Chemistry 310 Instrumental Analysis "Lecture"
Spring 2013

The lab, although given separate credit and separate title from Chemistry 310, is completely integrated to Chemistry 310. It is not possible to take Chemistry 310 without performing the laboratory exercises in 311.

The "lecture" section is designed to move along as closely as possible with the work in the lab. Time is allotted in each lecture section to discuss concepts and data obtained within the lab, as a result each student is expected to come to class prepared to ask questions and discuss the material from lab.

Grading
Best 2 of 3 exams 200
Final 100 (poster session)

Participation 40
Total 340 points

There is NO ROUNDING at the end. Grades are assigned by

Total Points		340
A	0.9	306
B	0.8	272
C	0.7	238
D	0.6	204

Grades of + and – are assigned at the discretion of the instructor.

The final consists of a poster presentation by each individual student discussing

A. Their data for standard lead analysis on the various instruments and the data with respect to their soils. Should be discussed with same criteria as for "B"
B. A complete analytical proposal for the analysis of a sample/target analyte of their choice. The validity of each step of the analysis must be justified.

The grade of the poster is determined by a panel of judges using a standard rubric (see attached)

http://usatoday30.usatoday.com/news/nation/smelting-lead-contamination/index

FINAL/Poster grading The "B" criteria for the poster.

Each individual is expected to identify some topic of interest for analysis in addition to the soil samples they have obtained.

The individual is to decide upon a method of analysis based upon a consideration of the limits of detection of the instrument with respect to the public health limits associated with the material to be analyzed.

As an example: suppose the EPA determines that soils containing lead above 400 ppm can cause an increase in the blood lead level of a child and must be remediated. The method decided upon by the individual involves sampling 1 g of soil, digesting 0.25 g of the soil, collecting the digestate into a 50 mL volumetric. During the analysis 5 mL of the digestate were brought to a 100 mL volume. The instrumental limits for this condition will be 0.24 ppm

$$LOD_{instrument} << \left(400\, ppm_{action\ level}\right) \frac{\left(\frac{10^{-6} g_{Pb}}{1 g_{soil}}\right)}{ppm} \frac{0.24 g_{soil}}{50 mL_{digestate}} \left(\frac{5 mL_{digestate}}{40 mL_{analysis}}\right) \tag{0.1}$$

$$LOD_{instrument} << \frac{400 x 10^{-6} x 0.24 g_{Pb} x 5}{50 x 40 mL_{analysis}} = \frac{0.24 x 10^{-6} g_{Pb}}{1 ml_{analysis}} = 0.24\, ppm$$

The instrument chosen must be able to make measurements below the value of 0.24 ppm. If not then a zero reading on the instrument could be obtained even when a sample has a final 0.24 ppm diluted value, leading to the conclusion that the soil would not have to be remediated.

The individual must demonstrate that each step of the method is accurate and contributes no error to the method. In the example above the student needs to demonstrate a method which ensures that

a) the solvent used to digest the sample did not ADD lead to the digestate.

b) the collection of the digestate into a 50 mL volumetric did not LOSE lead from the sample.

c) the method chosen for digestion does indeed quantitatively transfer a known amount of lead from the soil into the digestate.

Etc.

A. Poster Evaluation (1 pt each)

For this section see the following web site:
http://www.makesigns.com/SciPosters_Home.aspx
For poster templates and hints about preparing scientific posters

Presenter has spent enough time to

1. Write in scientific English
2. Spell Checked
3. Punctuation and style is appropriate.

Is the poster readable?

4. Title is visible easily
5. Sections are clearly marked and titles are easy to read
6. Font size is appropriate for reading

Is the poster content arranged well?

7. Sections flow in a logical fashion for the content
8. Graphics are placed in a logical place for the text content
9. Graphics add to the visual spacing of the poster and do not detract

Does the poster have the parts appropriate for a scientific presentation?

10. Title
11. Purpose/Hypothesis
12. Sampling/Procedures
13. Results/Conclusions
14. Cited Literature

Is the data presented in an understandable format?

