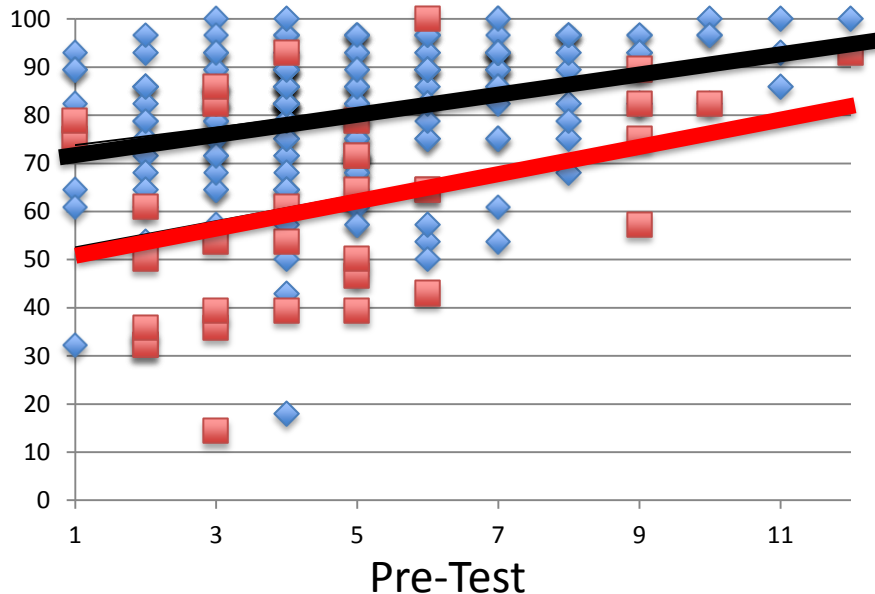
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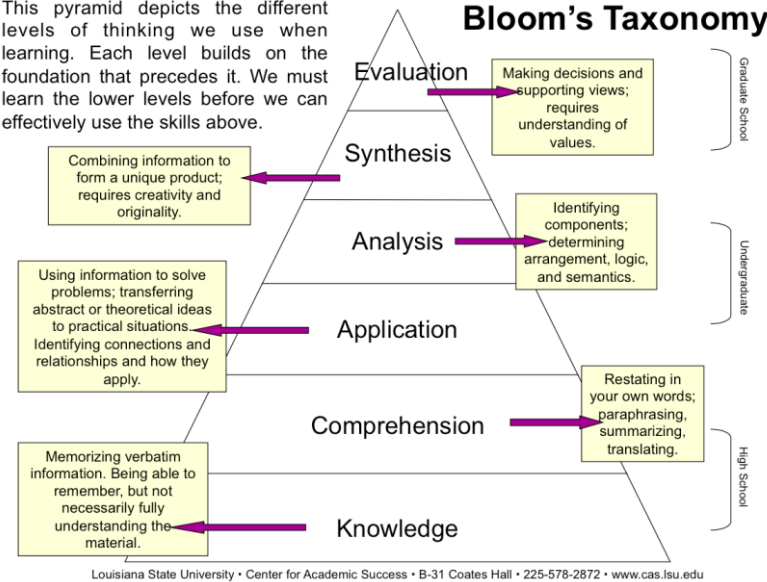
Student Data



"The approach I took was to treat lecture almost as a test. For example, before lecture I would read the material to be covered and do some practice problems. Then, during lecture, the sample problems and questions you asked were testing my knowledge. After lecture, I would then review any problems, questions, or topics covered in lecture that I struggled with."

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



Effective Metacognitive Strategies

- Using the textbook
- Previewing
- Paraphrasing, reading actively
- Going to class, participating, then reviewing
- Taking notes by hand
- Doing homework as assessment
- Learning from mistakes on homework
- Working in pairs or groups
- Creating practice exams and study material
- Aim for 100% mastery, not 90%!

