TRESTLE Scholars Community Spring 2017: How can I help students take ownership of their learning?

Reflections from Group Members

Our Faculty Scholars Group was focused on developing metacognitive activities to improve learning and studying skills in students and also teaching skills in faculty members at CU. The term 'Metacognition' has several facets. Broadly, metacognition involves reflecting on one's own thinking (and thereby learning) processes and use the knowledge and awareness (gained as a result of that introspection) to guide future decisions. In the classroom, metacognition can help students learn more about themselves, their own learning processes, and how they can achieve higher self-efficacy. It encompasses concepts of self-awareness, taking a learning stance in mindset, and being open to suggestions and criticism. A major goal of this group was to explore the elements of metacognition and become familiar with evidence-based practices and theory from the literature, in order to improve as educators and better facilitate student learning. We also learned to engage in our own instructor metacognitive practices so that we can continue to grow in our professions and better serve our students.

Group members noticed that metacognitive activities promoted self-awareness in the students. At an early stage in the course, they were able to analyze the level of effort needed to succeed in the course based on their current scores and commitment. Many more students were able to evaluate their ability to succeed and made an early decision to drop as opposed to receiving lower grades. The remaining students were able to evaluate their work and study habits to find better ways to succeed.

Some group members noted that even if there is not an immediate improvement in test scores, the emotional component seems to be strong. Students assume that we don't care about the learning process if we don't ask. This metacognition conversation opens up and prompts more of a conversation with students. The students will develop the language and have had the space/ thought about it, and can talk about it to the instructor, and with each other (one on one, or as a class) it creates a safe place to talk about their faults, flaws, ways to get better.

We explored a variety of ‘muddiest point’ and reflective questioning activities from the literature as well as from fellow instructor participants. We read a variety of published literature from specific disciplines, as well as the effect of ‘instructor talk’ in general. We learned about exam reflection activities such as ‘exam-wrappers’, discussed ways to improve student studying habits and the effect of mindset on performance, evaluated the methods and conclusions of studies on metacognition, as well as shared our trials and ideas from our own classes. Lastly, we discussed the concept of “growth mindset” and debated whether or not instructors are able to impact this facet of student learning.

We also noticed that self-reflective metacognitive activities can affect student buy-in to course assignments. One member teaching an upper division science writing course noted that she gave them the choice of asking questions or posting their intentions for how they will work so as to succeed in the class. Every single student opted to comment on ways they will organize their time and materials. Most of the ideas were along the lines of "I will set aside a specific time every day to work on this class" or "I will keep looking ahead so I don't get stuck scrambling at the last minute." She said that she saw them living up to their resolutions, as she was receiving questions about assignments a few days out, something that's never happened before.

The discussions in this group also brought self-awareness to us as instructors. It prompted discussions with colleagues in our departments, and it caused us to examine our own metacognition, and our own approaches to our discipline. This brought into the open the tacit aspects of our discipline, those habits of mind that we wish to transfer to our students, but may never have made explicit.

It will take a while to incorporate all this knowledge, and figure out how to best fit it into our classrooms. Especially important will be to develop exercises that strengthen this aspect in student learning, especially in upper division courses, that rely on developing critical thinking and research skills. In order for students to buy in and participate, we must have bought-in to the exercises ourselves. The best applications of what we learned is ahead. This group allowed us to at least start thinking about this potentially powerful self-learning tool and how to create exercises that fit with our disciplines and specific courses. The strongest outcome from this group was useful pieces of knowledge and the desire to put it to practice and implement campus wide. It was especially helpful learning from others, and trying things out and seeing how students reacted. We will continue applying these concepts and learning from them.

Participant Developed Activities and Reflections

The participants in this group received three assignments during the course of the semester. The assignment is posted first, and then various activities and reflections from the participants are included in this order:

1. Muddiest Point
2. Exam Wrappers
3. Instructor Metacognition

Muddiest Point

- Creates a positive learning environment that encourages open dialogue, self expression, and trust between instructor and student.
- Helps instructor facilitate students learning while keeping students actively engaged in the learning process rather than being passive participants who only receive information.
- Students who are regularly asked to identify the muddiest point tend to pay more attention not only to the content but to their understanding of this content which is a higher level of thinking.

Background:

Frederick Mosteller, a professor from Harvard, created this activity after teaching statistics for 42 years. He felt that no matter how polished his lectures were, students still experienced confusion. He advocates using the last 3-4 minutes of class to ask students three questions:

1. What was the most important point in the lecture?
2. What was the muddiest point?
3. What would you like to hear more about?

Faculty Feedback:

Some feedback from STEM professors at MIT indicated that this activity helped them plan their lectures and future offerings of the course. They were often surprised by what the students wrote. It can be very time consuming to read all the answers. They noted that a searchable database with answers to these questions can be created.

Student Feedback:

The students in these MIT courses indicated that this was a helpful activity if the answers to their questions get posted on the web. They felt that it helped them focus their study efforts. They did not feel that it was as useful if they were asked to do the activity too many times.

Other advantages:

Hopefully, student reflection increases retention! It may help students study more effectively since they can pinpoint areas of confusion. Lastly, student may pay more attention in lecture if they expect to be asked about the muddiest point.

General Procedure:

1. Pass out 3x5 cards near the end of lecture. You can also use websites such as www.nearpod.com, and have students type in their answers on their phone.

2. If the class is large, you can ask students to form groups of 3-4, and then the group passes in one card.

3. You can modify the questions such as: "I don't understand how to…..", "I was surprised to learn that ….." or try to tap into faulty prior knowledge by asking, "what did you learn today that is different than how you learned that topic in the past?"

4. Make sure to address the questions quickly, preferably by the next lecture period. You can post answers to the most common questions/misunderstandings on your D2L page, or summarize them at the beginning of the next lecture with a slide or handout. You could also ask LAs/TAs to work with this information during recitation.

Assignment: (to share on Monday, February 6th)

1. Please try this activity once in your class.

2. Feel free to modify the questions and feedback! It would be fun to hear the different ways that you each try this exercise based on your discipline and class size.

3. Also, feel free to e-mail your experience to the group before February 6th so that we can learn from your experience.

4. If you are not teaching a course this semester, write up a possible lesson plan that would include this activity. Try to imagine what the muddiest point might be for students. If you have a graduate student or former student in the course, maybe interview them about what was most confusing for them about that topic.

Muddiest Point Exercise for Mathematical Thinking

Katherine E. Stange, Mathematics Dept
Spring 2017

This activity is designed for *Math 2001, Introduction to Discrete Mathematics*, which is an introduction to mathematical communication and thinking in the context of sets, logic, counting, functions etc.

The following prompt is to be given to the class at the end of a class-period. The responses are collected and read by the instructor; the next class they can be used as the basis for a class discussion.

Prompt:

In mathematics, every truth should have a justification. What part of today's material did you feel least confident in your own ability to justify? In other words, you should never simply trust in mathematics; where did you feel you were blindly trusting?

The goal of this prompt was not merely to access the students' points of confusion, but to cause students to reflect on what role confusion and understanding play in mathematics. I hope to teach students that in mathematics, to understand something is *not* simply to know or trust a fact, it is *to be able to produce a logical justification for a fact*.

Results:

Student responses were very reflective in general (sometimes downright philosophical), but also pointed out explicit things they were confused about. Students readily admitted to "blindly trusting" in many cases, and talked honestly about "blindly following the rules". They also mentioned other aspects of the nature of mathematical trust, such as experimental evidence, convincing reasons and opposing arguments. It also prompted some general discussion of challenges, such as language barriers.

I was particularly pleased to have caused so many of them to articulate the difference between blindly following the rules and understanding why something gives the right answer.

