Small Changes in Transparency and Metacognition Improve Student Persistence and Engagement

Katherine LaCommare and Judy Nesmith
Department of Natural Sciences, University of Michigan - Dearborn

Workshop Purpose: Identify and share techniques for incorporating structure, transparency, and metacognition into your courses.

Tasks:

1. Follow the directions for the **pre-workshop assignment** on the worksheet at your table.

2. *Wait for the prompts* to complete parts one and two.

3. Share, then, as a table, post to Padlet

Assessment: Participation

| Our Campus	Our Course	Traditional Gateway Course
University of Michigan-Dearborn • Commuter Campus • ~50% FTIAC students	**Introduction to Organismal Biology** • Required for many majors • Annual Enrollment: 600 students • First science class for many • High DFWI	• Foundational • High Risk • High Enrollment "First time, full-time freshman who successfully completed a gateway course were more likely to persist." *Flanders, 2017*

Course Transformation: Small replicable changes
(After Gateways to Completion in Mar. 2018)

Photo by Jonas Jacobsson on Unsplash
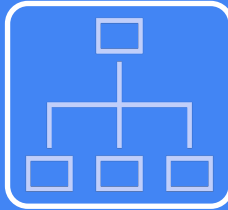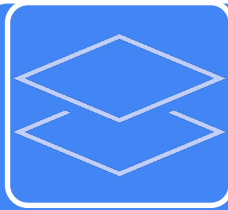
	Increased structure
	Transparency
	Metacognition

Changes in key metrics before and after course changes

Metric	Before Changes				After Changes			
					Before Covid		After Covid	
	F 16	W 17	F 17	F 18	W 19	F 19	F 22	W 23
DFWI RATE	32%	20%	17.5%	32.1%	9.2%	11.7%	20.4%	21.1%
Key Engagement Metrics					Surveyed students before and after F19 with Student Engagement Questionnaire (Handelsman, 2005): Mean self-assessment of engagement behaviors increased in all categories. Big gains in willingness to come to class (1.7 to 4.76) and putting forth effort (1.2 to 4.52).			
Evolution Exam Scores	72.7%	75%	71.3%	69.6%	77%	74%	75%	69%

Covid: W2020; Fall 2020; Winter 2021 (Online); Fall 2021 and Winter 2022 (Masks, Disruptions due to absences)
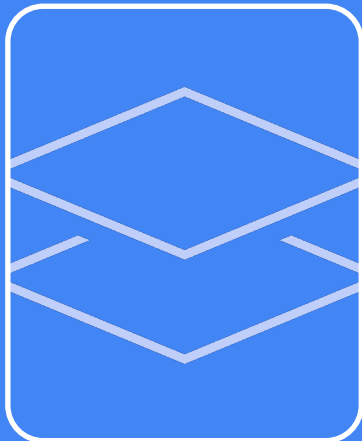
Structure and Transparency
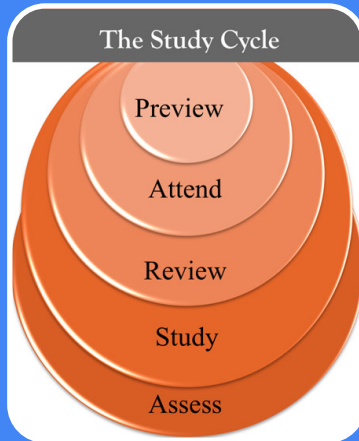
Structure (Freeman et al. 2011; Haak et al. 2011)

The Study Cycle: Preview, Attend, Review, Study, Assess

Weekly Clear instructions:

- Before-class, during-class, after-class that model study cycle (Cook et al 2013)
- Active-learning with peer-instruction in class
- Assessments mirror practice

Transparent Assignment Design
(Winkelmes, Boye and Tapp (2019)

Assignments, Class activities:

- Clarify purpose,
- Clear task lists,
- Clear communication of criteria of success

Example - Structure

Sample week module – Lab

Before:

- Prelab completed the night before.

During:

- Workshop group work completed at beginning of lab.