Students Need a Plan for Success

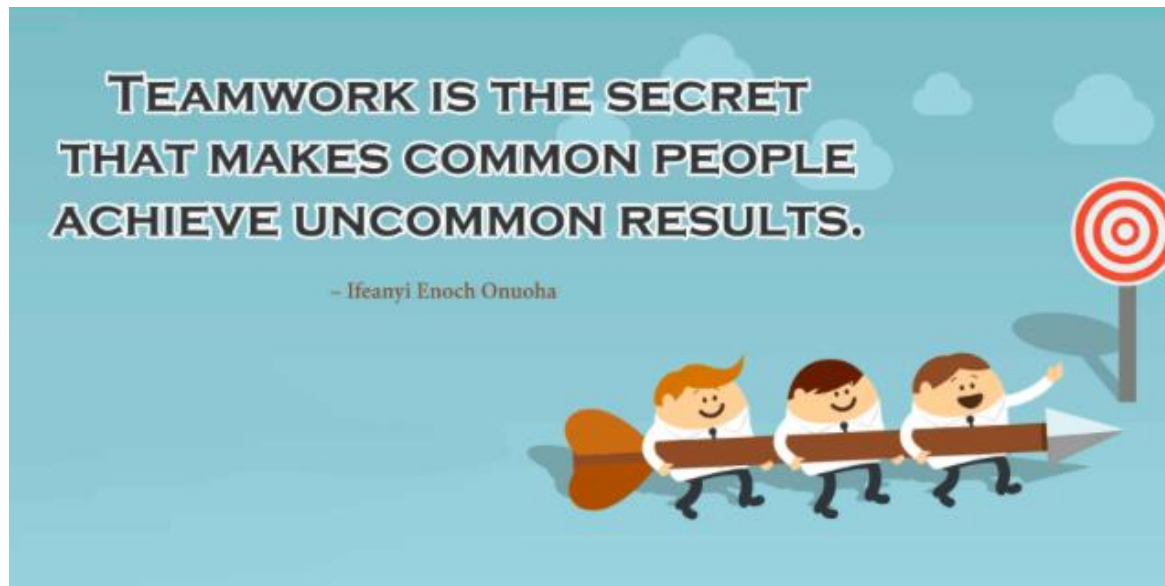
Best	Active reading, Take notes, Sample problems.	Treat class as a self-test. Address weaknesses	Reach mastery. Teach the material.	Work with classmates, write and share exam questions.
Better	Active reading	Mental Review. Coordinate class notes & book.	Review first, then use homework a self-test	Consolidate 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.
	Before Class	Class	After Class	Preparing for Exams

	Pre-class questions as homework	Frequent in-class questions	Post-class homework that includes earlier material, prompting recall of information.	Multiple timed practice exams with feedback
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The Class Format Can Support the Best Practices

We Are In This Together

- We have a plan. I will do my part. Let's make this happen!



Initial survey, n=282/328

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

“The statistics made me feel pessimistic but I was so grateful for the entire presentation. I'm definitely going to try as hard as I can to study! I'm very excited to start actually learning in college.”

Need a collaborative, positive, growth mindset message.

Weeks 1 & 2:
Pre-test in lab

Week 3:
In-class meta. session

Week 4:
In-Class meta. poll

Week 5:
First Mid-term exam

End of Semester Survey

Initial survey, n=282/328

“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.”

Students care if their instructors care.

“If more professors took the time to do things as simple as this, I'm sure they would find a much higher success rate. Most students, including myself, find motivation in being reminded that people other than themselves care whether or not they do well.”