15. Graphs have a title and number and are referred to properly in the text
16. Axis are labeled correctly
17. Font size on the Axis and Caption are readable
18. Units are present in the axis labels
19. Graphs have a caption
20. Tables are easy to read
21. Tables have decent column headings
22. Tables have Title and Number and are referred to properly in the text.

II. Project Evaluation (4 pt each)

The project purpose/definition

1. The project has a clearly defined comparison to be tested
2. The comparison to be tested has been literature searched so that expected differences/values/action trigger levels, if available, are presented.

Sampling

- The samples proposed for collection are adequate for the question proposed and the expected action limits
- The splitting of samples is sufficient to test solvents and spikes and test for the precision necessary to determine if the sample concentration is above the Limit of Detection.

Instrumentation

- The project instrumental methodology is appropriate
- The methodology is a validated method?
- If not the method selected has a defendable rationale
- The presenter has shown that the instrument works well in previous work or literature.
- The calibration curve is appropriate for the expected sample concentration.
- The calibration curve is shown to be appropriate for the sample matrix after preparation.
- The LOD and LR of the instrument selected is appropriate for the expected values or action level values for the type of sample collected.

Solvents and Blanks

- The presenter shows that the solvents and reagents will not contribute lead content.
- The presenter shows that the solvents and reagents will not affect the quality of the calibration curve.

Accuracy

- The presenter showed that he/she is capable of carrying a sample through preparation and to instrumental analysis accurately by use of a spiked sample
- The presenter has identified a certified reference material and demonstrate that he/she obtained data consistent with the certified values

OTHER –free point for the evaluator based on their subjective response to the poster.

Chemistry 311 Instrumental Analysis Laboratory
Spring 2013

This lab, although given separate credit and separate title from Chemistry 310, is completely integrated to Chemistry 310. It is not possible to take Chemistry 310 without performing the laboratory exercises 311.

Writing Intensive Class

This class is listed as writing intensive. For the University this means you should have a chance to rewrite labs. The type of writing asked for here has evolved as we have have gotten better at utilizing writing as a tool for learning. This semester we have incorporated the Science Writing Heuristic.

Materials and Equipment to Be Supplied by the Student

Flash drive, laptop computer, pencils, and calculator
Lab book, carbon tear out sheets

Responsibility of Students

There are four official lab times. Each lab is 4 hours long. Students are expected to

- arrive with a working knowledge of the content of the assigned lab and be ready to begin promptly in order to complete the various tasks.
- Have question written that they intend to answer in lab. *T.A.s will check your lab book for your beginning questions, appropriate calculations and procedure. This pre-lab is worth six points and will be subtracted, if not performed, from the individual grade of either the group or individual lab reports before grading. These points are non-refundable. I.E. the total points possible for the written lab become 94.*

The Process of the Science Writing Heuristic

Beginning Questions

a. Propose a beginning question to explore the purpose for doing the experiment.

b. A beginning question should be of the form "How does one variable depend on another variable?"

c. Beginning questions that are not acceptable include:

   1. "Why?" questions.
   2. Factoid questions.
   3. Questions that can be answered without doing the experiment.

d. Can you make a prediction to try to answer your beginning question?

Procedure and Tests

a. Propose your plan for how the beginning questions can be answered by doing the experiment. (This may be different from what you actually *do* during the experiment, but it is a start.)

b. Make an outline of precisely what you did (after sharing ideas with your group and drafting a group strategy).

- utilize the entire time including performing data analysis as the data is acquired
- maintain cleanliness. Grades can drop if laboratory cleanliness is not adhered to. Each group is responsible for the cleaning of all lab ware used and to return the equipment to the appropriate space. If this becomes an issue the groups, semester grade may be lowered by a full grade.

Groupings and Schedule

In order to allow each student hands on access to the equipment each lab is split into 2 to 3 groups, each group having no more than 3 participants. The groups will follow DIFFERENT schedules throughout the semester as indicated on the next page.
2 labs deal with manipulation of data.

Working in groups is not easy. We expect you to make an honest effort to evaluate your own contribution and that of your partners to the group. At week three you will be given an opportunity to restructure. If an individual performs so poorly within a group that they are not "desirable" they will be expected to complete the work on their own with no decrease in the amount of work.

