CHAPTER 5

Written, Verbal, and Visual Communication

Throughout the AP Chemistry laboratory experience, students must be able to communicate their experimental results to others in the chemistry community, including their peers. Every laboratory experience should include small group or classwide discussions of the questions posed by the lab and possible ways to address those questions. The students' discussion, guided by teachers or not, helps them to understand the relationships among the hypothesis, the ensuing protocol, and the results gained by following that protocol. These discussions typically take place in the traditional classroom setting; in addition, conversations can continue and be extended online, using a class wiki or Web page or a social media application, depending on the teacher's and student's preferences and time considerations.

Effective written communication should be a goal for all students. The National Math and Science Initiative actually encourages work not only in science and math but also in English because AP Chemistry students must be able to write clearly and concisely about their work, both in their courses and on the AP Exam. There are many methods students can use to communicate their results, and some of these are listed below. Each lab in this manual is unique and some may be better suited to one type of summative communication while others lend themselves to another. Teachers may want to use a variety of methods to evaluate student communication.

- The *traditional laboratory report,* in which each student prepares his or her own report, has been the standard practice.
- As the world of science has changed, the idea of a single author has become less pronounced in scientific literature. It is common to see several authors listed for a paper and, in the world of particle physics, for example, a paper might include a hundred authors. Students might be encouraged to *offer lab reports in pairs, trios, or even larger groups.*
- Individual and joint lab reports might then be grouped in *portfolio or lab notebook* fashion, allowing each student in a class to present a unique portfolio
- It has become common practice for college students, both undergraduate and graduate, to offer *poster presentations* of their work. Both the written portion and visual portion of the poster are important, as is the oral presentation that follows.
- Students working individually or in groups can produce *multimedia lab reports or projects* displaying and explaining their work using computers.
- Evaluation of each student's work by the instructor is essential, but *peer review* of others' work has become an increasingly common aspect of education. Written analyses by students of their own or others' work can lead to effective learning.

Student awareness of potential error and its effect on the quality of the answers gained is also paramount, and effective communication is the key to uncovering these potential errors. Students understand more about a laboratory exercise when they discuss it both before and after the procedure. Neber and Anton state that students gain more from laboratory work if they have discussed the meaning and process of the lab activity first. Teaching critical and analytical thinking may help students improve their ability to discuss and understand a lab. These discussions are key components of inquiry labs, as explained in Chapter 2. Additionally, students must be able to critique in an informed way the quality of the protocol and how it might be changed for the better if the experiment were to be repeated. New emphasis on methods of inquiry should allow a rich exploration of this concept.

Quality of Writing

While high school students write in most of their courses, in chemistry clear and concise writing are particularly important. An incomplete or out-of-order description of a lab procedure might lead to an ineffective or even dangerous outcome for the lab. To improve the quality and logic of responses written by students, there are a number of resources that contain tips for better writing in chemistry; some even show original and revised samples of laboratory prose. Such resources are listed at the end of this chapter.

Graphs

Because a graph is a convenient way to present data visually, students should follow certain conventions. Each graph should fill the space available and contain, at a minimum:

- Title, in the form of (dependent variable) versus (independent variable)
- Properly chosen axis: convention is x-axis independent variable, y-axis dependent variable
- Axes that must be labeled, including units
- A line or curve rather than connected data points

LAB REPORTS

A traditional, formal lab report might follow the dictates of the American Chemical Society and include the following sections: abstract, experimental, results, discussion, and references. A common high school structure has sections about the purpose, hypothesis, procedure and materials, data and observations, calculations, graphs, results and error analysis, and conclusion, though not all of these components are necessary or appropriate for all laboratory investigations. Typically lab reports are written in third person. You may choose to use the ACS formal lab report components, the common high school structure, or a combination of these two examples for students to use as a template to write their lab reports.

There is an online system available for guiding students through the lab report experience called "LabWrite" with sections for students, lab instructors, or professors. It includes rubrics for traditional lab reports. Many other rubrics are available on Rubistar, which also allows teachers to create their own rubrics. Links to Rubistar and LabWrite are provided in the reference section.

