Order Matters: Aligning Teaching with How People Learn and Becoming Metacognitive about Instructional Decisions

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Please sit with a person you don’t know! Make a new colleague!
Time to Think!

Write on an index card…

1. Your name
2. Department/Discipline/Campus
3. Two important things for others to know about who you are and what you value (culture, ethnicity, personal pronouns, family, hobbies, etc.)
4. Where would you start if someone asked you to plan a lesson on how to teach someone to make a peanut butter and jelly sandwich?
Meet a New Colleague!

Share with a person near you that you do NOT already know…

1. Your name

2. Department/Discipline/Campus

3. Two important things for others to know about who you are and what you value (culture, ethnicity, personal pronouns, family, hobbies, etc.)

4. Where would you start if someone asked you to plan a lesson on how to teach someone to make a peanut butter and jelly sandwich?
Becoming Metacognitive about Teaching

“I have to teach someone to make a peanut butter and jelly sandwich. How am I supposed to do that? What should I start with? How can this be so hard?”

Have you ever thought about teaching someone else how to make a peanut butter and jelly sandwich?

How would you start? What would you do first? Next? After that?

Who was the learner anyway? And had they made a sandwich before? Were they allergic to peanuts? How old were they? Should we let them have a knife?

Should we show them how first? Talk them through it? Let them have a go at it on their own?

Should we first teach them the names of all the tools and things we were going to use? Should we ask them why they needed to learn how to make a peanut butter and jelly sandwich in the first place?

What were the critical issues in teaching someone how to make a peanut butter and jelly sandwich?
Questions to Promote Instructor Metacognition about Teaching

Promoting Student Metacognition

Kimberly D. Tanner

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

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

Metacognition refers to one’s knowledge concerning one’s own cognitive processes or anything related to learning. It is a process of thinking about thinking. As such, attention to student metacognition may be considered parallel to the recent rise in emphasis on active learning in undergraduate biology education. However, the importance of metacognition in the process of learning appears to be elusive in the literature. Below is an excerpt from Flavell’s original writing, as well as several additional contributions and reflections on the topic. The importance of metacognition in the process of learning is a reregistering Bloom’s Taxonomy to enhance student learning in biology.
Faculty Development Programs

“The largest gain in learning productivity in STEM will come from convincing the large majority of STEM faculty that currently teaches by lecturing to use any form of active or collaborative instruction...”

– James Fairweather

Report: National Academies National Research Council Board of Science Education


But, Kimberly, how do I know where to add these things to what I already do?!?!
Becoming Metacognitive about Teaching – A Framework for Analysis

• Think about a recent class meeting you taught or experienced. You could also analyze a meeting that was not in a classroom setting.

• Identify the distinct ‘pieces’ of this class session. (*eg.*, gave a quiz, lectured on cell cycle, lectured on mutations, *etc.*)

• Record each of these ‘pieces’ on single index card. You will likely end up with several index cards that reflect the pieces of your class session...
Becoming Metacognitive about Teaching – A Framework for Analysis

• Share each of the pieces of your class session with a partner.

• Discuss which ‘pieces’ represent some form of active learning.
Big Idea: *Teaching and learning are fundamentally about changing the human brain.*

(a) Synapses are strengthened or weakened in response to activity.

(b) If two synapses are often active at the same time, the strength of the postsynaptic response may increase at both synapses.

So, how do we plan and structure learning experiences to optimally and literally change students’ minds?!?!
If learning is about brain changing, then students...

1. ...must be awake, attending, and interested!
2. ...need to activate related knowledge/memories/ circuits so that they connect these to new understandings.
3. ...are only then likely ready for constructing new knowledge (circuits)!
4. ...need opportunities to **practice** using new ideas in new contexts.
5. ...need opportunities to self-assess their understanding and identify confusions.
Active learning increases student performance in science, engineering, and mathematics

Scott Freeman, Sarah L. Eddy, Miles McDonough, Michelle K. Smith, Nnadozie Okoroafor, Hannah Jordt, and Mary Pat Wenderoth