Points and Grades:

There are 10 labs periods scheduled. The first is introductory, and the final are for work on your poster project. That leaves 8 labs for 800 points. One lab is dropped, so the net total possible points are 700. There is no rounding of grades. Two of those labs will be individual lab reports (IR and ICP-MS). The remainder (6) will be graded as group efforts. The rubrics for the individual lab reports are attached below.

Total points		700
A	0.9	630
B	0.8	560
C	0.7	490
D	0.6	420

Grades of – and + MAY be assigned at the discretion of the instructor in consultation with the TAs. Lack of cleanliness can result in a full grade drop.

	Lab Report Grading	points	
Individual	Beginning Question and procedure	6	non-refundable
Individual	End Reflection	16	non-refundable for content (editing of grammar/spelling/etc. can occur for subsequent submission)
Group	Bulk of Lab Report	78	
	total	100	

LAB REPORT FORMAT

They are submitted electronically, 1 week after the lab was completed.
You will receive a marked and edited copy of the lab 1 week after submission.
You have 1 week to either
a) respond to the written comments and return the lab for a higher grade
Or
b) accept the preliminary grade.
It goes without saying that I expect the papers submitted to be spell checked.
This process applies to all labs.

Each lab should contain the following sections:

A. A descriptive title

Notice that this document contains the group name, an indication that it is the first submission, the date of that first submission, and a title. When submitted electronically the version number should be indicated. Thus the **electronic file name** for this would be should be : **Boy Mus Soi IR 02 24 version 1**

Group Name: Lead Zeppelin
Shaun Boyes
Jonathan Muscolino
Zachary Soiya
Submission 1: February 24, 2010

Utilizing Infrared Spectroscopy to Determine the Presence of Lead in EDTA-Binding

C. Introduction/Purpose/your proposed question

C. Short Materials/Methods (DO NOT COPY AND PASTE METHODS FROM THE INSTRUCTIONS) section rewritten by the students to reflect their knowledge of the methods. You may wish to use what you write for your lab book for entrance into the lab (see above under responsibilities).

C. Data AND Discussion combined.

Data here refers to analyzed data in the form of Tables and Graphs.

You may have written lab reports for other classes in which your data was presented and then the discussion. I require a different format. The format required is intended help you interpret your data. I want to see well made graphs/tables within the context of your discussion/interpretation of the data. As part of the discussion a few select articles have been provided so that you need not research the literature extensively to find the context for your data. I have also included some trigger words/questions to be discussed by your group in preparing the lab report.

Writing a list of answers is NOT ACCEPTABLE. The data acquired within the lab should be used to illustrate important concepts identified by the reading and discussion of the students. You should consider this section to be a story telling section.

What is the story/point/question posed by you of this lab?
Why is it an interesting story?
What are the elements of the exercises in the lab that are essential to the story telling process?

For labs in which lead is the analyte **YOU MUST submit an LOD table** as part of your discussion section which provides a concentration based limit of detection determined by your group for the current lab and ALL preceding labs. You will discuss the differences between the current lab and ALL preceding labs as part of section C.

D. Individual Reflections For Each Student Come Before any appendices

Reflection (16 points total):

- Have I identified and explained sources of error and assumptions made during the experiment?
- How have my ideas changed, what new question do I have, what new things do I have to think about?
- How does this work tie to concepts about which I have learned in class?
- To what can I refer in my text, my notes, or some real-life application to make a connection with this laboratory work?

E. Appendix (Raw data as necessary)

Separate submissions individually:

Evaluation (no points)
For the first 3 weeks, you should send in at the same time as the lab report is submitted an individual evaluation of the type and quality of work performed by your other team members.

FORMATING
1. Each graph should contain a labeled X and Y axis.
2. The font size in excel before import into your document should be bold, and at a minimum, 14 font.
2. The legend for any graph or table should be attached to the graph/table – No widows/orphans. A widow and orphan is a title that occurs on one page with the graph following on the second.
3. The graphs and figures should have a descriptive title and be numbered sequentially.
4. The graph location within the document follows immediately from the first discussion of that graph or figure.
5. Do not rotate the graphs. Keep them aligned with the document for ease of reading.

