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2017-2018 Writing Fellows Program

Writing in analytical chemistry: connecting the classroom and the laboratory

Summary: Students often find Chem 311: Analytical Chemistry challenging because in addition to being writing intensive, it includes a rigorous required laboratory component. Ideally, students will make strong connections between what we discuss in lecture, what we do in the lab, and what they write in their lab reports. In practice, these components often compete for students' attention. My initial goal as a Writing Fellow was to revise the writing components of this course so that they complement, rather than compete with, the laboratory component. To do this, I piloted a variety of writing assignments that bridged the lecture and the lab: (1) reading assignments to socialize students to norms of disciplinary writing, (2) laboratory notebooks that emphasized writing-to-learn, and (3) scaffolded formal lab reports that built student skills over the semester. While in some instances I found synergy between course content and writing skills, I also realized the need to carve out more time to discuss writing as a scientist in class; not every assignment could do double-duty as a means to both content and process.

Motivation and Background

I routinely teach Chem 311: Analytical Chemistry, which is the first course in the analytical chemistry sequence for chemistry and biochemistry majors and one of two courses offered to fulfill the writing emphasis part 2 requirements. Students often find this course challenging because in addition to being writing intensive, it also includes a rigorous required laboratory component. The introductory and organic chemistry laboratories emphasize development of practical lab skills and concept comprehension. In contrast, the Chem 311 lab exercises are more complex, and students are required (often for the first time) to obtain precise and accurate results. Since arriving at Trinity, I have struggled to balance the writing component of this course with the sophisticated laboratory sequence without overwhelming students. The first time I taught the course, the enrollment was eight students: three reported spending 13-15 hours per week preparing for class and five reported spending 16 hours or more. In my second iteration of the course, I streamlined the laboratory assignments to address this workload while maintaining rigor, but was still not satisfied with the result. In the past, students have written two formal lab reports and a project proposal while also completing numerous other homework assignments and informal lab reports. However, I do not feel that students make strong connections between what we are talking about in lecture, what they are physically doing in the lab, and what they are writing about in their lab reports. To address this, I piloted a three-pronged approach (outlined below) to integrate the lecture, laboratory, and writing components of the course. Participating in the Writing Fellows program allowed me to undertake these changes in conversation with other faculty on campus and to inform my teaching with best practices in writing-to-learn and other writing pedagogies. As noted in the concluding section, these conversations helped me to identify further areas for growth in developing the writing curriculum in Chem 311.

1. Use reading assignments to socialize students to norms of disciplinary writing.

In February 2017, I received a Cottrell Scholar Award, which provides funding for early career faculty in chemistry, physics, and astronomy to undertake both a research and an education

project. For my education project, I proposed to develop a series of assignments for the analytical chemistry curriculum at Trinity based on the primary literature in the field. Studies of teaching and learning have identified several ways in which reading the primary literature enhances student learning, from enhanced content knowledge to attitudinal changes.[1–5] One major goal for me in developing these assignments is to use them, in part, to direct students' attention to the norms of scientific writing, particularly for disciplinary writing between experts.[6] My goal was for these assignments to bridge lab and lecture by illustrating for students how course content applies to current cutting-edge experiments. While the assignments succeeded in showing students how to apply course content in new ways, I was surprised to find that students did not internalize the norms of scientific writing, even after completing 7 such assignments using primary articles. In their own writing, students maintained habits of writing associated with the teaching laboratory rather than research writing. During our discussions in the Writing Fellows program, my colleagues suggested that the students may be focusing intensely on understanding the science while completing these assignments, leaving little attention for rhetoric or formatting. Based on this observation, I intend to scale back the scope of these assignments and reduce some course content coverage to make room for more explicit, stand-alone discussions of research writing in chemistry during class.

2. **Revise laboratory notebook guidelines to emphasize writing-to-learn.**

The laboratory notebook is meant to be a complete, contemporaneous record of a scientist's work in the laboratory. Unfortunately, the nature of many activities in the teaching laboratory, in which experiments are pre-designed for students, make this challenging. In practice, student laboratory notebooks are often nothing more than a regurgitation of information from the laboratory manual. Objectives are cribbed from the title of the laboratory exercise; procedures are mindlessly copied from the manual to the notebook; and data are recorded without reflection on their validity or meaning. Recently I learned of a writing-to-learn strategy for student laboratory notebooks developed by a professor of organic chemistry at Chicago State University.[7] Students divide the page of their laboratory notebook into columns. In one column they record the steps of the laboratory procedure. In the neighboring column, they write an explanation for the rationale behind each step. Similarly, in one column they record their observations and data. In the adjacent column, they record any inferences or conclusions that can be drawn from their results. I implemented this style of laboratory notebook in Chem 311 this fall and Chem 312 in the spring. I also tested collection of lab notebook pages at the end of the laboratory (rather than 1 week later) to encourage students to think more actively about how lecture topics connect to the laboratory while they are conducting the experiments. In my opinion, this writing-to-learn activity was very successful. Students were more engaged in their note-taking during lab, more thoroughly examined their data during the experiments, and began to think about the meaning of the data before starting to write the lab report. I intend to repeat this practice in the next iteration of the course. One change I will make is to give students extensive feedback on their initial attempts at this practice and encourage and reward improvement over the course of the semester.

3. **Build up student skills in disciplinary writing over the course of the semester.**

After teaching the Chem 311 course the first time, I revised the rubrics that I used to grade lab reports to emphasize the use of data as evidence in student arguments about chemical concepts. Since then, I have learned of a published hierarchy of writing tasks in chemistry; writing tasks range in complexity from listing (in which a student simply uses important terms) to analysis and argument.[8] I planned to revise further the rubrics and lab report guidelines based on this hierarchy for Fall 2017 but was not able to complete this task before submitting the lab manual for printing. I intend to revisit this during Summer 2018, keeping in mind the other

lessons I learned during the Writing Fellows program. Traditionally the lab component of the course has included one formal lab report on a 1-2 week pre-designed lab exercises and a second formal report on a 3-week student-initiated project. I would like to revise the laboratory so that the first report is based on at least 3 weeks of laboratory experiments, allowing the students to compose the report gradually as they accumulate data. I also plan to share the idea of the hierarchy of writing tasks with the students to make clear how their writing should improve over the course of the semester. By sharing this hierarchy with students and using it to structure rubrics, I hope to encourage them to move beyond dropping keywords to actively applying course concepts in their writing. By making sure that both major writing assignments are spread over multiple weeks in lab, I hope to make space for more revision and reflection as well.

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