Sample student responses:

In the first day, we learned a new way to find the product of two integer. However, my group members find that it is not work for two odd numbers, which I didn't find.

Overall, I find set theory to be pretty straightforward. On the last homework, however, I felt that I was constructing complicated truth tables to prove/disprove statement without understanding the actual statements fully.

I feel least confident justifying the truth/false statements. I feel that I blindly trust the rules that are given and we follow just because we are told to follow them instead of asking why we follow them.

Nowhere. I really think I understand everything and can justify anything we've covered so far.

As someone who dislikes processes and step-by-step flow charts, I usually rush through my reasoning without really taking the time to construct opposing arguments. Because of this, I have a bit of trouble justifying mathematical statements such as "if the discriminant < 0, the quadratic equation has no solutions." Using truth tables to justify different combinations of statements has been very helping in slowing my down and to see how different combinations interact with one another.

The P only if Q statement from worksheet where in the P implies Q statement that you can have P be false but then Q still be true.

Muddiest Point for Recitations
John Nardini

I am sharing an activity based on the “Muddiest point” assignment. I was a teaching assistant for APPM 2360 (Differential Equations with Linear Algebra), which is a weekly meeting time for students to clarify topics from class and work on new problems. The class itself focuses on methods of solving differential equations with an introduction to topics from linear algebra. The class is required by most engineering disciplines, and is often the last required math class for these degrees. Most students are sophomores and juniors, with some advanced freshmen.

While we discussed muddiest point as a way to gather students’ thoughts and generate a general picture of what topics are troubling students after lecture, this would not work in a recitation environment. Recitation is a place for students to review their understanding of class material and work on new problems, so I decided to use the muddiest point as a way to drive the initial discussion during recitation. This was particularly helpful for me, as I often begin recitation by asking students if they have any questions on course material. This question is often answered by a sea of blank stares. With the muddiest point at the beginning of recitation, however, I got a much better sense of how students felt in class.

Response	Via
Picard’s Theorem	Text (US)
Isoclines	Text (US)
Picard’s Theorem	Text (US)
Direction fields / isoclines, Picard’s theorem	Text (US)
Methods of approximation	Text (US)
Picard’s theorem	Text (US)
Logistic equation problems, solutions to logistic equation	pollev.com/johnnardini329
Direction fields/isoclines	pollev.com/johnnardini329
Logistic equation and bifurcation	pollev.com/johnnardini329
I second isoclenes	Text (US)

I've included the responses I received when the week before Exam 1, I asked students to respond to the question "What topics from class are you struggling with?" Students had the option of answering this question via a text message or online. To help jog students' memories, I wrote on the board some of the current class material, including "Picard's theorem", "direction fields", "logistic equation", etc. The poll shown here was particularly helpful for me because we had covered Picard's Theorem in the previous week's recitation, so I had assumed that students would now feel comfortable with it. This turned out to be wrong, however, as it was still the most common trouble area for students. This led to another discussion of Picard's Theorem in recitation that I would not have considered having previously.

Modifications for future semesters:

- Opening up discussion for any topic covered during the semester, as opposed to current class material, will require more preparation from me. I was not expecting to cover Picard's Theorem in this recitation because it had been discussed previously, and was thus probably not fully prepared to spend the first 10 minutes of recitation discussing it. This certainly will require more preparation in the future, such as keeping notes on all class material throughout the semester and bringing these notes to recitation.
- I struggled a lot with this activity because while the most common response was Picard's Theorem, there is still a wide array of topics that students clearly did not understand. It simply would not have been possible to cover all topics mentioned during one recitation, but I do feel disappointed that the students that answered "Isoclines","direction fields", and "logistic equation" did not get their muddiest point covered. This could potentially be fixed with a more focused weekly muddiest point or encouraging these students to bring their questions to office hours.

Muddiest Point Exercise

Robert Buchwald

Honors EBIO 1220 – 16 students

Spring 2017

I used Polleverywhere.com to gather anonymous responses from students to 3 questions. Below are the questions with a subset of answers:

1. What was the most important point from today's lecture?
    a. New discoveries have shown the Kingdom System is inaccurate
    b. The differences between Eukaryotic cells and Bacteria
    c. MRSA is no Bueno
    d. Bacteria can be bad, but can be very beneficial
2. What would you like to hear more about?
    a. Slime (x5)
    b. Endosymbiosis
    c. The scary looking protists
3. What was the muddiest point (the least clear part)?
    a. Why the Eukaryotic supergroups are different
    b. Eukaryotic phylogenies
    c. N-fixing bacteria

This exercise was very helpful for me to ascertain whether the students came away from the lecture with the desired information. It also helped me see the weak spots in my presenation.

Muddiest Point Exercise

Atreyee Bhattacharya

ENVS 4100 – 17 students

ENVS 3525- 47 students (cornerstone class)

Spring 2017

I primarily focused on the muddy point activity in two of my classes, both of which were research intensive. In both these classes, students worked in groups of 3-5.

(A) In ENVS 4100 (Coral reefs), each group of students (2-4) worked on one aspect of a case study and at the end of 2-3 weeks, there would be class presentations on figures they would develop to explain the research. At the end of the class, we have several original figures that forms the backbone of a research paper; three students from that class are currently writing up the paper in order to submit to a journal. My sense is it would require two more members of the class during the edit phase.

I asked questions such as the following at the end of class presentations

Please post a 100-200 word summary of research so far, main questions you will follow up with and how will you research this? What issues do you foresee and how do you think you will overcome this?

This exercise was meant to make students aware of the progress of research with a clear goal of having figures ready for a publication. Based on student's responses, which varied between wanting to know everything about coral reefs to being skeptical about the nature of work, I understood, more than my students that students inherently had no experience writing papers (beyond class papers) and very little understanding about how to work on research with an actual intent of publications. I can say that these questions may not have helped the students much but it definitely helped me understand the need to bolster these skills in students (at least in ENVS). I would be interested in writing a proposal for a course (with a few other faculty members most likely) that is intended to develop these skills in students.

(B) In ENVS 3525 (Arid environment), each group (5-6) of students defined a research question that the they explored learning GIS and data visualization and presented their original findings as an information brief, followed by a poster presentation. In the first half of the course, I had students read segments of books and answer questions such as the following in a discussion post (every week, which I think is a tad too much)

- In each segment, which was the most important concept that you will use for your research? Why?

- In each segment, which concept do you think *could* be important, but you would like to know more in lecture to determine the value in your research? In other words which concept seemed most difficult in each segment that you will like our class lecture to cover?
- In each segment, which concept was most important that you understood fully, but you would like to have as a resource for your group in D2L?

This exercise was very helpful for me to ascertain whether the students came away from the readings with the desired information. It also allowed me to advise students on their research topics as well as carve out special lectures in class (using the board) to hammer out problematic aspects. However, students did not value this work as much. I suspect because, as we discussed in the last day of Trestle, that campus wide, there is not a lot of focus on introspection as an empowering skill. The course that I plan to develop would again have this aspect being a core mission.

An important note: The advantages of muddy point might be more effective in lecture-based classes for the instructor. I am not convinced that students have the background necessary to take advantage of the metacognitive aspect. Which is why, the advantage of this activity in research-based classes is not tremendous. Perhaps another set o questions that allow students to understand connections…but not sure if that falls under metacognition as we discussed in Trestle.

Exam Self-Reflection
("Exam Wrappers")

- Helps students to identify their own individual areas of strength and weakness to guide further study.

- Students will reflect on the adequacy of their preparation time and the appropriateness of their study strategies.

- Students can characterize the nature of their errors to find any recurring patterns that could be addressed.

Background:

One of the earliest uses of this strategy was called "Error Analysis". (DuBois & Staley, 1997) A copy of this paper along with a short summary will be uploaded to the google drive folder. There are three components: test-question analysis, information-processing analysis and self-management analysis. Please see summary for more details.