Grading of the individual lab reports

Table 2. Assessment Rubric for Solutions to Laboratory Problems (39 points total)[1]

Section	Criteria	Description & Characteristics
Introduction	Context	Report demonstrates a clear understanding of the 'big picture' and addresses the following questions: • Why is this question important/useful/ necessary in chemical analysis? • What do we know already? What problem/question is this experiment addressing?
	Accuracy & Relevance	Content knowledge described relevant to this experiment is accurate, relevant, and provides appropriate background information, including defining critical terms.
Questions & Hypothesis/es	Testable	Hypothesis/es and/or questions are clearly stated, testable, scientifically relevant and consider plausible alternative explanations where necessary.
Methods	Controls & Replication	Appropriate controls (including appropriate replication) are present and explained.
	Experimental Design	Experimental design is likely to produce salient and fruitful results. The design focuses on relevant tests for the hypothesis/es & question(s) posed.
Results	Data Selection	Data chosen are comprehensive, accurate, and relevant.
	Data analysis	Data analysis is appropriate for hypotheses tested and appears correctly performed and interpreted with relevant values reported and explained.

[1] derived from Timmerman, et. al 2011

Section	Criteria	Description & Characteristics
	Data presentation	Data are summarized in logical format. Table or graph types are appropriate. Data are properly labeled including units. Graphs are appropriately labeled and scaled. Captions, if any, are informative and complete.
Discussion	Conclusions	Conclusions are clearly and logically drawn from data provided. A logical chain of reasoning from hypothesis to data to conclusions is clearly and persuasively explained. Conflicting data, if present, are adequately addressed.
	Alternative Explanations	Alternative explanations (hypotheses) are considered and clearly eliminated in persuasive discussion.
	Limitations of design	Limitations of the data and/or experimental design and corresponding implications for data interpretation are discussed.
Connection to other knowledge		Writer provides a relevant, accurate, and reasonable discussion of how this experiment relates to other knowledge in the chemistry.
Writing quality		Grammar, word usage and organization facilitate understanding of the report.

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Alanah's Schedule Spring 2013

	Mon	Tues	Wed	Thur	Fri
8:30		Lab 01W	Lab 03W		
9:20					Group meeting 11-12-11
10:25	T.A. Meeting				
11:30					
12:20	Office Hour	Office Hour			Office Hour
1:40-2:30	Class DU-118		Class Du-118		Class DU-118
2:45		Lab 02W			
3:45			Faculty Council Once/month	Lab 04W Chem Seminar 4-5:15 LSB 145	Lab 03W
4:55					
	On-Line Quant Ibero Mexico				
6:00					
6:35					
7:35					

Alanah's Travel Schedule:

Jan 28-29 National Science Foundation Panel, Washington D.C.
Mar 16-17 Pittcon Orlando, Analytical Sciences Digital Library Executive Committee
Mar 10?? 1 week Vietnam Faculty Exchange
May 12-17 Electrochemical Society Meeting Toronto, Board Meeting

