Inquiry-Based Writing in the Laboratory Course

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Scientific writing is increasingly recognized as a key component of an undergraduate scientific education. As an integral part of scientific practice, scientific writing is best learned in the context of doing science (1, 2). Because students “do” science (as opposed to “learn about” science) almost exclusively in laboratory courses (3, 4), they need to learn the skills of scientific writing there.

The inadequacies of the traditional lab, in which students go through the motions of laboratory work in a series of “cookbook” activities, have been widely recognized. Inquiry-based approaches to lab instruction are transforming the undergraduate lab by having students undertake actual experiments designed to help them learn to think scientifically (5–7). However, educational reform has yet to overcome the inertia of the traditional school “lab report.” Even in inquiry-based settings, such lab reports remain largely inauthentic and make-work affairs, involving little actual laboratory work in a series of “cookbook” activities, which students go through the motions of lab work (8). The experience is structured well.

In short, the inquiry philosophy has not yet been extended to include what might be called “inquiry-based writing.” In our view, successful inquiry-based writing requires three modifications to the inquiry lab. First, lab courses should give students practice in forms of writing actually used by scientists. Second, writing tasks must be aligned with the activity of the lab so that students have something meaningful to say. And third, student writing must have a real audience (see the chart).

Forms of Writing in the Lab Course

Broadly speaking, recent reforms to writing in the lab course can be classified as either “writing to learn” (WTL) or “writing as professionalization” (WAP). Much of this work has taken place in chemistry education (8). In the WTL approach, writing tasks are designed to help students engage with the scientific method and learn scientific ideas by reflecting on their experience. An exemplary version is the Science Writing Heuristic (SWH), which reframes the traditional school lab report as guided questions, providing opportunities for personal reflection about both the science and the scientific process (9). For example, in contrast with traditional lab reports—in which students insert content into boxes labeled “Methods,” “Results,” and so on—the SWH asks students to address thought-provoking questions such as “What can I claim?” and “How do I know?” (10).

In WTL, writing is primarily a tool to enhance scientific learning; it treats writing as a means rather than an end. When scientific writing is taught without regard to rhetorical function, expectations set for student reports are likely to be at odds with those of professional scientific discourse. SWH instructors, for example, are expected to check whether each student “lists all data” (11). Yet a key skill in communicating science is selecting which data to present.

The first step toward inquiry-based lab writing is to assign forms of writing that working scientists use. This step has been taken by the WAP approach (12). Students in WAP classes produce professional forms such as the conference poster; the research proposal; the review article; and, in the lab course especially, the experimental research report (13–15).

But because lab courses do not generally replicate the professional research settings that produce actual journal articles, assigning the experimental report brings its own pedagogical challenges. Consider what happens in the introductory sections of the typical research report: Researchers describe a knowledge gap in the literature and then explain how their current research fills that gap (16). But even in an inquiry-based lab, students have no research agenda and lack the breadth of knowledge needed to discuss their experiments in the context of the primary literature. Writing standard introductions for such labs can only be a sham. Students are not positioned to learn how to write such introductions until they have a scientific idea of their own to advance and at least a cursory knowledge of the related literature, probably late in their undergraduate studies.

The same problem exists with the teaching of the Methods (or Experimental) section. Because teaching the entire scientific paper at once is inherently problematic; one described strategy is to begin with the part that seems easiest on the surface: the Methods (14). Yet asking students to write Methods for experiments where the procedure is specified in detail in a lab manual, a common practice in WAP-style courses, requires that they engage in yet another kind of sham, because there is little for them to do but parrot back selected details from the manual. As students well know, those

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Designing effective inquiry-based writing assignments

Give students practice in authentic forms of scientific writing

Consider a wide variety of professional genres, including experimental reports, methods papers, proposals, and peer reviews.

Consider only part of a genre as a whole assignment

Ensure that students have something meaningful to say

Design assignments for the curriculum rather than the individual course.

Assign only those parts of a genre that match the realities of the lab setting.

Abandon any part of an assignment that lacks an authentic communicative function.

Create a real communication scenario

Position students as apprentice scientists.

Position instructors as scientific readers.

Assign only as much writing as instructors can read and respond to thoughtfully.

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Writing lab reports in science classes can be more productive and engaging if the experience is structured well.
who will actually read these reports already know what was done. Devoid of an authen-
tic communicative purpose, students have no basis for deciding which details should
be included. Students should learn to write Methods in more advanced lab courses when
they are designing their own experiments or at least substantially altering stan-
dard protocols.