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To test the hypothesis that lecturing maximizes learning and course performance, we metaanalyzed 225 studies that reported data on examination scores or failure rates when comparing student performance in undergraduate science, technology, engineering, and mathematics (STEM) courses under traditional lecturing versus active learning. The effect sizes indicate that on average, student performance on examinations and concept inventories increased by 0.47 SDs under active learning (n = 158 studies), and that the odds ratio for failing was 1.95 under traditional lecturing (n = 67 studies). These results indicate that average examination scores improved by about 6% in active learning sections, and by nearly 10% for students in classes with traditional lecturing were 1.5 times more likely to fail than were students in classes with active learning. Heterogeneity analyses indicated that both results hold across the STEM disciplines, that active learning increases scores on concept inventories more than on course examinations, and that active learning appears effective across all class sizes. The greatest effects are in small (n ≤ 50) classes. Trim and fill and fail-safe n calculations suggest that the results are not driven by publication bias. The results also appear robust to variations in methodological rigor of the included studies, based on the quality of controls over student quality and instructor identity. This is the largest and most comprehensive metaanalysis of undergraduate STEM education published to date. The results raise questions about the continued use of traditional lecturing as a control in future studies, and support active learning as the preferred, generally validated teaching practice in regular classrooms.

constructivism | undergraduate education | evidence-based teaching | scientific teaching

2014 PNAS Meta-Analysis
n=225 studies
with pre- and post-assessment measures
“If the experiments analyzed here had been ... trials of **medical interventions**, they may have been **stopped for benefit** — meaning that enrolling patients in the **control condition** [lecturing] might be discontinued...” — Freeman, et al, PNAS, 2014.
One Method for Reflecting on Teaching Choices:

The 5E Learning Cycle Model

Engage
Explore
Explain
Elaborate
Evaluate

Developed by BSCS in 1987...

http://bscs.org/bscs-5e-instructional-model
Learning, Brain Changing, and the 5E Model...

**ENGAGE:** must be awake, attending, and interested!

**EXPLORE:** need to activate related knowledge/memories/circuits so that they connect these to new understandings.

**EXPLAIN:** are only then likely ready for constructing new knowledge (circuits)!

**ELABORATE:** need opportunities to **practice** using new ideas in new contexts.

**EVALUATE:** need opportunities to self-assess their understanding and identify confusions.

What might this look like in a course?
Analyzing Your Class Session and Becoming Metacognitive about the Order of Things:

Applying the 5E Model

With your partner, give each ‘piece’ of your respective classroom sessions a designation of one of the E’s.

Remember to be a skeptical and critical friend to your partner in helping them assign their E’s.
Learning, Brain Changing, and the 5E Model...

**ENGAGE:** must be awake, attending, and interested!

**EXPLORE:** need to activate related knowledge/memories/circuits so that they connect these to new understandings.

**EXPLAIN:** are only then likely ready for constructing new knowledge (circuits)!

**ELABORATE:** need opportunities to **practice** using new ideas in new contexts.

**EVALUATE:** need opportunities to self-assess their understanding and identify confusions.
Tweaking Your Most Recent Class Session: 
*Alignment with the 5E Model*

With your partner, go back to your class sessions and think about...

- Could I just switch the order of the cards?
- Could I just add a single card somewhere? If so, where and why?
- Could I transform an Explain card to be another type of E card? How?

If I were to make JUST ONE CHANGE... WHAT WOULD IT BE?!?!?
Strategies for Using the 5E Model in Your Teaching

• Start your class/lesson with something that Engages students and Elicits their prior knowledge.

• Allow for Exploration before you Explain or give mini-lectures.

• Collect some form of assessment/Evaluation from your students every class.
Teaching and learning are fundamentally about changing the human brain.

But what does classroom sound have to do with learning?!!
Explore these ideas further...

Translations of Education Research Literature for Scientists and Everyone!

Approaches to Teaching and Learning Feature

http://www.lifescied.org/cgi/collection/approaches_to_biology_teaching_and_learning
INTRODUCTION

Kimberly D. Tanner

For Further Reading...

Feature
Approaches to Biology Teaching and Learning
Order Matters: Using the 5E Model to Align Teaching with How People Learn
Kimberly D. Tanner

Feature
Approaches to Biology Teaching and Learning
Promoting Student Metacognition
Kimberly D. Tanner

Teaching as Brain Changing: Exploring Connections between Neuroscience and Innovative Teaching
Melinda T. Owens and Kimberly D. Tanner*
Science Education Partnership and Assessment Laboratory, San Francisco State University, San Francisco, CA 94132
Reflection...

On one side of your index card...

— One thing that you learned in this session that will influence your teaching...

On one side of your index card...

— One thing that surprised you during this session...
Thank you for choosing to spend your time with me today...

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Director, SEPAL

SEPAL
The Science Education Partnership & Assessment Lab
San Francisco State University