Date	Week #	Proposed Experiment			
		Schedule 1	Schedule 2	Schedule 3	Schedule 4
Tuesday, January 15, 2013	1	Lab Intro, expectations, etc. (AM: Cuneo 212; PM: FH 129)	Lab Intro, expectations, etc. (AM: Cuneo 212; PM: FH 129)	Lab Intro, expectations, etc. (AM: Cuneo 212; PM: FH 129)	Lab Intro, expectations, etc. (AM: Cuneo 212; PM: FH 129)
Thursday, January 17, 2013		Lab Intro, expectations, etc. (FH 129)	Lab Intro, expectations, etc. (FH 129)	Lab Intro, expectations, etc. (FH 129)	Lab Intro, expectations, etc. (FH 129)
Friday, January 18, 2013		Lab Intro, expectations, etc. (FH 129)	Lab Intro, expectations, etc. (FH 129)	Lab Intro, expectations, etc. (FH 129)	Lab Intro, expectations, etc. (FH 129)
Tuesday, January 22, 2013	2	Statistics (AM: Cuneo 212; PM: FH 129)	Statistics (AM: Cuneo 212; PM: FH 129)	Statistics (AM: Cuneo 212; PM: FH 129)	Statistics (AM: Cuneo 212; PM: FH 129)
Thursday, January 24, 2013		Statistics (FH 129)	Statistics (FH 129)	Statistics (FH 129)	Statistics (FH 129)
Friday, January 25, 2013		Statistics (FH 129)	Statistics (FH 129)	Statistics (FH 129)	Statistics (FH 129)
Tuesday, January 29, 2013	3	Electronics (Matthew) (AM: Cuneo 212; PM: FH 129)	Electronics (Matthew) (AM: Cuneo 212; PM: FH 129)	Electronics (Matthew) (AM: Cuneo 212; PM: FH 129)	Electronics (Matthew) (AM: Cuneo 212; PM: FH 129)
Thursday, January 31, 2013		Electronics (Matthew) (FH 129)	Electronics (Matthew) (FH 129)	Electronics (Matthew) (FH 129)	Electronics (Matthew) (FH 129)
Friday, February 01, 2013		Electronics (Matthew) (FH 129)	Electronics (Matthew) (FH 129)	Electronics (Matthew) (FH 129)	Electronics (Matthew) (FH 129)
Tuesday, February 05, 2013	4	Digestions (JM and MR) (FH 402)	Digestions (JM and MR) (FH 402)	Digestions (JM and MR) (FH 402)	Digestions (JM and MR) (FH 402)
Thursday, February 07, 2013		Digestions (JM and MR) (FH 402)	Digestions (JM and MR) (FH 402)	Digestions (JM and MR) (FH 402)	Digestions (JM and MR) (FH 402)
Friday, February 08, 2013		Digestions (JM and MR) (FH 402)	Digestions (JM and MR) (FH 402)	Digestions (JM and MR) (FH 402)	Digestions (JM and MR) (FH 402)
Tuesday, February 12, 2013	5	UV-Vis (Jonathan) (FH 002)	UV-Vis (Jonathan) (FH 002)	IR (Mary) (FH 314)	IR (Mary) (FH 314)
Thursday, February 14, 2013		UV-Vis (Jonathan) (FH 002)	UV-Vis (Jonathan) (FH 002)	IR (Mary) (FH 314)	IR (Mary) (FH 314)
Friday, February 15, 2013		UV-Vis (Jonathan) (FH 002)	UV-Vis (Jonathan) (FH 002)	IR (Mary) (FH 314)	IR (Mary) (FH 314)
Tuesday, February 19, 2013	6	IR (Mary) (FH 314)	IR (Mary) (FH 314)	UV-Vis (Jonathan) (FH 002)	UV-Vis (Jonathan) (FH 002)
Thursday, February 21, 2013		IR (Mary) (FH 314)	IR (Mary) (FH 314)	UV-Vis (Jonathan) (FH 002)	UV-Vis (Jonathan) (FH 002)
Friday, February 22, 2013		IR (Mary) (FH 314)	IR (Mary) (FH 314)	UV-Vis (Jonathan) (FH 002)	UV-Vis (Jonathan) (FH 002)
Tuesday, February 26, 2013	7	ASV (Jonathan) (FH 402)	IC (Matthew) (FH 313)	GC module (Dr. Fitch) (FH 314)	No Lab Scheduled
Thursday, February 28, 2013		ASV (Jonathan) (FH 402)	IC (Matthew) (FH 313)	GC module (Dr. Fitch) (FH 314)	No Lab Scheduled