The term "Exam Wrappers" was coined by researchers at Carnegie Mellon led by Marsha Lovett in a book called "Using Reflection and Metacognition to Improve Student Learning Across the Disciplines, Across the Academy" by Naomi Silver, Matthew Kaplan, Danielle LaVaque-Manty, Deborah Meizlish, James Rhem.

In the book, "How Learning Works: 7 Research-Based Principles for Smart Teaching", Susan Ambrose addresses how students generally react to exams. "All too often when students receive back a graded exam, they focus on a single feature – the score they earned. Although this focus on 'the grade' is understandable, it can lead students to miss out on several learning opportunities that such an assessment can provide." (Ambrose et al, 2010)

General Procedure:

You can give a handout on the same day that you give back graded exams. Students are then reflecting on their performance immediately. An example is shown below. Ambose suggests that the professor collects the exam wrappers to determine how students analyze their strengths and weaknesses in test-taking, but also how they studied for the exam. The professor can show some responses anonymously in class to demonstrate powerful study strategies, or to give coaching about how to modify study strategies.

The exam wrapper is then returned to students one week before the next exam, either in recitation or a smaller section where there is an opportunity for discussion. The students can discuss what they will try or modify from their previous study sessions for the exam.

Example:

This form will help you to analyze your exam performance and find strategies that work best for you in learning the material for this course. Self-assessing your progress and adjusting your study strategies accordingly is what effective learners tend to do. Please answer the questions below sincerely. Your responses will have no impact on your grade, but they will inform the instructional team about how we can best support your learning. We will return your completed form before the second exam so that you can use your own responses to guide your approach to studying next time.

1. Approximately how much time did you spend preparing for this exam? _____
2. What percentage of your test-preparation time was spent in each of these activities?

    1. Skimming textbook chapters
    2. Reading textbook chapters thoroughly
    3. Reviewing your own notes
    4. Working on practice exam questions
    5. Reviewing materials from blackboard
    6. Other

        (Please specify: _____)

3. As you look over your graded exam, analyze where/how you lost points. Fill in the blanks below with the number of points you lost due to each of the following:

    1. Trouble applying definitions
    2. Trouble remembering structures
    3. Lack of understanding of a concept
    4. Not knowing how to begin a problem
    5. Careless mistakes
    6. Other

        (Please specify: _____)

4. Based on your responses to the questions above, name 3 things you plan to do differently in preparing for the next exam. For instance, will you just spend more time, change a specific study habit (if so, name it), try to sharpen some other skill (if so, name it), use other resources more, or something else?

What can we do to help support your learning and your preparation for the next exam?

Assignment: (to share on Monday, February 20th)

Create an exam wrapper for your class. Make 14 copies. Consider what questions that you want to ask and how you will use the information that you receive!

Exam Wrapper Activity

Kathryn Plath

These are the exam reflections I designed for Chemistry 1031 – Environmental Chemistry 2. This is a small course (~20 students) that is primarily taken by non-science majors to fulfill a core requirement.

This class focuses on water chemistry and uses many real world examples. The exams are a mix of multiple choice questions and short answer questions, approximately half of the exam is problems to solve, and the other half covers the concepts and specific scenarios discussed in class. The goal of these reflections was to encourage students to engage with their role in the class and to get them to think about their studying and analyze what is effective and what is not.

Table 1. This is a schedule of the reflections and exams, along with the points associated.

Date	Activity Name	Purpose	Points Associated
Wed, Feb 15	Exam 1		
In Class on Mon, 20, due on Fri, Feb 24	Exam 1 Reflection	Describe a student's study habits, analyze exam for missed points, and reflect on which strategies were successful	3 pts Extra Credit
Mon, Mar 6	Exam 2 Prep	Make a plan for studying for the next exam, consider topics covered, then the students were provided with the Study Guide for the exam, and asked about which topics surprised them and which topics they predicted they would need to study more	No Points
Wed, Mar 15	Exam 2		
In Class on Mon, Apr 3, due Fri, Apr 7	Exam 2 Reflection	Describe how they changed their approach for Exam 2, and what the outcome was, both in terms of scores and understanding. They were also asked about their plans for the third exam, and what they thought we should do as a class for the third exam.	3 pts Extra Credit
Wed, Apr 19	Exam 3		
Tues, May 9	Reflection as part of Final Exam	The students were asked to reflect on why we did these reflections, what they learned from the reflections, and which topics in class they enjoyed the most.	10 pts on exam (out of 200 pts)

On the reflections prior to the final exam, I tried to comment on each student's work and to guide them on areas where their answers were very surface (yes/no answers, or when they used phrases like "study more" or "study harder"). By the time of the final exam, I decided to award points on the final exam to encourage them to think about the reflections as a whole.

Things I would change:

- Several students were new to the reflection process and consistently gave yes/no answers. I think I could avoid this with a better introduction to the activity, and better worded questions.
- In the reflections, some of the students struggled to see the purpose of the reflections. I plan to address this by giving a better introduction, and by scheduling time for a class discussion on it.
- The students like the reflections (or maybe just the extra credit) more than I had anticipated, so I would prep in advance for each reflection to give them back when they get their exams and to have more time for the students to finish them in class.

Reflection Acitivities:

Exam 1 Self-Reflection:

1. Exam 1 Score: _____
2. Approximately how much time did you spend studying for this exam?
3. Describe your test preparation.
4. Reflect on your exam score. Are you happy with your score? Do you feel it represents your best work and effort? How does this score affect your goals for the next exam in this course? Did the content of the exam surprise you in some way?
5. Approximately what percentage of your test-preparation time was spent in each of the following activities?

   Reading the textbook chapters

   Reviewing your notes

   Reviewing the posted lecture notes

   Working on the practice exam questions

   Reviewing homework assignments

   Reworking recitation activities

   Other (please specify)

6. As you look over your graded exam, analyze where/how you lost points. Fill in the blanks below with the number of points you lost due to each of the following:

   Trouble applying definitions

   Lack of understanding of a concept

   Not knowing how to begin a problem

   Careless mistakes

   Other (please specify)

7. List 3 way in which your test preparation went well for you.

8. Based on your responses to the questions above, name 3 things you plan to do differently in preparing for the next exam. For instance, will you spend more time (describe which activities you will put more time into), change a specific study habit (if so, name it), use other resources more, or something else?

Exam 2 Preparation Reflection:

1. Describe in detail your plan to study for the second exam.
2. Approximately what percentage of your test-preparation time do you plan to spend on each of the following activities?

   Reading the textbook chapters

   Reviewing your notes

   Reviewing the posted lecture notes

   Working on the practice exam questions

   Reviewing homework assignments

   Reworking recitation activities

   Other (please specify)

3. Thinking about the material covered in chapter 5 (all the material since the last exam).
4. List three types of numerical problems you think could be on the exam.
5. List three chemistry concepts we covered for this exam.
6. List three applications or real world situations we covered for this exam.
7. Looking over the study guide, which topics did you not remember? Which topics do you know you need to study more?

Exam 2 Reflection:

1. Explain how you changed your study habits and/or approach to the course between Exam 1 and Exam 2.
2. a. Did this change improve your score?
   b. Do you feel you understood the material better than you had for the first exam? Explain your answer.
   c. Be specific. Explain how/why you feel this happened.
3. Describe your plan to study for the third exam.
4. Explain what changes you intend to make for the third exam.
5. With the final exam approaching, what do you think we should do as a class to prepare?

Reflection as part of the Final Exam:

3. (10 pts) The points for these questions will be based on if your answer is thoughtful and reflective, uses complete sentences, and NEVER answer with just a yes, no, or single phrase.

a. What do you think was the purpose of our reflections in class?

b. What do you think you learned from the reflections?

c. What was the most interesting topic we covered this semester? Explain your answer.