- In lab data collection, data analysis, class discussion

After:

- Quiz the following week for assessment

- Mirrored in lecture (Nesmith and LaCommare)
- Lectures are taught by many instructors in this multi-section course. *We do not have TA's.* Labs and lab materials are coordinated to be consistent for all sections.

Example - Transparency

From this...

Student Learning Goals
- Students will be able to explain what it means to say that mutations occur at random.
- Students will be able to explain that mutations occurring during each individual's reproduction leads to genotypic variation in the population.

Driving Questions
- Is there a pattern to how mutations occur?
- Could we predict what mutation(s) an organism's offspring will have?
- How is genetic sequence variation in a population created?

To this...

Student Learning Goals
- Students will be able to make predictions based on information and logic.
- Students will be able to express their predictions graphically.
- Students will be able to analyze data and draw conclusions.

TASKS
1. **Read** through the procedures of this activity.
2. **Predict** your experimental outcomes
3. **Record** three replicates of your mutation data.
4. **Upload** your mutation data to the student data spreadsheet linked in this activity (pg 3) by the date your instructor provides.
5. **Compare** data sets and **Answer** the discussion questions.

ASSESSMENT
1. Upload of mutation data during lab. Assessed for completion and timeliness.
2. Submission of questions and graphs assigned to your group.
3. Quiz next week and questions about this lab on your next exam.

Increased emphasis on data analysis through use of prelabs and workshops enhances understanding of evolutionary processes.

Topics of the RaProEvo	Item number	% students correct pre-test	% students correct post-test
Mutations influence on evolution	1	33%	49%
	2	61%	63%
	3	67%	74%
	10	61%	74%
	11	63%	79%
	15	26%	42%
Recombination	6	44%	47%
Accidental death (single event)	4	44%	74%
	8	72%	72%
Random phenomena (catastrophe)	12	51%	44%
Process of natural selection	5	72%	51%
	9	77%	91%
	14	79%	81%
	16	72%	63%
Probability of events	7	61%	70%

Student understanding of evolutionary mechanisms pre-instruction and post-instruction. Highlighted cells indicate significant gains. (t-test $p<0.05$). n=43.

RaProEvo - Randomness and Probability test in the context of Evolution. [Fiedler, D., Trobst, S., & Harms, U. (2017)]

Purpose: Practice incorporating structure and transparency

Tasks:

1. Follow the instructions and answer questions in **Part 1 – Structure and Transparency** of the worksheet.

2. Share, then, as a table, post to Padlet

3. Be prepared to discuss with group.

Assessment: Participation

Metacognition

Metacognition - "Thinking about thinking:" Shown to improve performance, motivation, retention (e.g. Cook et al 2013; Mutambuki et al 2020; Harding 2023).

In our courses, we use metacognitive tasks to help students:

- Figure out what they know and what they don't know

- Build confidence in their level of understanding.

- Become aware of how they think through problems and learn.

- Apply this knowledge to build more effective study skills

We combine metacognitive tasks with peer instruction.

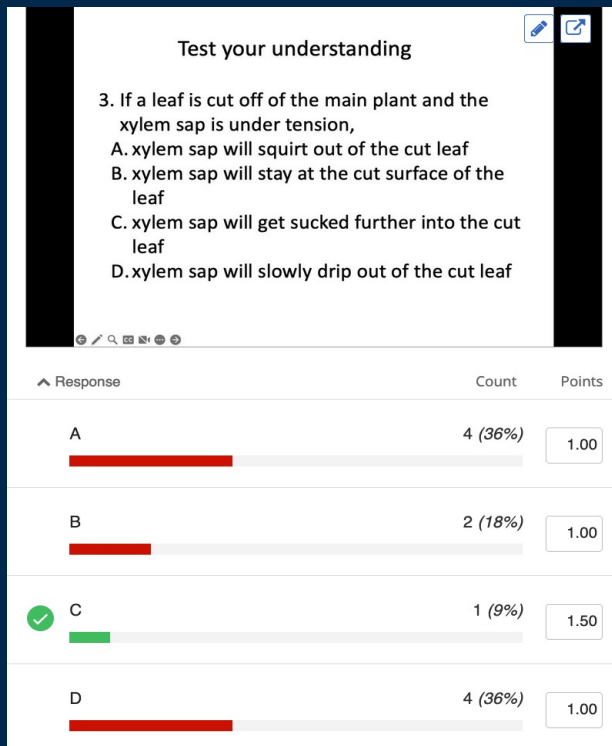**Purpose:** Consider the importance of metacognition