Friday, March 01, 2013		ASV (Jonathan) (FH 402)	IC (Matthew) (FH 313)	GC module (Dr. Fitch) (FH 314)	No Lab Scheduled
Tuesday, March 05, 2013	8	SPRING BREAK -- NO CLASS	SPRING BREAK -- NO CLASS	SPRING BREAK -- NO CLASS	SPRING BREAK -- NO CLASS
Thursday, March 07, 2013		SPRING BREAK -- NO CLASS	SPRING BREAK -- NO CLASS	SPRING BREAK -- NO CLASS	SPRING BREAK -- NO CLASS
Friday, March 08, 2013		SPRING BREAK -- NO CLASS	SPRING BREAK -- NO CLASS	SPRING BREAK -- NO CLASS	SPRING BREAK -- NO CLASS
Tuesday, March 12, 2013	9	No Lab Scheduled	ASV (Jonathan) (FH 402)	IC (Matthew) (FH 313)	GC module (Dr. Fitch) (FH 314)
Thursday, March 14, 2013		No Lab Scheduled	ASV (Jonathan) (FH 402)	IC (Matthew) (FH 313)	GC module (Dr. Fitch) (FH 314)
Friday, March 15, 2013		No Lab Scheduled	ASV (Jonathan) (FH 402)	IC (Matthew) (FH 313)	GC module (Dr. Fitch) (FH 314)
Tuesday, March 19, 2013	10	GC module (Dr. Fitch) (FH 314)	No Lab Scheduled	ASV (Jonathan) (FH 402)	IC (Matthew) (FH 313)
Thursday, March 21, 2013		GC module (Dr. Fitch) (FH 314)	No Lab Scheduled	ASV (Jonathan) (FH 402)	IC (Matthew) (FH 313)
Friday, March 22, 2013		GC module (Dr. Fitch) (FH 314)	No Lab Scheduled	ASV (Jonathan) (FH 402)	IC (Matthew) (FH 313)
Tuesday, March 26, 2013	11	No Lab Scheduled	No Lab Scheduled	No Lab Scheduled	No Lab Scheduled
Thursday, March 28, 2013		No Lab Scheduled	No Lab Scheduled	No Lab Scheduled	No Lab Scheduled
Friday, March 29, 2013		EASTER BREAK -- NO CLASS	EASTER BREAK -- NO CLASS	EASTER BREAK -- NO CLASS	EASTER BREAK -- NO CLASS
Tuesday, April 02, 2013	12	IC (Matthew) (FH 313)	GC module (Dr. Fitch) (FH 314)	No Lab Scheduled	ASV (Jonathan) (FH 402)
Thursday, April 04, 2013		IC (Matthew) (FH 313)	GC module (Dr. Fitch) (FH 314)	No Lab Scheduled	ASV (Jonathan) (FH 402)
Friday, April 05, 2013		IC (Matthew) (FH 313)	GC module (Dr. Fitch) (FH 314)	No Lab Scheduled	ASV (Jonathan) (FH 402)
Tuesday, April 09, 2013	13	ICP-MS (Dr. Fitch) (LSB 445)	ICP-MS (Dr. Fitch) (LSB 445)	ICP-MS (Dr. Fitch) (LSB 445)	ICP-MS (Dr. Fitch) (LSB 445)
Thursday, April 11, 2013		ICP-MS (Dr. Fitch) (LSB 445)	ICP-MS (Dr. Fitch) (LSB 445)	ICP-MS (Dr. Fitch) (LSB 445)	ICP-MS (Dr. Fitch) (LSB 445)
Friday, April 12, 2013		ICP-MS (Dr. Fitch) (LSB 445)	ICP-MS (Dr. Fitch) (LSB 445)	ICP-MS (Dr. Fitch) (LSB 445)	ICP-MS (Dr. Fitch) (LSB 445)
Tuesday, April 16, 2013	14	Analyze Ghost Factory Samples (ICP-MS, ASV, and/or IC); Clean-up lab spaces, supplies, equipment, etc.			
Thursday, April 18, 2013		Analyze Ghost Factory Samples (ICP-MS, ASV, and/or IC); Clean-up lab spaces, supplies, equipment, etc.			
Friday, April 19, 2013		Analyze Ghost Factory Samples (ICP-MS, ASV, and/or IC); Clean-up lab spaces, supplies, equipment, etc.			
Tuesday, April 23, 2013	15	Analyze Ghost Factory Samples (ICP-MS, ASV, and/or IC); Clean-up lab spaces, supplies, equipment, etc.			
Thursday, April 25, 2013		Analyze Ghost Factory Samples (ICP-MS, ASV, and/or IC); Clean-up lab spaces, supplies, equipment, etc.			
Friday, April 26, 2013		Analyze Ghost Factory Samples (ICP-MS, ASV, and/or IC); Clean-up lab spaces, supplies, equipment, etc.			

