**Peer-Graded Assignment #3** **November 3, 2016**
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For your final peer-graded assignment, we're asking you to synthesize what you've learned in this course about STEM teaching by drafting a lesson plan for a topic you might teach to undergraduates one day. Where the first peer-graded assignment focused on content (learning objectives) and the second focused on process (learning activities), this one requires you to bring content and process together—along with assessment methods and strategies for inclusive teaching.

To complete this assignment, you'll need to submit a 2-3 page lesson plan focused on a single class session you might teach. You'll also respond to a series of questions asking you to reflect on the choices you made as you designed your lesson, and to connect those choices to the principles and practices discussed in this course. It's your responses to these questions that will be evaluated by your peers, with your lesson plan as context.

Although there's no standard format for undergraduate STEM lesson plans, we're asking you to use a specific format for this assignment to make it easier for your peers—who may be in different disciplines—to make sense of your lesson plan. The lesson plan you submit should include the following sections, each clearly marked:

A. Context – Describe a course you might teach in which you would use this lesson plan. Identify the kinds of students (e.g., for majors, non-majors, freshman or seniors) you would expect to see in this course, as well as how many students might be in the course. If it seems relevant, include information on the course schedule (e.g. 50-minute class sessions three times a week) and physical environment (e.g. lecture hall with stadium seating, lab with multiple benches) you can imagine for this course.

> **Context:** This activity will be performed in one 3-hour organic chemistry laboratory session. The students will be sophomore and junior chemistry, biochemistry, and chemical engineering majors. Students meet twice a week for three hours at a time.

B. Objectives – What learning objectives do you have for this lesson? Be as specific as you feel is appropriate, but bear in mind that your peer evaluator might not be in your discipline, so mind your jargon. Remember Bloom's taxonomy.

1. Given an experimental procedure from the organic chemistry literature, repeat the experiment to verify the authors' results. (understand)
2. Design an experiment based on the scientific method and literature to optimize a reaction for maximum product yield and purity. (apply/create)
3. Interpret spectroscopic data to determine the reaction product(s). (analyze)
4. Evaluate the work of peers to assess their use of the scientific method in planning an optimization experiment. (evaluate)

B. Activities – What learning activities have you planned for this lesson? Your description should give a good sense of how you're planning to use class time and what you'll ask your students to do during class. Although the focus of your lesson plan should be a single class session, feel free to describe learning activities that would occur before and/or after that class session. You need not draft slides or handouts or other materials, although you may find it helpful to include talking points or instructions to students in your lesson plan.

**Topic:** Introducing students to experimental organic synthesis via ring-closing metathesis, adapted from *J. Chem. Ed.* **2010**, *87*, 721-723.

**Activity:** In groups of two over four laboratory sessions, students will study the effects of various factors on the ring-closing metathesis reaction of diethyl diallylmalonate using Grubbs's second-generation catalyst.

**Session 1:** The instructor will introduce the topic with relevant scientific and historical literature background. Students will repeat the synthesis, purification, and characterization from a key literature reference according to the published conditions (Fu, G. C.; Nguyen, S. T.; Grubbs, R. H. *J. Am. Chem. Soc.* **1993**, *115*, 9856–9857) with the optimization conditions presented, but its results withheld. Each group will be assigned a research question relevant to the optimization of the experiment, such as "How sensitive to water is the catalyst?," "What is the optimal catalyst concentration?," "What is the minimum amount of solvent needed for the reaction?," "What is the best solvent for column chromatographic purification of the product?," and others. The groups of students will be split in half such that while half the group is repeating the literature procedure, the other half is working in groups to plan their experiment. While the students are planning their experiments, the instructor will circulate, ask guiding questions and discuss their plans with them, allowing them to obtain and implement feedback before performing the experiment in Session 2.

**Session 2:** The student groups that spent time planning their experiments during Session 1 will perform two experiments during Session 2: the repeat of the literature procedure and the first iteration of the student-designed experiment. The student groups will at this time plan their experiments and obtain and implement feedback from the instructor.

**Session 3:** At this point, all of the student groups will have repeated the literature procedure, planned, and performed their own experiments. During Session 3, the students will evaluate their results and repeat their experiment several times to ensure the data is meaningful. Once again, the instructor will circulate in the lab to talk to students and ask guiding questions.

**Session 4:** Student laboratory reports will be due in the format of a peer-reviewed journal article and should provide an original introduction, detailed experimental procedure, data, discussion of their findings, a conclusion, and references. Each group will also orally present their experimental results to the class, with the students assessing their peers' use of the scientific method, results, and analysis using a worksheet distributed by the instructor. The activity will conclude with a larger class discussion of the optimal reaction conditions and discussion of the process as it relates to how significant accomplishments in science are achieved. At the very end of class, students will be asked to use the same peer evaluation worksheet to assess themselves according to the same criteria.