Tasks:

1. Follow the instructions on **Part 2 – Metacognition: Question #1** on the worksheet. Answer the prompts individually.
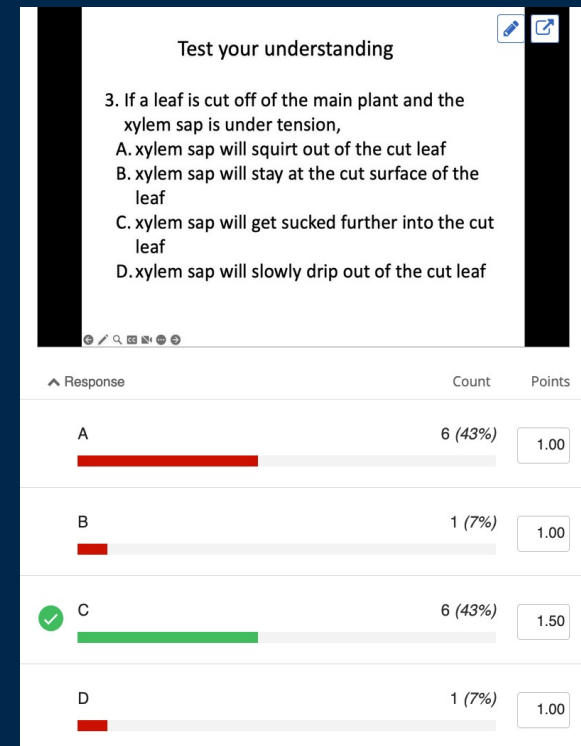
Assessment: Participation

Example: Peer instruction Using i<Clicker polls and incorporating confidence checks.

Peer discussion in small groups then, 2nd attempt.

1st attempt, individually

Test your understanding

3. If a leaf is cut off of the main plant and the xylem sap is under tension,
   A. xylem sap will squirt out of the cut leaf
   B. xylem sap will stay at the cut surface of the leaf
   C. xylem sap will get sucked further into the cut leaf
   D. xylem sap will slowly drip out of the cut leaf

Response	Count	Points
A	4 *(36%)*	1.00
B	2 *(18%)*	1.00
✓ C	1 *(9%)*	1.50
D	4 *(36%)*	1.00

After individual attempt,
Students rate their confidence level as:
Low
Medium
or high

Test your understanding

3. If a leaf is cut off of the main plant and the xylem sap is under tension,
   A. xylem sap will squirt out of the cut leaf
   B. xylem sap will stay at the cut surface of the leaf
   C. xylem sap will get sucked further into the cut leaf
   D. xylem sap will slowly drip out of the cut leaf

Response	Count	Points
A	6 *(43%)*	1.00
B	1 *(7%)*	1.00
✓ C	6 *(43%)*	1.50
D	1 *(7%)*	1.00

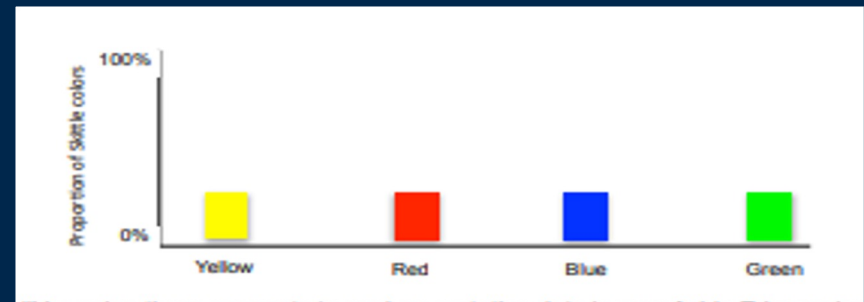**Example:** Students complete pre-lab assignment individually then discuss in workshops prior to lab exercises.

Lab workshops prior to the lab uncover misconceptions.