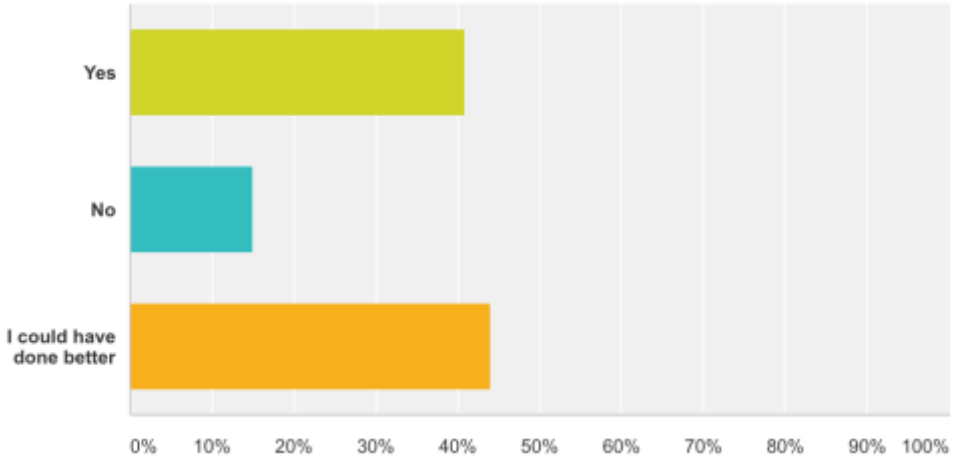
Extra Credit. (3 pts) Tell me about something you studied, but I did not put on the exam. Explain the topic.

Exam Reflection Activity

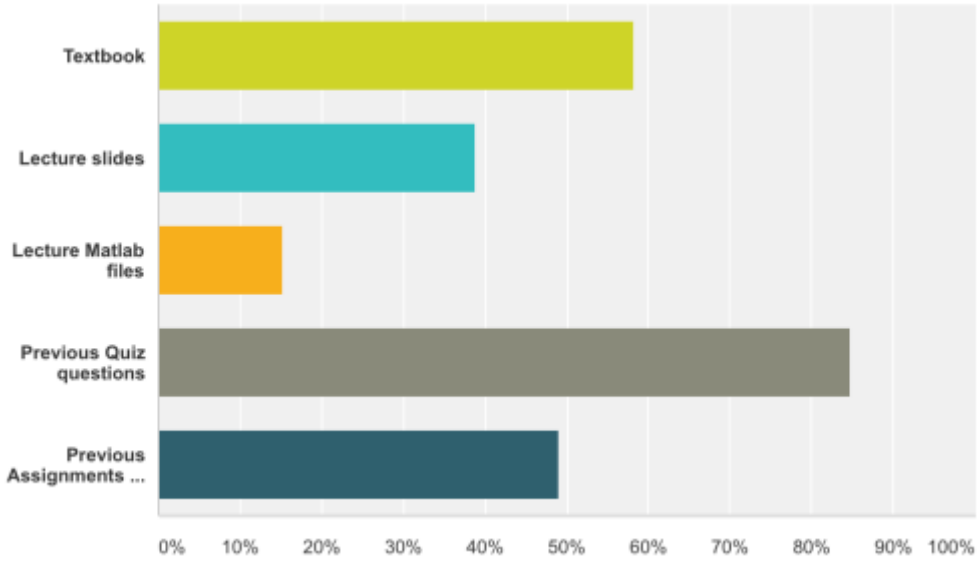
Ioana Fleming (CSCI 1320 - Intro Programming w/ Engineering)

The following survey was sent to students after Midterm Exam and Midterm Programming Practicum (not all questions are included here). Out of 265 students enrolled in the course, 180 took the survey. The answers are presented in graph form.

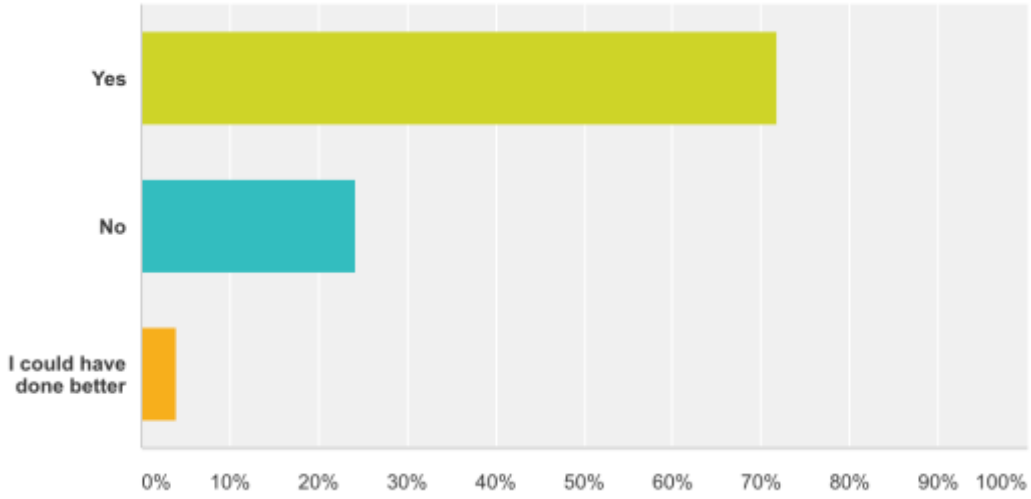
1. **Are you happy with you Midterm Exam score?**



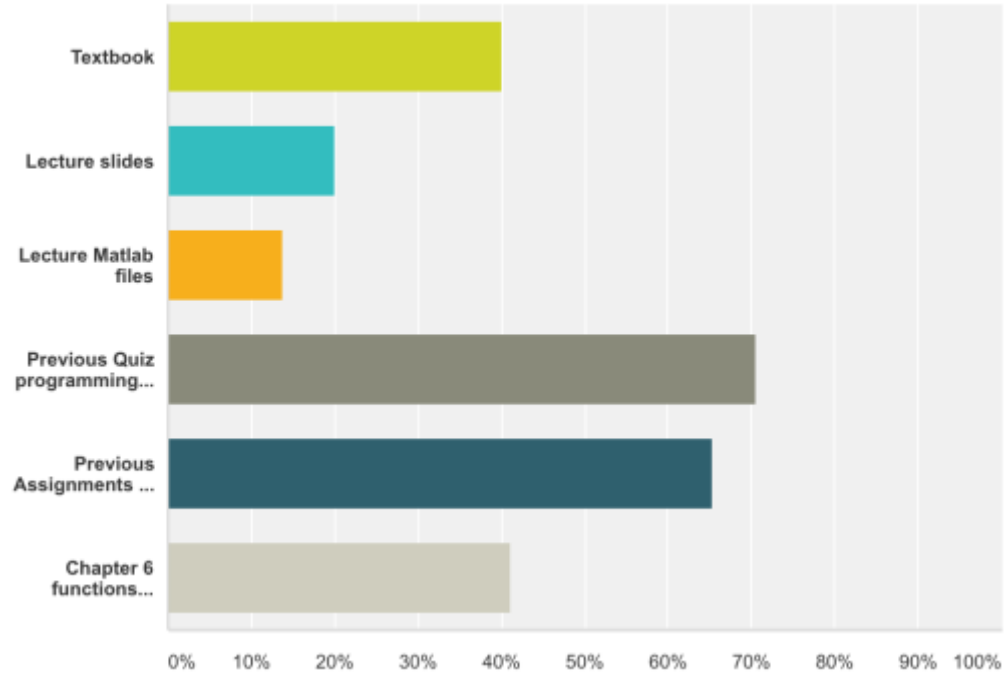
2. **When preparing for the Midterm Exam, which materials were helpful? (check all that apply)**



3. **Are you happy with you Midterm Practicum score?**



4. **When preparing for the Midterm Practicum, which materials were helpful? (check all that apply)**



5. **Tell us something about your own learning. What could you be doing differently to help you succeed in this class?**

Sample answers:

"I could study more and try and get to more of the lectures, I learn by observing and doing, and repeating."