C. Assessments – What formal or informal assessments have you planned to know if you've met your learning objectives? You need not draft specific exam questions, but you should identify when and how you will determine the extent to which you learning objectives have been met either through formative and/or summative assessment methods Assessments might come during the class session described above or later in the course.

**Formative Assessments:** Instructor discussions and feedback regarding experimental planning over the course of the activity.

Addresses Objectives #2 and #3

**Summative Assessments:** Lab report and peer assessment worksheets.

Addresses Objectives #1 and #4

Following are the questions you'll be asked to answer regarding your lesson plan.

1. Objectives – How have you followed recommended practices in identifying your learning objectives? In particular, have you expressed your goals in terms of what students will achieve or be able to do? Are your goals well-defined and measurable? Are they at appropriate levels of Bloom's taxonomy?

   I used Bloom's taxonomy to aim the objectives of this lesson to the areas of understand, apply, and analyze in order to build students' knowledge from the base level of the taxonomy to higher levels. I ensured that the learning objectives were specific to the activity, focused on what students will be able to achieve, and measurable.

2. Misconceptions – What potential student misconceptions have you identified in your lesson plan? How have you planned to surface and respond to these misconceptions?

   My lesson plan addresses misconceptions students may have about how scientific research is performed. Many students think that groundbreaking research can only be performed by 'geniuses' and it is out of their reach as 'normal' people or 'just students'. I will surface and respond to these misconceptions in the introduction to the experiment, by providing students with a scientific and historical background of the development of ring closing metathesis, developed by the Nobel Prize awarded chemist Robert Grubbs. In the debriefing discussion, I will emphasize to students the process of the development of this notable chemical reaction based on the scientific method, as well as biographical information about Grubbs and the students who worked with him on this work. Hopefully these discussions will emphasize to students that everyone starts out at a basic level but, with persistence and hard work, can accomplish great things.

3. Practice & Feedback – What opportunities for students to have meaningful practice and feedback have you planned for this lesson? What kinds of feedback would you expect students to receive and from whom?

   Students have the opportunity to obtain meaningful practice and feedback during the process of planning their experiments. Students will work in groups, thereby having consistent peer feedback while planning. Additionally, the instructor will have discussions with each student group during the planning process and after the first iteration of the experiment is performed, allowing students to obtain feedback from the instructor, revise their experimental plan, and perform the revised experiment several times before the final summative assessment. Lastly, students will receive feedback from their peers. The group presentations will allow students to both evaluate their peers and themselves on their use of the scientific method in the completion of this activity.

4. Inclusive Teaching – What aspects of your lesson plan are intended to create a learning environment that welcomes full participation by all students? Why might they do so? Have you planned activities that might leverage the diversity of perspectives and experiences among your students?

   Using two-person student groups encourages students to trust, work with, and learn with their partner. A classroom culture of embracing diversity and acceptance will enhance inclusivity, as the instructor will lead by example. Diversity may be incorporated by the students' interpretations of the topic to their area of study, as the course will be composed of chemistry, biochemistry, and chemical engineering majors. As a result of this diversity, each student may have a different approach to problem solving. Working in groups and having large group discussions leverage this diversity to benefit the entire class.

5. Sequencing – Why have you sequenced the learning activities you describe in your lesson plan in the order you have planned them?

   My intention with the sequencing of this lesson plan is to introduce students to the way the scientific method is used in research. First, they will be introduced to the literature, then they will repeat the literature procedure. This will be followed by formulating hypotheses based on the questions that each group is asked to address. They will use their knowledge gained from the literature and other coursework to design an experiment that will address the question, and collect and analyze data. Lastly, they will formulate a conclusion based on their results. From my experience in undergraduate and graduate school research, this is the method by which science is done.

6. Alignment – What are 2 or 3 ways your objectives, assessments, and activities are in alignment? Be specific about connections you have planned among these three components.

   Objective 1 (understand/repeat the literature) is in alignment with the activity of the initial introduction to the activity and students' reading of the literature, and with the assessment of the final lab report, which requires an introduction with literature references.

   Objective 2 (apply/create) is in alignment with the portion of the lesson plan that includes designing and performing the experiment, and will be assessed by the periodic discussions with the instructor, the final laboratory report, class presentations, and the peer and self-evaluations.

   Objective 4 (evaluate) is in alignment with the portion of the lesson plan that includes peer evaluation, which will be assessed by the peer and self-evaluation worksheets.

7. Evidence-Based Practices – How has research on STEM teaching and learning, including but not limited to studies mentioned in this course, informed the teaching choices you made as you planned your lesson?

   STEM education research on inquiry-based labs and problem-based learning was the greatest contributor to planning this lesson. The concept of backwards-faded scaffolding in terms of the instructor gradually pushing students to work more and more independently was also useful. Lastly, group work and peer feedback were implemented to enhance student engagement and learning.