Weeks 1 & 2:
Pre-test in lab

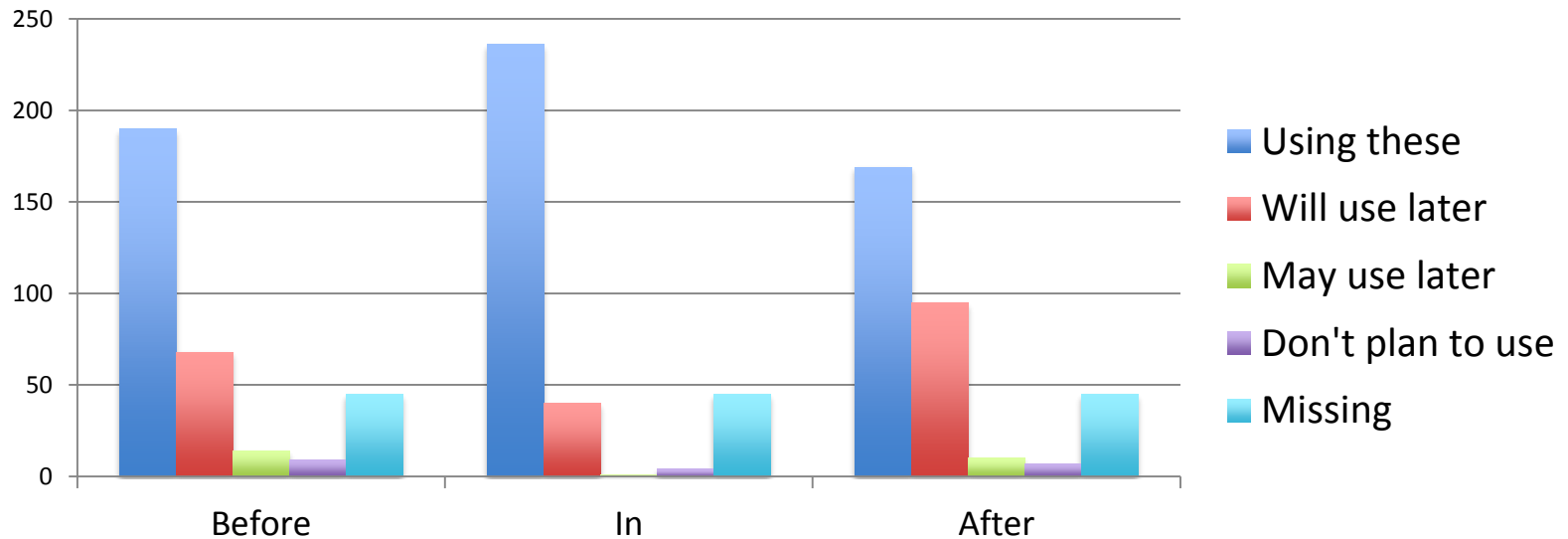
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In-class meta. session

Week 4:
In-Class meta. poll

Week 5:
First Mid-term exam

End of Semester Survey

What is your perspective on these strategies?



Before class: previewing, writing an outline, and active reading.

In-class: writing down notes by hand, identifying specific problem solving strategies, and mentally reviewing material after class.

After class: doing homework as a self-test, making sure to learn from mistakes, and summarizing the information each week.

With McGuire's in-class approach many students are initially motivated to use these learning strategies.

Predictions for MT1



Survey 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.

- Before class learning.
- In-Class.
- After class/homework.
- Exam preparation.

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**End of Semester
Survey**

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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.