"I could be working more with others, as not only can one learn a lot from the errors of others but also from helping them get past them."

"I could use the textbook more often"

"Going to all the lectures. Starting the assignments earlier."

"I could read the textbook before coming to class."

"I could start early on assignments and go to office hours when I have questions rather than being prideful and trying to grind through it."

"Take more time to read textbook"

"Read the textbook more diligently"

"Have made a friend in the class with which to talk to about the material sooner."

"I could go to office hours more and re-read the textbook"

"If I spent more time going over notes and going over my previous code to study for exams."

“I wish i could do small assignments and code them so that when it comes to the larger projects i will be more prepared.”

“I feel like I’m doing fairly well. I tend to use Google a bit too much on some assignments and labs”

“I can start my assignments and labs earlier to ensure I have enough time to finish rather than procrastinating so long”

“Not use Google as often when I am stuck or confused.”

“Trying more on my own before getting help from others”

“Taking more time to fully understand the basics”

CSCI-1300-100: CS 1: Starting Computing, David Knox

425 students / 192 study habit responses

46% freshman, 32% sophomore, 13% junior, 3% senior

A:31%, B:20%, C:8%, D:1%, F:10%, Drop:28%

308 completed course (72%)

DWF: 39% DWF was a little higher than previous semesters, but D and F grades are down.

I believe that because of the TRESTLE scholars group materials, I promoted self awareness in the students. At an early stage in the course, they were able to analyze the level of effort needed to succeed in the course and their current scores and commitment. Many more were able to evaluate their ability to succeed and made an early decision to drop as opposed to receiving lower grades. The remaining students were able to evaluate their work and study habits to find better ways to succeed. About 80% (C- or better) of the students who completed the course obtained the skills required to advance to higher level courses.

Actual assignment

This form will help you to analyze your performance on the practicum and find strategies that work best for you in learning the material for this course. Self-assessing your progress and adjusting your study strategies accordingly are methods used by effective learners.

Please answer the questions below sincerely. Your responses will have no impact on your grade, but they will inform the instructional team about how we can best support your learning. We will review your completed form before the second practicum so that you can use your own responses to guide your approach to studying that material.

Question 1: What percentage of the lectures did you attend?

Question 2: Approximately how much time (in hours) did you spend outside of

lectures preparing for this practicum?

Question 3: What was your score?

Question 4: Did your score meet your expectations?

Question 5: What types of techniques did you use leading up to this practicum?

Select one or more:

a. Attend the help session

b. Complete the practice practicum

c. Multiple attempts of practice practicum

d. Reviewing your own notes

e. Reviewing the lecture slides

f. Reviewing the lecture videos

g. Reviewing solutions to homework

h. Reviewing other online resources

i. Skimming the book chapters

j. Reading the book chapters

k. Reading the tutorial

l. Doing the self-test problems in the book

m. Participating in a study group

n. Writing or RE-writing your own notes

Question 6: What other study techniques were used?

Question 7: Why were you not able to provide a working solution to the problems on the practicum?

Select one or more:

a. I had trouble knowing where to begin

b. I had trouble understanding what the problem was asking

c. I had trouble developing the algorithm

d. I had trouble knowing how to solve the problem

e. I had trouble developing the algorithm

f. I had trouble remembering the syntax

g. I made careless mistakes

Question 8: Can you identify other areas of problems you encountered on this practicum?

Question 9: Based on your responses to questions above, name three things you plan to do in preparing for the next practicum. For instance, will you spend more time, change a study habit (if so name it), try to sharpen some other skill (name it), use other resources, or something completely different?

Question 10: Anything else you want to tell your instructors or your future self?

Using Peer Critique to Enhance Metacognition

Jean Hertzberg

Dept. Mechanical Engineering CU Boulder

TRESTLE Scholars group Spring 2017

Aesthetics of Design is an elective for graduates and undergraduates in Mechanical Engineering. Students from art-oriented disciplines such as Technology, Arts and Media are also welcome, but there are few in the class. The course focuses on aesthetic aspects of design via hands-on design-build experiences. Students individually create dynamic artifacts of their own choice with the assistance of teammates. Content includes major design movements since 1900, constructive critique practice, hand sketching techniques and other selected industrial design topics. Students publish their design work on an archival public blog which provides a professional portfolio element.

There is very little formal grading in this course. One course goal is to remove grades as a driving motivation, and shift the motivation to production of authentic, creative work. Timely, constructive feedback is likely to be important, but in scaling this class up to 50 students, the feedback can't be provided by the instructor. Instead, students are asked to critique each other throughout the semester. Critique technique was discussed explicitly in lecture, and the quantity of critique that was expected was clearly defined. Critique as an important professional skill was also discussed, and was reinforced by a guest lecture. However, the importance of critique as a metacognitive exercise in this context was not discussed in class.

After the first warm-up design experience, which occupied the first third of the semester, students took a survey which included a few metacognitive questions about critique, such as 'did you get useful feedback from other students?' and 'did you *give* useful feedback?'. Survey results, based on an an informal emergent coding carried out by the course TA are presented below.

Q14 **Did you read the critique(s) of your report? If so, was it helpful? How so? If not, are you going to do so in the next few days?**	
Good feedback / suggestions	27
Too nice / Not useful critique	9
More critical feedback	5

Q15 **Was the in-class feedback you got helpful? How so?**	
Yes	31

No	5
Ideas / Suggested Improvements / Questions	21
Somewhat helpful / Not enough critical feedback	7
Preferred conversational feedback	5
Preferred written feedback	1

Q16 **Was the in-class feedback you gave helpful? To you? To your podmates?**	
Yes	15
Maybe / Hopefully	27
No / Not confident	4

Q17 **Please give suggestions for making feedback more helpful**	
Just fine	13
Too positive, try to be critical	5
Critique Template	5
Critique exercises / guest lecture	3
More time	3
Focus on Specifics	2
Anonymous	1
Critique requirements (word count, etc)	1
Request help via blogs	1
Feedback from more people	1
Teacher's Feedback	1

After this survey, the TA noted that both the quality of the students' posted work and their critiques seemed to improve.

Students were also asked to grade themselves for the first project:

Q5 **What grade do you give yourself for this project?**	
A / A-	34
Between A and B	2
B+ / B / B-	8

Thus a significant fraction did not simply give themselves an A.

At the end of the semester, an extensive exit survey asked similar questions, plus an explicit metacognitive prompt: 'Did doing critique teach you anything about yourself? About your work? About

your process?' Although ninety percent of the respondents agreed that they had learned from doing critique, what they learned varied widely, from ideas that were useful to their own projects, to being able to accept critique. This showed me that having more focused learning objectives for this metacognitive exercise would be fruitful, and that I should be even more explicit in class about the value of the metacognitive assignments I give.

The survey texts are appended below for reference. Please contact me with any questions.

