Small Changes in Transparency and Metacognition Improve Student Persistence and Engagement

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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
<table>
<thead>
<tr>
<th>Our Campus</th>
<th>Our Course</th>
<th>Traditional Gateway Course</th>
</tr>
</thead>
</table>
| **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)

- Increased structure
- Transparency
- Metacognition

Photo by Jonas Jacobsson on Unsplash
## Changes in key metrics before and after course changes

<table>
<thead>
<tr>
<th>Metric</th>
<th>Before Changes</th>
<th>After Changes</th>
<th>Before Covid</th>
<th>After Covid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F 16</td>
<td>W 17</td>
<td>F 17</td>
<td>F 18</td>
</tr>
<tr>
<td>DFWI RATE</td>
<td>32%</td>
<td>20%</td>
<td>17.5%</td>
<td>32.1%</td>
</tr>
<tr>
<td>Key Engagement Metrics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evolution Exam Scores</td>
<td>72.7%</td>
<td>75%</td>
<td>71.3%</td>
<td>69.6%</td>
</tr>
</tbody>
</table>

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)

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 LaCommarre)
- 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

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?

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.

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

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.

**1st attempt, individually**

![Image of i>Clicker poll results]

**After individual attempt, Students rate their confidence level as:**
- Low
- Medium
- High

**Peer discussion in small groups then, 2nd attempt.**

![Image of i>Clicker poll results]
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.

<table>
<thead>
<tr>
<th>EXIT TICKET: Which concepts do you feel the most confident with and which do you feel the least confident</th>
<th>Least Confident (1) – I could do it after a lot of studying and I may need clarification on some concepts before I understand it.</th>
<th>Pretty Confident (2) – I could do it after a bit of studying</th>
<th>Most Confident (3) – I would be capable of doing it from memory right now or with a little bit of review</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review the terms from Lesson 2. Which term(s) do you feel the least confident in applying?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>I could.....</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Draw and label the sexual life cycle.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Explain cell theory and the role of cell division, meiosis and mitosis in it.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Mitosis:</strong> Explain the function, state how many daughter cells result from it and draw the chromosomes of the parent and daughter cells.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Meiosis:</strong> Explain the function, state how many daughter cells result from it and draw the chromosomes of the parent and daughter cells</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>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)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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

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.

(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

  – Defines gateway courses, discusses why these courses require attention in the college curriculum if an institution is going to adequately address retention issues.


  – Provides specific retention data.
Resources: Adding Structure to reduce failure rates

  - Describes increased structure and shows how it improves performance.

  - Specifically addresses achievement gap for underrepresented groups in STEM.

  - Provides specific retention data.
Resources: Transparent Assignment Design

  — 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

  — 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](https://doi.org/10.1021/acs.jchemed.0c00254)