High Achievement

Bounce back

Always strong

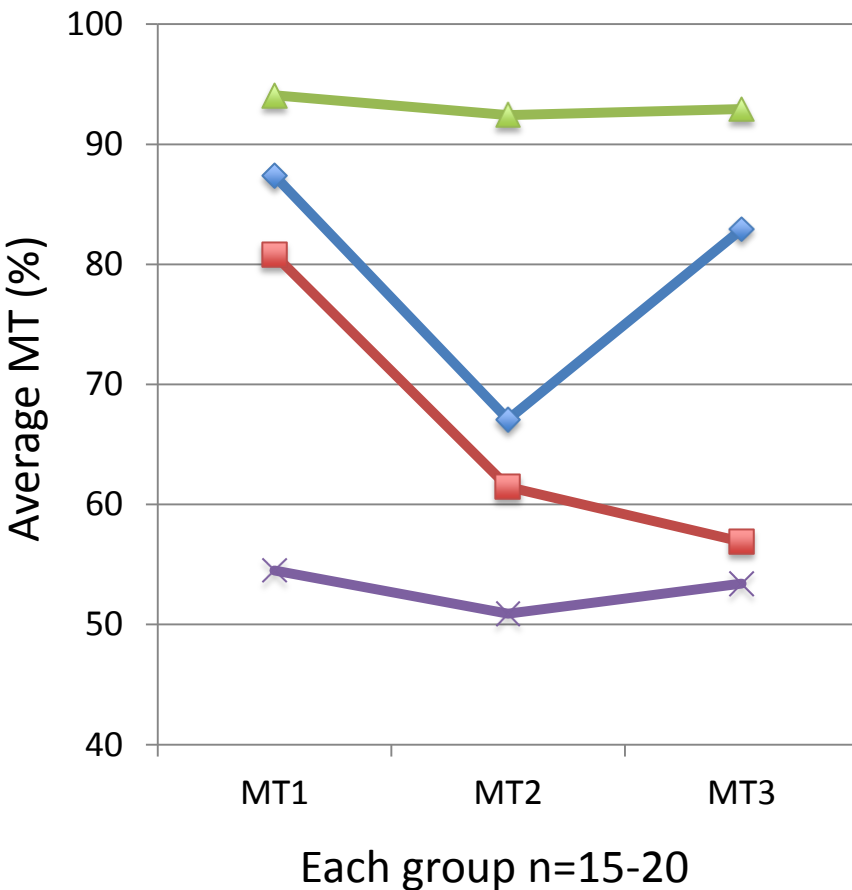
Constant

Variable

Steady decline

Always weak

Low Achievement



Course Structure & Practices

Textbook & active reading,
pre-class homework.

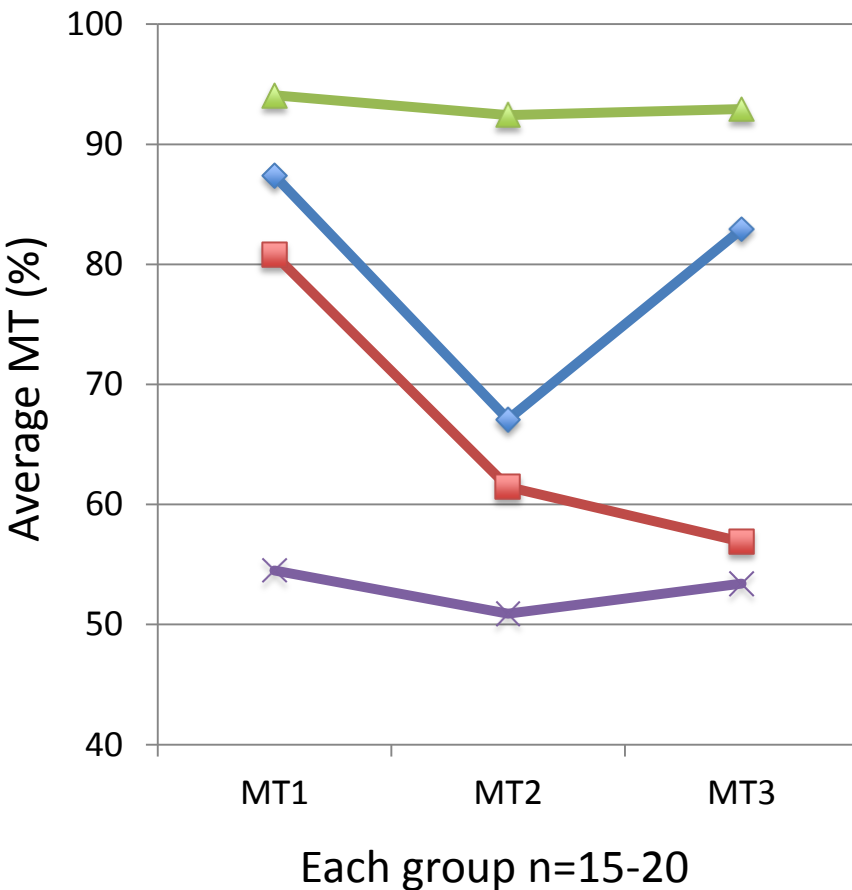
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Different Perspectives on Learning?