Post warm-up survey, given in week 5

Upcycle Project Post Survey

1) Outside of class, how many hours did you spend in
   a) planning/design?
   b) fabrication (hands-on) of final version?
   c) documenting your work?
   d) reading/critiquing others' work?
2) Do you wish you had spent more or fewer hours? In which design/fab phase?
3) What would have inspired you to make that change?
4) Was your effort appropriate for 1/3 of a three credit course?
5) What grade do you give yourself for this project? (Note, I will ask this for the course at the end of the semester)
6) What was the hardest part of this project?
7) What would have helped you with this hardest part?
8) What do you think of the quality of the artifacts produced by others in your pod overall?
9) What do you think of the aesthetics of the artifacts produced by others in your pod overall?
10) What do you think of the quality of the presentations of the others in your pod overall? (Enough info given? Was there enough time/ too much time per presentation?)
11) Did you ask for or get help from any of your teammates with your project? What kind of help? How much of their time did you get?
12) Did you volunteer to help any of your teammates? Why or why not?
13) Please give suggestions for making our team structure more useful (without using grades to motivate behavior)
14) Did you read the critique(s) of your report? If so, was it helpful? How so? If not, are you going to do so in the next few days?
15) Was the in-class feedback you got helpful? How so?
16) Was the in-class feedback you *gave* helpful? To you? To your podmates?
17) Please give suggestions for making feedback more helpful
18) Do you plan to finish/improve your Upcycle project and/or report before the end of the semester?

Post Course Survey

AesDesPost 2017

Q1 In the first part of this survey we are looking for your input on specific aspects of the course, and the second part is very like the pre-course survey, so we can see changes. Please add comments freely.

Q2 For your main project, how many hours did you spend outside of class on

a) deciding/planning/design? (1)
b) fabrication (hands-on) (2)
c) documenting your work? Writing posts, etc. (3)
d) reading/critiquing others' work? (4)

Q3 Do you wish you had spent more or fewer hours? In which design/fab phase?

Q4 What would have inspired you to make that change?

Q5 What was the hardest part of the main project?

Q6 What would have helped you with this hardest part?

Q7 Was your effort on the main project appropriate for 2/3 of a three credit course?

- Yes, my effort was more than enough (1)
- Maybe yes (2)
- Maybe no (3)
- No, I should have spent more time (4)

Q8 What grade do you give yourself for this project?

Q9 What grade do you give yourself for the whole course? Why?

Q10 Did you ask for or get help from any of your teammates with your main project? What kind of help? How much of their time did you get?

Q11 Did you volunteer to help any of your teammates? Why or why not?

Q12 Please give suggestions for making our team structure more useful (without using grades to motivate behavior)

Q13 Did you get enough feedback to improve your design? From your team, from the class, from the instructors, from the public? Was it too nice, or too harsh?

Q14 Were the critiques (both in-class and on posts) you got helpful? How so? What was the most helpful feedback you got? How did it feel to get that feedback?

Q15 Were the critiques you gave helpful? To you? To your podmates?

Q16 Did doing critique teach you anything about yourself? About your work? About your process?

Q17 What did you learn about critique? Did your approach to critique change during the semester? Did it get easier?

Q18 Guest lectures: were they valuable? Should there be more or fewer of them? Different type? Not required?

Q19 Regular in-class activities: Please comment on: Sketching, Aesthetics Tour, Universal Principles of Design, History of Design Movements, Ideation/Brainstorming, The Chair Case Studies, Current Designers. What would you like more or less of? Additional topics?
Video/lecture/discussion/sketching/presentations balance? The Aesthetics Game? Spend more time on brainstorming, or on updates with your team?

Q20 Writing blog posts: Are you happy with your posts? Did they help you think through your design?

Q21 What did you accomplish in this course? Are you satisfied with those accomplishments?

Q22 What is the most useful thing you learned in this course?

Q23 What motivated you to achieve in this course? To spend time on it?

	Motivated me a lot (1)	Motivated me a little bit (2)	Demotivated me (3)
Wanted to make something by myself (1)	❍	❍	❍
Wanted to learn new skills (2)	❍	❍	❍
Publication on an archival site (3)	❍	❍	❍
Feedback (4)	❍	❍	❍
Wanted to make a great gift for someone (5)	❍	❍	❍
I became obsessed with my project (11)	❍	❍	❍
Wanted to show peers or friends what I can do (6)	❍	❍	❍
Wanted to show my family what I can do (7)	❍	❍	❍
Wanted to show future employers what I can do (8)	❍	❍	❍
Wanted to get a good grade (9)	❍	❍	❍
Other, please specify (10)	❍	❍	❍

Q24 How do you identify yourself professionally? Are you primarily a student, engineer, machinist, artist, journalist, blogger, etc.? How about secondarily?

Q25 What are your professional goals? Have these changed substantially this semester?

Q26 Read the following statements and mark whether you agree or disagree with each.

	Agree (1)	Disagree (2)
I am interested in a career that is predominantly focused on design. (1)	❍	❍
I am interested in using some design principles in my future career, but not as the central focus. (2)	❍	❍
I will not seek out careers in design, but I won't avoid them either. (3)	❍	❍
I would prefer to avoid design as my central work activity. (4)	❍	❍
I will actively avoid working in design in the future. (5)	❍	❍

Q27 Please respond to the following statements with the response that best expressesyour opinion.

	Completely Agree (1)	Somewhat Agree (2)	Neutral or no opinion (3)	Somewhat Disagree (4)	Completely Disagree (5)
I think designing objects or systems is enjoyable (1)	❍	❍	❍	❍	❍
I think providing an object or service that other people will use is enjoyable (2)	❍	❍	❍	❍	❍
I think solving the challenges that come up during a design project is enjoyable (3)	❍	❍	❍	❍	❍
I find most new, challenging activities enjoyable. (4)	❍	❍	❍	❍	❍

Q28 What is your definition of aesthetics? Did it change during this semester?

Q29 How often do you both notice and think about design outside of classwork? Choose the answer thatbest describes your recent average.

- ❍ Hourly (1)
- ❍ Several times per day (2)
- ❍ About once a day (3)
- ❍ A few times per week (4)
- ❍ A few times per month or less (5)

Q30 How often do you use knowledge that you have gotten in your degree program outside of classwork, in your daily life?

- ❍ Hourly (1)
- ❍ Several times per day (2)
- ❍ About once a day (3)
- ❍ A few times per week (4)
- ❍ A few times per month or less (5)

Q31 Do you enjoy using knowledge that you have gotten in your degree program outside of classwork, in your daily life?

Q32 Please respond to the following statements with the response that best expressesyour opinion about the course.

	Completely agree (1)	Somewhat agree (2)	Neutral, or no opinion (3)	Somewhat disagree (4)	Completely disagree (5)
This was a difficult course (5)	❍	❍	❍	❍	❍
This was a fun course (6)	❍	❍	❍	❍	❍

Q33 Any other comments on the course? Strengths or suggestions for improvements?

Q34 I am a student majoring in

- ❑ Mechanical Engineering (1)
- ❑ Art or Design (2)
- ❑ Technology, Arts and Media (5)
- ❑ Another discipline or program: please specify (3) _____
- ❑ I am not a student (4)

Q35 I am a student associated with the ATLAS Institute (seeking a degree or certificate).

- ❍ Yes (1)
- ❍ No (2)

Q36 I am

- ❍ Male (1)
- ❍ Female (2)
- ❍ Other or decline to answer (3)

Q37 Class standing

- ❍ First year (1)
- ❍ Sophomore (2)
- ❍ Junior (3)
- ❍ Senior (4)
- ❍ Graduate Student (5)

Q38 The last two questions are just to match your pre and post course responses while maintaining your anonymity. The answers don't matter as long as you use the same ones as you did at the beginning of the semester. (If you can't recall exactly, please do your best.) My first pet's name was

Q39 The name of the first street I lived on was

Integrating Reflection & Metacognition Activities into Exams, Quizzes, and Homework

Cheryl Pinzone

Below are the metacognitive activities that were integrated into several assignments in a small introductory Biology course. The course is General Biology I (EBIO 1210) offered though the School of Continuing Education. This was a Hybrid, Flipped course, where video lectures and pre-class assignments were done online, we met once a week for 2 hours and completed primarily active-learning activities (>90% of time), and then post-class assignments were completed online. Many of the students in the class were minorities (>50%), on academic probation, or international students with English as a second language. There were approximately 40 students enrolled in the course this semester.