Students asked: Proportions of randomly made skittle colors (4 colors)
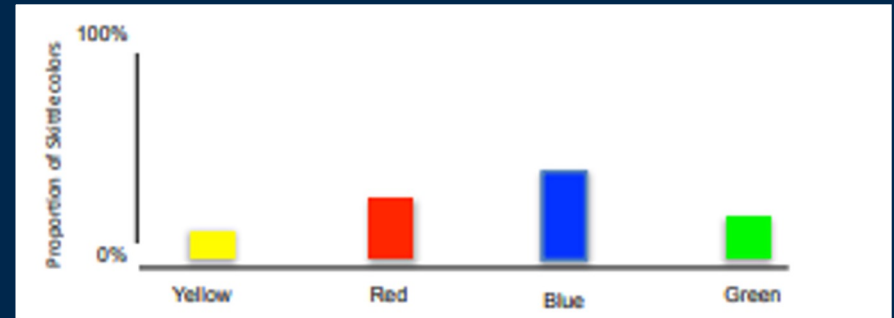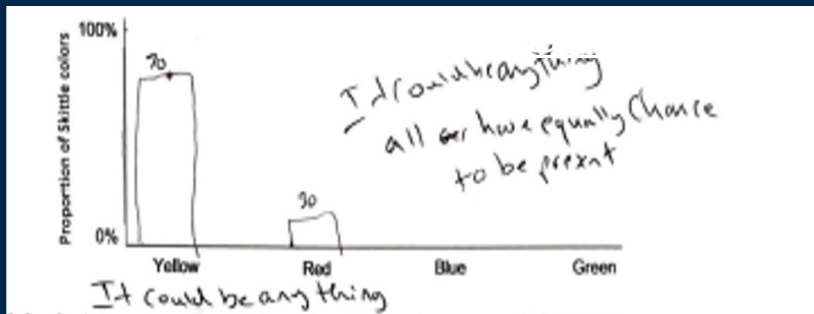
Students asked: Proportions of non-randomly made skittle colors (4 colors)

Example: Students take a pre-test and rank each question with their confidence level, then reflect

1. Look at the questions you got right and wrong.
- How many questions that you think you got right (responses A and B) did you actually get right? _1_
- How many questions were you not confident or didn't know (responses C and D) but you actually got right? _3_
- How many questions did you think you got right (responses A and B), but actually were wrong? __7__
- How many questions were you not confident or didn't know (responses C and D) did you get wrong? __1__ .

Response:

I was extremely surprised after the results, since I felt really confident about my answers and reasoning. I definitely did understand the concept better after having to explain my reasoning to others. Even when I explained the answers I thought were right, but in actuality were wrong, I realized my mistakes as I was explaining it to my classmates. I need to really analyze the possible answer(s) for each question and then figure out which one(s) best support the answer. I also need to review the Google Docs that were shared between each group, then test myself on the questions and see if I can come to the right conclusion with the right reasoning. I feel less confident right now, but believe that I will regain the confidence I had initially after I study the questions and understand the mistakes I made while choosing my answers. I do believe that I need to improve my study habits, but am not sure how. All I do is review content and memorize, but I know that I need to do much more than that and apply critical thinking skills to successfully complete this course.

Example: Students asked to rate their confidence before and after a concept is taught and then to identify study strategies.

EXIT TICKET: Which concepts do you feel the most confident with and which do you feel the least confident			
Review the terms from Lesson 2. Which term(s) do you feel the lest confident in applying?			
I could…..	Least Confident (1) – I could do it after a lot of studying and I may need clarification on some concepts before I understand it.	Pretty Confident (2) – I could do it after a bit of studying	Most Confident (3) – I would be capable of doing it from memory right now or with a little bit of review
Draw and label the sexual life cycle.			
Explain cell theory and the roll of cell division, meiosis and mitosis in it.			
Mitosis: Explain the function, state how many daughter cells result from it and draw the chromosomes of the parent and daughter cells.			
Meiosis: Explain the function, state how many daughter cells result from it and draw the chromosomes of the parent and daughter cells			
For the concept that you are least confident with come up with a plan to study that concept before the next class period: (Go to SI, Office Hours, Study Group, Read)			

Example: Students take a quiz individually. Quiz includes confidence prompts. Then, students take the quiz in a small group. Retakes can target individual questions.