- I have always been good at Chemistry and this class was easy.
- I have never been good at Chemistry and these strategies didn't work.
- During the semester, I realized I needed to change my approach.
- During the semester, I did not know how to change my approach.
- I shouldn't be expected to teach myself.
- I should have made different choices.

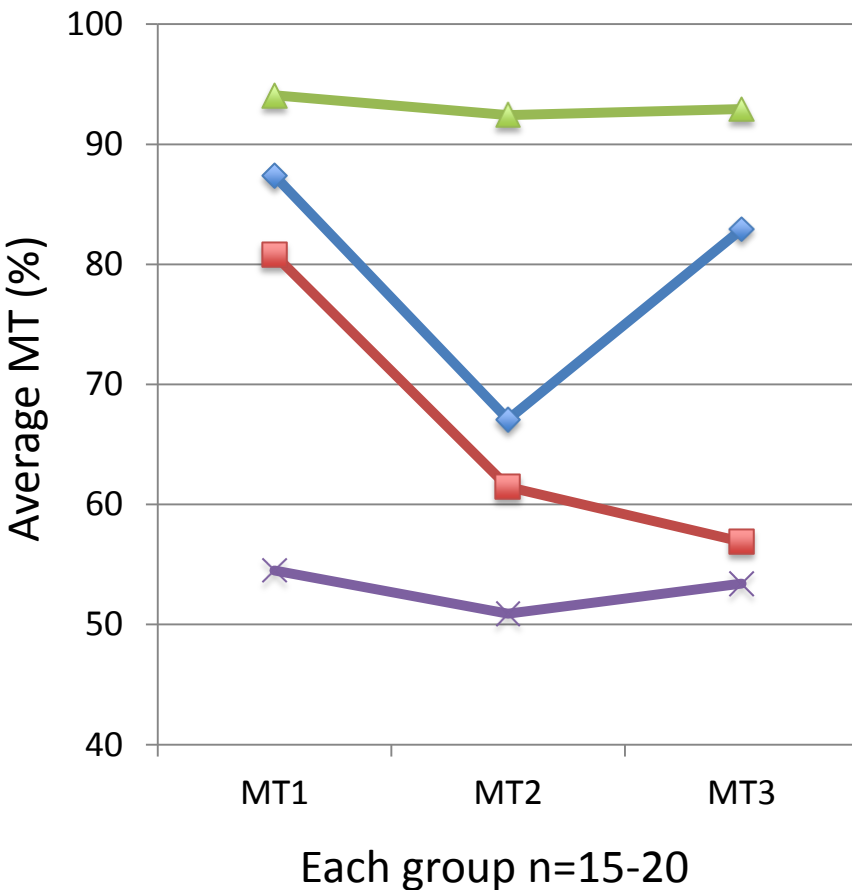


Different Use of Class Resources?

- Before class
- In-Class
- After class, homework
- Exam preparation

Incredible Exam Preparation

Transforming Instructional Material



- I return to note packets, then make an important ideas sheet, then return to the important ideas/possible exam question lists I wrote down and make sure all of those points are addressed on the important concept page.
- I then begin taking practice tests and go over with a friend the answers and we explain the ones we get wrong to each other.
- The night before the exam we go to a whiteboard and we rotate teaching different sections.

Greater Metacognition

“I started doing more after MT1 because the material started to get more difficult.”