There were a few different activities implemented, and in a couple of different formats. Some metacognitive questions were embedded into quizzes and exams as short answer questions. Other times, they were asked during class (beginning or end), and students turned in a sheet of paper with their answers. After the course, students were asked as homework to read an article, reflect on it and the course as a whole, as well as give advice to future students. To improve, I will keep the end of class reflection questions more consistent in future semesters.

Timing	Activity type	Questions asked
Prior to class	Quiz	***Why are you taking this class? What are your career/life goals? What 3 skills would you like to learn? How can you apply a growth mindset to your own life?***
Week 2 / 14	End of class reflection	***What was the most important point from either the video lecture or in class? What was the most difficult concept? What do you want to learn more about?***
Week 4 / 14	End of class reflection	***What was the most important thing you learned? What are you most confused about? What are you going to read more/learn more about next?***
Week 6 /14	Beginning of class	***What are your goals for the rest of the semester? Are they different than at the start of this course?***
Midterm	Exam	***What was the most important/interesting thing you learned from the first half of the semester? What can you do to be more prepared for the final exam?***
Week 9 / 14	End of class reflection	***How can you improve for the rest of the semester in this class? What things can you do that would make group-work more efficient?***
Week 11 / 14	End of class reflection	***What was the most important thing you learned from this week's lesson? What was super confusing? What do you want to spend time learning about related to next week's lesson?***
Week 14 / 14	End of class reflection	***What did you learn? How are you learning? What else do you need to learn?***
After last class	Homework	***What factors influenced how you learn when you were growing up, and when you were taking this class? Read this article: goo.gl/lmS6MO How much do you agree with the author's points? If I were to pass on information to next semester, what advice would you give them on how to succeed (in this course and in college)? Has this class helped you take control over your learning, if so, in what ways? What have you learned about yourself during this course?***

Since the goal of this semester was to help students take control of their learning, I will report some responses from the summative question (given as homework after the final class):

Has this class helped you take control over your learning, if so, in what ways?

This class improved my conscientiousness. I learned the best ways that I can study and retain information, and learned a lot about my own working habits. One of the best ways for me to learn is to discuss interesting topics with my peers.

I learned that sitting in a lecture for hours is not effective for my learning, but rather talking to classmates and discussing problems is much more helpful. I found that I'm more likely to be prepared when I know that someone (fellow classmates) are depending on me to help them out.

This class allowed me to expand the variety of experiences I have had with different methods of learning, which I think has helped me both in school and life. I learned how to manage my time better, and that it is much easier to understand materials by talking to my classmates. I felt more accountable for myself, and completing the workload.

I learned that the normal 300+ person lecture is not the way I learn science, because this class was quite a bit more productive and much easier to learn in. I also learned that getting to know your peers in an academic setting is an important way to learn, and works well for me.

This class helped me to face some problems, not to give up, just try again. Some questions about assignments were not easy to answer, but I just tried to think more and talk to others.

This class helped me be more resilient and organized, and how I can improve myself in academics and in working as a team/group. I felt much more accountable for the information and not missing class. It assured me that groups are very helpful and beneficial in many ways.

This class has helped me to be more engaged in what I'm learning about. I was motivated to read ahead, even though in other classes I never read ahead before. But in this class I would have a good amount of information about the topic when entering the classroom. I learned that no matter how much life throws at me, I can still finish out strong in the end.

This class showed me that even with my crazy busy life, I do have time to study and to finish my homework. I usually can't focus for more than twenty minutes, but this class I was able to work for the full two hours. It taught me if I put my mind to it anything is possible. Just because I had one bad semester, I am not a failure! If I put the work in, I will succeed in school.

I felt more on top of my assignments, I think because of the super inclusive environment. I felt like I grew genuine connections with other students, and got better with time management skills. I was shy at first, but as time went on, I felt more comfortable to share my thoughts.

Yes, the way the class was designed made me try harder, because not only was I trying to get a good grade but others were counting on me to know things so we could pull all our knowledge together. I had to figure things out instead of being forced to regurgitate everything, which allowed me to remember more.

I learned to do work earlier, instead of at the last minute. I normally procrastinate, but during this course I learned about myself that I should just get things done sooner. I was a lot less stressed, and much happier because of it. I'm glad I learned this new technique.

Exam Metacognition Exercise

Robert Buchwald

45 Students in an Intro Bio class

This was really more of a metacognitive exercise to get students thinking about how to study for the exam. For many, this would be their first college-level science exam. The survey was conducted anonymously through Polleverywhere.com. The first question was given before the review. Below is the question and a subset of responses:

1. How are you planning to study for the exam?
    a. Reading my notes over and over
    b. Hope and pray
    c. Cramming
    d. Go over all my homeworks
    e. Reading the book

The next two questions were given after a review, where I focused on effective study techniques:

2. What are the most difficult topics that are going to be on the exam?
    a. Nucleic Acids & lipids
    b. Structure of bonds
    c. Anything chemistry related
    d. Structure of polymers
    e. Everything
3. What changes could you make to your study plan to study better and more efficiently?
    a. Relax
    b. Focus on the topics I struggled answering during the review
    c. Trying to explain the material to someone else
    d. Come up with “because” statements

This exercise was helpful for students to begin thinking about their study process and what is and isn’t effective.

Exam Wrapper Activity – Rebecca Ciancanelli

I am sharing an activity based on the "Exam Wrappers" assignment. It was designed for a small chemistry lecture course. The course is General Chemistry I, CHEM 1113, and the lecture is reserved for students in the Student Academic Success Center programs. These students are low income, first generation and/or underrepresented students at CU. There are 23 students in the course this semester, and they took three exams this semester.

The activity that I shared involved self-reflections by each student. Students were asked to reflect on the questions show in the table below. I gave them five minutes of class time, and they wrote their answers on a blank sheet of paper. After the first survey, I attached their previous self-reflections to the blank piece of paper that they were using for the current self-reflection. Therefore, they created a long document by the end of the semester that included all of their self-reflections.

Date	Activity	Questions
Friday, Feb 3rd	First survey	***What does it take to be successful in a chemistry course? How will you plan to study for Exam 1? Please be specific and list at least three activities.***
Tuesday, Feb 7th	**First exam**	
Thursday, Feb 9th	Self-reflection	***Name three reasons why you were successful or unsuccessful on Exam 1. How do you participate in class, how do you study outside of class?***
Friday, Mar 3rd	Self-reflection	***How will modify your study habits for Exam 2? What are three actions that you will take?***
Tuesday, Mar 7th	**Second exam**	
Thursday, Mar 9th	Self-reflection	***How did your study strategies work for Exam 2? What will you change for the third exam?***
Tuesday	**Third exam**	

These self-reflections allowed for better discussions during office hours. I could directly ask students about their answers and ask them to expand. I used these documents to have meetings with several students to make plans to study for the final. In the example student document included, the student showed dramatic improvement after identifying that she needed to start studying earlier. She also details her strategy of taking practice exams and how that improved her confidence ("I feel most comfortable for this exam".)

<u>Modifications will be made to this activity next year in the following ways</u>:

- I plan to revisit students' answers for the first survey, so that I can change the questions to get more thoughtful responses.
- I will give another three minutes to the activity, and ask students to share with a partner about the process (not necessarily their answers but what they are learning from the activity)

- I will share student responses anonymously with the class to promote more detailed responses.