Using the Science Writing Heuristic Approach

Background

The Science Writing Heuristic, SWH, is a method that has been devised to encourage you to use hands-on guided inquiry laboratory activities to actively negotiate meaning and construct conceptual knowledge. Inquiry tasks, when correctly designed, stimulate your thinking about the underlying concepts related to the laboratory. The "answer" is not obvious from the outset.

The SWH provides an alternate format for you to guide your peer discussions and your thinking about and writing about how hands-on guided inquiry activities relate to your own prior knowledge via beginning questions, claims and evidence, and final reflections (Table 1). Although making observations in the SWH format may be similar to traditional verification work, the process of making claims and supporting them with evidence helps you to construct a deeper understanding of the concept(s) being explored by the laboratory exercise. Data collected via experimentation may be interpreted in more than one way. You must collaborate to construct possible explanations for what has been observed. Reflection on how your knowledge has changed helps you to confront possible misconceptions and construct a deeper, more appropriate understanding of the topic(s) being investigated.

Your learning environment is important. The Science Writing Heuristic requires an effective student-centered learning environment. The more you are able to make decisions, the more ownership, responsibility, and accountability you feel towards the laboratory exercise. You become more engaged—you exert more effort, are more interested in the outcome, and learn more as a result.

Table 2 outlines some differences between a traditional laboratory and a Science Writing Heuristic laboratory. A Science Writing Heuristic classroom is consistent with any other classroom employing an active learning strategy that promotes collaboration. You are responsible to one another to complete all necessary tasks, record your data and observations appropriately on the chalkboard for all to share, and attempt to formulate claims based on the evidence collected. The ensuing discussions help you and your classmates to connect your experimental work with related chemistry ideas, constructing your own understanding of the concept(s) under consideration.

We will use a specific format for the laboratory report that requires you to write. We do not use a fill-in-the-blank-style report.

Table 1. Comparing student report formats for the Science Writing Heuristic and traditional laboratory.

The Science Writing Heuristic	
Standard Report Format	*SWH Student Template*
1. Title, purpose. 2. Outline of procedure. 3. Data and observations. 4. Balanced equations, calculations, error analysis, graphs. 5. Discussion.	1. Beginning Questions—What are my questions? 2. Tests and Safety—What will I do? How will I stay safe? 3. Observations—What can I see? 4. Claims—What can I claim? 5. Evidence—How do I know? Why am I making these claims? 6. How do my ideas compare with other ideas? 7. How have my ideas changed?

Table 2. Comparing a traditional laboratory session to a student-centered laboratory session.

	Traditional Lab	Student-centered Lab
Pre-lab	The instructor gives step-by-step directions, asks for questions related to "cookbook" procedure.	a. Students write beginning questions (BQs) on chalkboard. b. Together the class discusses which BQs to investigate. c. Students talk about how to divide the tasks among groups, and what data needs to be collected. d. Students prepare class data table on chalkboard.
Students Perform Experimental Work	Students follow procedure outlined in lab manual or outlined by instructor. Students stay at their own experimental work station and talk mainly with their partner (unless they ask the instructor a question).	a. Students perform lab work necessary to answer their own questions. b. Students talk with other group members and other lab groups about what they are finding.
Data Collection	Lab partners check with one another to be certain that both have all data, then leave.	a. Each group enters data in class data table on the chalkboard. b. Groups who have finished "their" part walk around the classroom to check with other groups to determine whether any other group needs help in completing their task(s) or calculations.
Discussion	Student may ask a question of partner and/or instructor, then leaves the classroom.	a. As soon as more than half of the data has been entered in the table, students begin to look for trends to answer their BQs. If data does not agree with an apparent trend, they may repeat their work. b. When all data is on the board, students critically evaluate the information. c. Students work together to negotiate meaning, construct a concept, answer BQs. d. Students write and discuss an appropriate claim and provide supporting evidence.