LAB NOTEBOOKS

The labs in this manual are inquiry-based rather than traditional in their instructional approach. Inquiry labs do not necessarily lend themselves to traditional lab reports and assessment, and teachers may want to consider alternatives to traditional lab reports when students do inquiry labs. As discussed more extensively in Chapter 2, one widely used inquiry program, the Science Writing Heuristic (SWH), employs a different structure for student lab write-ups, in which students do their write-ups in a lab notebook. Students answer a series of directed questions:

- What is the beginning question?
- How will I conduct the investigation?
- How will I stay safe?
- What observations and measurements did I make?
- What can I claim? What evidence do I have to support the claim?
- How do my ideas and results compare with others and to the literature?
- How have my ideas changed?

Each SWH lab write-up lab is scored using a rubric similar to the following one:

Criteria (each given 0–4 points)	4	3	2	1	0
1. Can the beginning questions be potentially answered by the results of the lab?					
2. What is the quality of the data and observations?					
3. Are the claims a direct result of the data and observations?					
4. How well are your data and observations used in your evidence?					
5. Are the claims backed up in the evidence?					
6. How well does the student answer all of the questions asked in the lab report write-up for this experiment?					
7. How well does the student analyze the data and observations to make the experimental measurements of observations meaningful?					
8. Do the results of the experiment come close to the accepted values or identify an unknown compound correctly or show an accepted comparison, trend, etc.?					

Criteria (each given 0–4 points)	4	3	2	1	0
9. In the reflection and readings how many sources are used and how are they connected?					
10. Do the student's reading and reflection discuss the student's initial questions? Do they aid the student's claims and evidence?					
TOTAL POINTS EARNED (out of 40)					

A link to more information about the Science Writing Heuristic is found in the reference section.

ALTERNATIVE APPROACHES TO LAB REPORTS

While the preceding sections present traditional methods for writing lab reports, there are other approaches you can consider. Examples include:

- **Journal Articles:** A student might write a lab report in the format of a journal article. A sample and instructions for writing reports as a journal article are available in the references section.
- **Group Projects:** Students can pursue a collaborative writing process for their lab report by using Google Docs, which allows students to create, store, and share documents, spreadsheets, and the like as they pursue such a process. Furthermore, while students are unlikely to be held to professional standards, high school students can still effectively review one another's work, using peer-reviewing standards from the ACS, or even using a free Web-based system from UCLA. The Green Stoichiometry lab in this manual provides information and practice with peer review as part of the investigation and postlab.
- **Multimedia Presentations:** Increasingly, poster or multimedia presentations are a common experience for college science students.

WEB RESOURCES

- RubiStar, a free online tool to make and save rubrics: *http://rubistar.4teachers.org/index.php*
- Science Writing Heuristic guide for implementing and assessing inquiry labs: *http://avogadro.chem.iastate.edu/SWH/swhwkshpmanual.pdf*
- Writing to improve performance in AP Chemistry: *http://apcentral.collegeboard.com/apc/members/courses/teachers_corner/45234.html?type=print*
- Writing guide for chemistry: *http://www.chem.orst.edu/writing/WritingGuide2000.htm*
- A brief guide to writing in chemistry: *http://chemistry.kenyon.edu/getzler/08F-CourseFiles/BriefGuideWritingChemistry.pdf*

- Write like a chemist:
  http://books.google.com/books/about/Write_Like_a_Chemist.html?id=qbCLfparjlcC
- Writing a traditional formal lab report:
  http://www.clarion.edu/70757.pdf
- LabWrite, an online system for guiding students' lab reports:
  http://labwrite.ncsu.edu/index_forprof.html
- Lab report in journal article format:
  http://chemlab.truman.edu/CHEMLAB_BACKUP/LabReports_files/LabReports.htm
- Google for Educators, including Google Docs:
  www.google.com/educators/p_docs.html
- Chemistry portfolios:
  http://www.flaguide.org/tools/portfolios/chem108/chm08.php
- Poster presentations:
  http://web.presby.edu/writingcenter/newsletter/posters.html
  http://www.ncsu.edu/project/posters
  http://lorien.ncl.ac.uk/ming/Dept/Tips/present/posters.htm
- Alternative methods of presenting and assessing lab work:
  http://www.wmich.edu/chemed/documents/alternative.pdf
  http://www.njea.org/news-and-publications/njea-review/december-2008/alternative-science-lab-reports
- Graphing data from the chemistry lab:
  http://www.ncsu.edu/scivis/lessons/Beerslaw/chemdata.html

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