Example of a student response to the self-reflections:

February 3rd – Self-reflection in class

What does it take to be successful in a chemistry course? (Third week of the semester)

Practice a lot of calculations. Read over the chapter and do practice problems. Learn why things happen, don't just memorize.

How will you plan to study for Exam 1? Please be specific and list at least three activities. (Third week of the semester)

I will come on Monday for the review session. I will do one practice exam one my own at home. I will do practice problems and make flashcards for naming.

February 7th – Exam 1: 51%

February 9th - Self-reflection in class

Name three reasons why you were successful or unsuccessful on Exam 1. How do you participate in class, how do you study outside of class?

I was unsuccessful on this exam because I didn't ask enough questions in class when I was confused. Sometimes, I would rush through my ALEKS assignment because I had other assignments to finish. Probably, everything that is going on in my personal life right now, but I know it's not an excuse to do horrible on an exam.

March 3rd – Self-reflection in class

How will modify your study habits for Exam 2? What are three actions that you will take?

I will make time to study in a quiet place and make myself understand the concepts. The three actions that I will take are: meet with my tutor on Sunday and study with her, come to the review session on Monday and practice problems in the textbook.

March 7th – Exam 2: 52%

March 9th - Self-reflection in class

How did your study strategies work for Exam 2? What will you change for the third exam?

I also failed Exam 2. The multiple choice questions are the ones that I got more points off. I did meet with my tutor several times but still didn't get the grade that I wanted. For the third exam, I already started practicing and working on practice exams. Overall, this exam is the exam that I feel most comfortable for and I will try to take the exam in a room alone.

April 11th – Exam 3: 80.5%

Instructor metacognitive activities

- Helps instructors to identify their own individual areas of strength and weakness.
- Helps instructors become more self-aware – how are you communicating with students? Are your methods effective?

Background:

Consider taking on a metacognitive activity in your teaching over the next couple of weeks. Here are some ideas:

- Record yourself or watch a lecture capture of yourself teaching. What do you notice about how you speak to students?
- Carefully write out your learning goals for your lecture. Ask your students at the end of lecture what they thought that the most important points of lecture were. How does it compare?
- Evaluate one of your lectures in terms of addressing prior knowledge/concepts. Could the students follow the sequence and see how each topic relates? Could they create a concept map?

Example: Here are the categories for Instructor Talk. Categorize yourself!

Table 1. Overview of emergent categories and subcategories of Instructor Talk

Category	Subcategory
Building the Instructor/Student Relationship	• Demonstrating Respect for Students • Revealing Secrets to Success • Boosting Self-Efficacy
Establishing Classroom Culture	• Preframing Classroom Activities • Practicing Scientific Habits of Mind • Building a Biology Community among Students • Giving Credit to Colleagues • Indicating That It Is Okay to Be Wrong or Disagree
Explaining Pedagogical Choices	• Supporting Learning through Teaching Choices • Using Student Work to Drive Teaching Choices • Connecting Biology to the Real World and Career • Discussing How People Learn • Fostering Learning for the Long Term
Sharing Personal Experiences	• Recounting Personal Information/Anecdotes • Relating to Student Experiences
Unmasking Science	• Being Explicit about the Nature of Science • Promoting Diversity in Science

Here are the questions that you can work with.

Table 3. Sample self-questions to promote faculty metacognition about teaching

Activity	Planning	Monitoring	Evaluating
Class session	• What are my goals for this class session? How did I arrive at these goals? • What do I think students already know about this topic? What evidence do I have for my thinking? • How could I make this material personally relevant for my students? Why do I think this? • What mistakes did I make last time I taught this and how can I not repeat these?	• What do I notice about how students are behaving during this class session? Why do I think this is happening? • What language or active-learning strategies am I using that appear to be facilitating learning? impeding learning? • How is the pace of the class going? What could I do right now to improve the class session?	• How do I think today's class session went? Why do I think that? What evidence do I have? • How did the ideas of today's class session relate to previous class sessions? To what extent do I think students saw those connections? • How will what I think about how today's class session went influence my preparations for next time?
Overall course	• Why do I think it's important for students pursuing a variety of careers to learn the ideas in my course? What are my assumptions? • How does success in this course relate to my students' career goals? How might I reveal these connections to them? • What do I want students to be able to do by the end of this course? Still be able to do 5 yr later?	• In what ways am I effectively reaching my goals for students through my teaching? How could I expand on these successful strategies? • In what ways is my approach to teaching in this course not helping students learn? How could I change my teaching strategies to address this? • How is my approach to teaching this course different from last time I taught it? Why?	• What evidence do I have that students in my course learned what I think they learned? • What advice would I give to students next year about how to learn the most in this course? • If I were to teach this course again, how would I change it? Why? What might keep me from making these changes? • How is my thinking about teaching changing?

<u>Assignment</u>: (to share on Monday, March 6th)

Come up with a method to work on developing your metacognitive skills. Be ready to share your ideas with the group!

Metacognitive Activity: Discipline-Specific Modes of Thought

Katherine E. Stange, Mathematics Department

Spring 2017

The goal of this activity, the first part of which was initially suggested to me by Faan Tone Liu of the Mathematics Department, is to identify discipline-specific modes of thought. I would define *modes of thought* as cognitive and metacognitive techniques that are shared and used by members of a specific discipline (such as mathematics) in research, teaching and understanding.

For an instructor, the primary goal of the activity is to identify and describe the distinct modes of thought the instructor wishes to pass on to his/her students as skills. These modes of thought are often so well internalized by a specialist in a discipline as to be transparent. By enunciating them and making them explicit goals of our teaching, we give ourselves the opportunity to reflect on how to teach them.

This activity could perhaps be modified to be a useful student activity.

Instructor activity:

1. Identify and describe as many discipline-specific modes of thought as possible.
2. Choose a few (perhaps three) that are most important to teach to our students, if they are to become experts in our discipline.
3. Reflect on how one might teach these modes of thought.

Example (for myself, as a mathematician):

Phase 1: Listing modes of thought.

1. Pattern-finding.
2. Mentally following blueprints.
3. Adjusting parameters/inputs and observing the effects.
4. Creatively generating novel examples.
5. What-if? thinking.
6. Looking for loopholes.
7. Free-association.
8. Exhaustively exploring a logic tree.
9. Lining up situation with hypothesis (matching).
10. Tracing an example through a general logical argument/recipe.
11. Comparing with intuition.
12. Sanity checks.
13. Extracting the big picture / creating a skeleton.
14. Creating a plan.
15. Fantasizing.
16. Tracing cognitive dissonance to its source.
17. Forgiving mistakes.
18. Phrasing questions precisely.
19. Resolving a contradiction.
20. Testing hypotheses by examining consequences.
21. Skepticism.
22. Creating challenge/response or game out of a logical process.
23. Drawing a picture.
24. Collecting data.
25. Evaluating whether you know something.
26. Finding alternative explanations.

Phase 2: Choose important ones.

1. Forgiving mistakes.
2. Tracing an example through a general logical argument/recipe.
3. Evaluating whether you know something.

Phase 3: Ideas for how to teach these.

1. *Forgiving mistakes.*
   Demonstrate the value of mistakes as part of the process of discovering a correct proof. Model the activity of trying many avenues and learning from the ways in which they fail, in order to discover how to modify an insufficient proof.
2. *Tracing an example through a general logical argument/recipe.*
   For proofs given in class or the book, assign examples and have students work through with the examples.
   Give false proofs and assign students examples to work through in order to locate the error.
3. *Evaluating whether you know something.*
   Ask students to avow whether they know something. Find something they claim to know, and ask for a justification. Ask them "why?" for each aspect of their explanation until you have drilled down to an "I don't know". I wonder how one could implement this type of exchange effectively -- perhaps with non-mathematical knowledge, i.e. things about the real world? Don't want it to be discouraging.