BIOL 130 – Winter 2022– QUIZ 1 – Basics of Genetics – 16 points

Answer using i<clicker student

1. I feel prepared for this quiz.

a) Very much   b) Mostly   c) A little   d) Not at all

2. In peas, the *SBE1* gene codes for starch-branching enzyme. From the following list, select the best definition of a gene.

a) The portion of the chromosome that an individual inherits from the parent.
b) Any heritable nucleotide sequence in the DNA.
c) A section(s) (or location) of DNA that encodes information and influences traits in the phenotype.

¶
a)·Did·very·well·(>·=·7·correct)→ b)·Did·well·(7·correct) → c)·Did·OK·(5-6·correct)·········d)·Did·poorly·<·5·correct¶
¶
¶

(d) It is impossible to tell from the information given.

After your group has selected the correct answer, in the space below, explain why each of the other choices are incorrect.

Purpose: Practice incorporating metacognition into class activities

Tasks:

1. Follow instructions and answer **Part 2- Metacognition: Questions #2 - #4** of the worksheet.

2. Answer all the prompts.

3. Be prepared to discuss with group.

Assessment: Participation

Thanks!

The following slides have references to literature and resources that we used and that you may find useful.

Resources: Gateway Courses and Student Retention

- Koch (2017). *It's About the Gateway Courses: Defining and Contextualizing the Issue.* New Directions for Higher Education, no. 180. Winter 2017. Wiley Periodicals, Inc. DOI: 10.1002/he.20257.
  - Defines gateway courses, discusses why these courses require attention in the college curriculum if an institution is going to adequately address retention issues.
- Bloemer, W., Day, S., & Swan, K. (2017). *Gap analysis: An innovative look at gateway courses and student retention.* Online Learning, 21(3), 5-14. doi: 10.24059/olj.v21i3.1233
- Flanders, Gordon (2017) *The effect of Gateway Course Completion on Frehman College Student Retention.* Journal of College Student Retention: Research, Theory & Practice 2017, Vol. 19(1) 2–24.
  - Provides specific retention data.

Resources: Adding Structure to reduce failure rates

- Freeman, Scott, David Haak,and Mary Pat Wenderoth (2011). *Increased Course Structure Improves Performance in Introductory Biology.* CBE— Life Sciences Education Vol. 10, 175–186, Summer 2011
  - Describes increased structure and shows how it improves performance.

- Haak, David C. Janneke HilleRisLambers,1 Emile Pitre,2 Scott Freeman (2011). *Increased Structure and Active Learning Reduce the Achievement Gap in Introductory Biology*. Science 332: 1213 – 1216. June 2011.
  - Specifically addresses achievement gap for underrepresented groups in STEM.
- Flanders, Gordon (2017) *The effect of Gateway Course Completion on Frehman College Student Retention*. Journal of College Student Retention: Research, Theory & Practice 2017, Vol. 19(1) 2–24.
  - Provides specific retention data.

Resources: Transparent Assignment Design

- Peplow et al. (2021) *Transparent Assignment Design: A multidisciplinary Survey Assessing Students' Perceptions*. Journal for Research and Practice in College Teaching Volume 6, Issue 1. 2021
  – Describes Transparent Assignment Design.

- Leuzinger and Grallo (2019) *Reaching first-generation and underrepresented students through transparent assignment design.* Accessed from: digitalcommons.csumb.edu

Resources: Metacognition

- Cook et al. (2013) *Effect of teaching metacognitive learning strategies on performance in general chemistry courses*. Chemical Education Research Volume 19 (8): 961-967. 2013. https://doi.org/10.1021/ed300686h
    – Describes Transparent Assignment Design.

- Mutambuki et al (2020) *Metacognition and Active Learning Combination Reveals Better Performance on Cognitively Demanding General Chemistry Concepts than Active Learning Alone. J. Chem. Educ.* 2020, 97, 7, 1832–1840. Publication Date: June 25, 2020. https://doi.org/10.1021/acs.jchemed.0c00254