Alignment and Audience
The second step toward inquiry-based lab writing is aligning student writing with lab activity. Short of the independent research project, no undergraduate course can repli-
cate the total context of the research envi-
ronment necessary to produce experimental reports in full. But if we relax the assump-
tion that students must produce entire experi-
mental reports for every lab or even in every course, we can design tasks that give
students something to say: Introductions are
written by advanced students undertaking
original research; methods, by intermediate
students who design experiments. In most
lower-level labs, students have no research
agenda nor do they design experiments.
They do, however, generate and evaluate
data; thus students at this stage can present
and discuss results.

Yet to fully engage in laboratory writ-
ing, student authors need not only something
to say, but also someone to say it to. Of the
methods common approaches to laboratory
writing considered here, WTL is not parti-
cularly concerned with the reader, and WAP
assignments typically ask students to imagine
that they are addressing, broadly, scientists in
the field, an abstraction that means little, and
provides little useful guidance to novices.
Therefore, the third and final step toward
inquiry-based writing is to provide students a
tangible audience for their written work.

Picture the standard introductory-level
titration lab. Now imagine that some students receive contaminated reagents, but they do
not know who received which. Now, imag-
ine that students are given, at random, either
contaminated or uncontaminated reagents,
but they do not know who received which.
This inquiry-based version engages students in
meaningful scientific inquiry, and yet the
instructor still operates primarily as a grader.
But if the instructors, too, are kept ignorant of
the distribution of reagents, they cannot know
what the results should be. Instead of
grading a product in which claims match
expected outcomes (13), they must read stu-
dent writing as scientists, evaluating how
clearly and convincingly each case is made.
And once instructors shift from mere graders
to readers, students cannot merely reproduce
the form of scientific argument but must
actually make scientific arguments (17).

What would inquiry-based writing in this
lab look like? No longer compelled to have
students write an introduction or describe
methods, we might ask them to write only a
single, well-designed page. This page would
include a main claim supported by key
results, appropriate visual displays, analy-
sis of error, and so forth. Although consid-
erably shorter than the typical lab report,
this assignment makes authentic rhetorical
demands, requiring students to argue for an
interpretation of their data under constraints
typically faced by the writing scientist. Sim-
ilar to the body of a “letter” or “short com-
munication,” this highly condensed writing
can help students learn to construct a repre-
sentation of their data that is both selective
and compelling (does not ignore results that
challenge the hypotheses).

The Inquiry-Based Writing Lab
When writing tasks are integral to lab activ-
ity and when student writing has a real audi-
ence, students are more likely to find such
tasks meaningful and engaging, and instruc-
tors can respond to such writing as the sci-
entists they are, rather than as evaluators of
standardized work or grammarians. Fur-
ther, eliminating unproductive writing tasks
allows both student and instructor to spend
more time doing important work. Students
can concentrate on a limited number of skills
that are essential for writing science but
rarely the subject of extended instruction:
how to decide which data to present; how to
use graphs, tables, and other visual displays
effectively; and how to discuss those graphic
supports in the accompanying prose. Instruc-
tors in turn can demand higher-quality work
and provide more-useful feedback.

Some may worry that under our proposal
students will not learn how to write a com-
plete research report. Although undergradu-
ate science majors should have the oppor-
tunity to design their own experiments and
take on a scientific research project of their
own (5), this is unlikely before the senior
year. The senior-year research project there-
fore provides the proper occasion for learn-
ing to write the research report in its entirety.

Those who oversee undergraduate sci-
cence labs may have pragmatic concerns
about the cost of change: the time involved
in redesigning assignments, the need to train
teaching assistants differently, the need to rethink evaluation, and so forth. All seri-
ous pedagogical reform has costs, especially
reform involving deep changes in mindset
and practice. But there are long-term savings
as well, when we consider the reductions in
the amount of writing students produce.

Many institutions may find it impractical
to implement all three proposed modifica-
tions at once. Thus, we suggest implement-
ing change in the order we have described,
each modification is a precondition for
the next. Finally, some instructors and stu-
dents will find the transformation uncomfort-
able. But just as with inquiry-based labs, transitional discomfort is necessary to gain the advantages provided by a more
realistic approach.

What is required of inquiry-based writ-
ing is precisely what is evaluated in day-to-
day communication among scientists: care
and integrity in handling data, clarity and
persuasiveness of communication, relevant
and compelling results. If we are serious
about improving students’ abilities as sci-
entific communicators, we must take them
seriously both as apprentice scientists and as
apprentice writers of science.

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