Implementing the Science Writing Heuristic (SWH) Approach

Brandon Fetterly, University of Wisconsin—Richland

brandon.fetterly@uwc.edu

Jason R. Poock, Marshalltown Community College

Jason.Poock@iavalley.edu

Thomas J. Greenbowe, Iowa State University

tgreenbo@iastate.edu

http://avogadro.chem.iastate.edu/SWH/homepage.htm

“Much as we might think so, teachers are not ‘in control’ of learning, students are.” (Hand, 2003)

A Paradigm for Learning

- Knowledge can be gained through active participation by the learner in effective activities.
- Students teach each other and they teach the instructor by revealing their understanding of the subject.
- Teachers learn by this process…by steadily accumulating a body of knowledge about the practice of teaching.

Teaching is enabling.

Knowledge is understanding.

Learning is active construction of subject matter.

R. F. Elmore in *Education for Judgment*, Harvard Business School, Boston, MA. Edited by C. R. Christensen, D. A. Garvin, and A. Sweet, 1991.

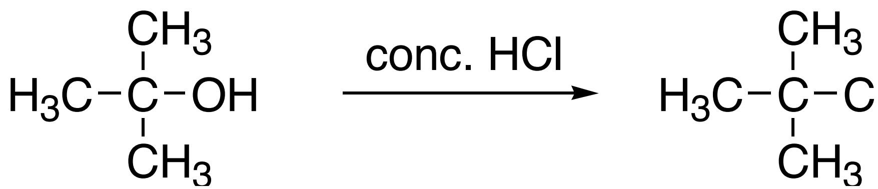
Two Views of Laboratory Work

- **Traditional verification or cookbook laboratory exercises do not best serve the needs of most students**
  - **Explicit directions for doing the complete exercise are given**
  - **Emphasis is on applying laboratory techniques**

- **Inquiry and collaborative learning have successfully been used in a variety of science laboratory courses to**
  - **engage students by emphasizing learning**
  - **motivate students to think about the ideas and concepts underlying laboratory work**
  - **increase students' ability to reason and problem solve**

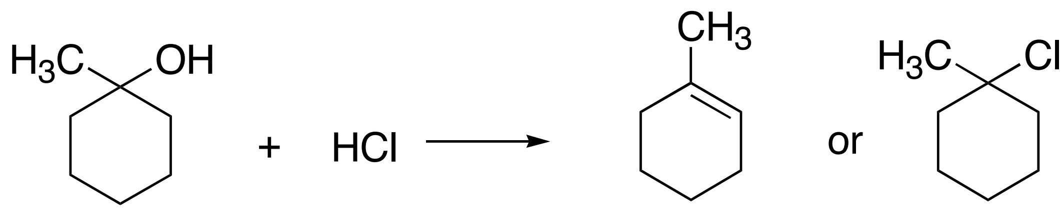
McKeachie, 1978; Pavelich and Abraham,1979; Hofstein and Lunetta, 1982; Todd and Pickering, 1988; Burns, Berka, and Kildahi, 1993; Lazarowitz and Tamir, 1994; Leonard,1994; Keys, Hand, Prain, Collins, 1999; Farrell, Moog, and Spencer, 1999; McElveen, Gavardinas, Stamberger, and Mohan, 1999; Coppola,1999; Centko and Mohan, 2001; Horowitz, 2003; Mullins, Vedernikov, and Viswanathan, 2004; Deming and Cracolice, 2001; Oliver-Hoyo, Allen, and Anderson, 2004; Greenbowe and Hand, 2005.

Traditional Nucleophilic Substitution Laboratory



- Given
  - the complete reaction mechanism
  - Step-by-step procedure
  - "…this is a unimolecular substitution or S_N1 reaction"
  - Tertiary > secondary > primary (3° > 2° > 1°)

A POGIL/SWH Laboratory



- Substitution vs. Elimination
  - Same reaction as before, but framed in different context
  - Alluded to a previous aromatic substitution lab emphasizing how different products can be produced
  - Alluded to the dehydration lab – why didn't substitution happen?
  - Catalytic amounts vs. equimolar amounts
  - Discussion of carbocation stability

Question of the Day

What Role Does a Solvent Play In Nucleophilic Aliphatic Substitution Reactions?

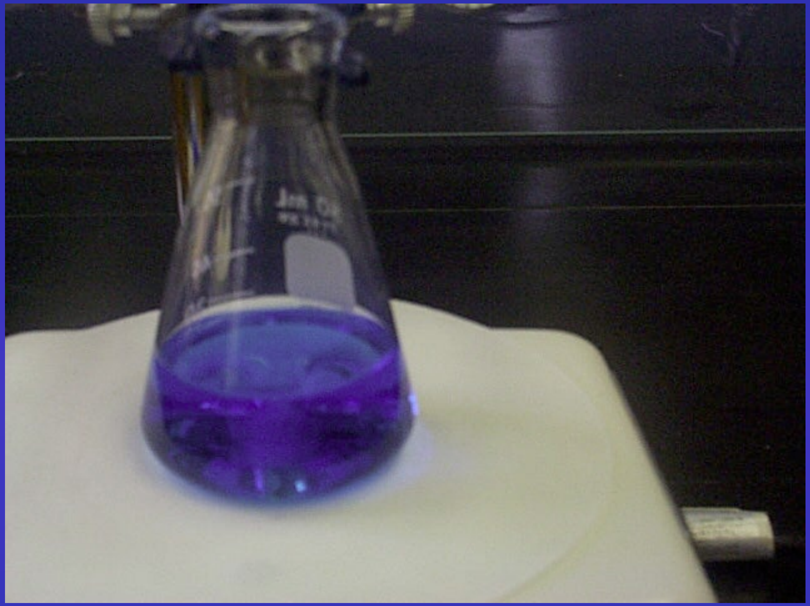
What do students predict?

- Keeps reagents in solution.
- Makes reaction faster
- Slows down reaction
- Determines the mechanism

- How do we design a series of experiments to test these hypotheses?
- Note: The apparatus, materials, and reagents available to use are provided in the lab manual.

What Role Does Solvent Play In Nucleophilic Aliphatic Substitution Reactions?

1. The **reagents** for this experiment (water, organic solvents, aqueous NaOH) are dispensed from burets into the Erlenmeyer flask.
2. Bromothymol blue indicator is added from a dropping bottle.
3. The HCl and the alkyl halide substrates are dispensed by means of Eppendorf pipets into test tubes that are emptied as quickly as possible into the reaction vessel.

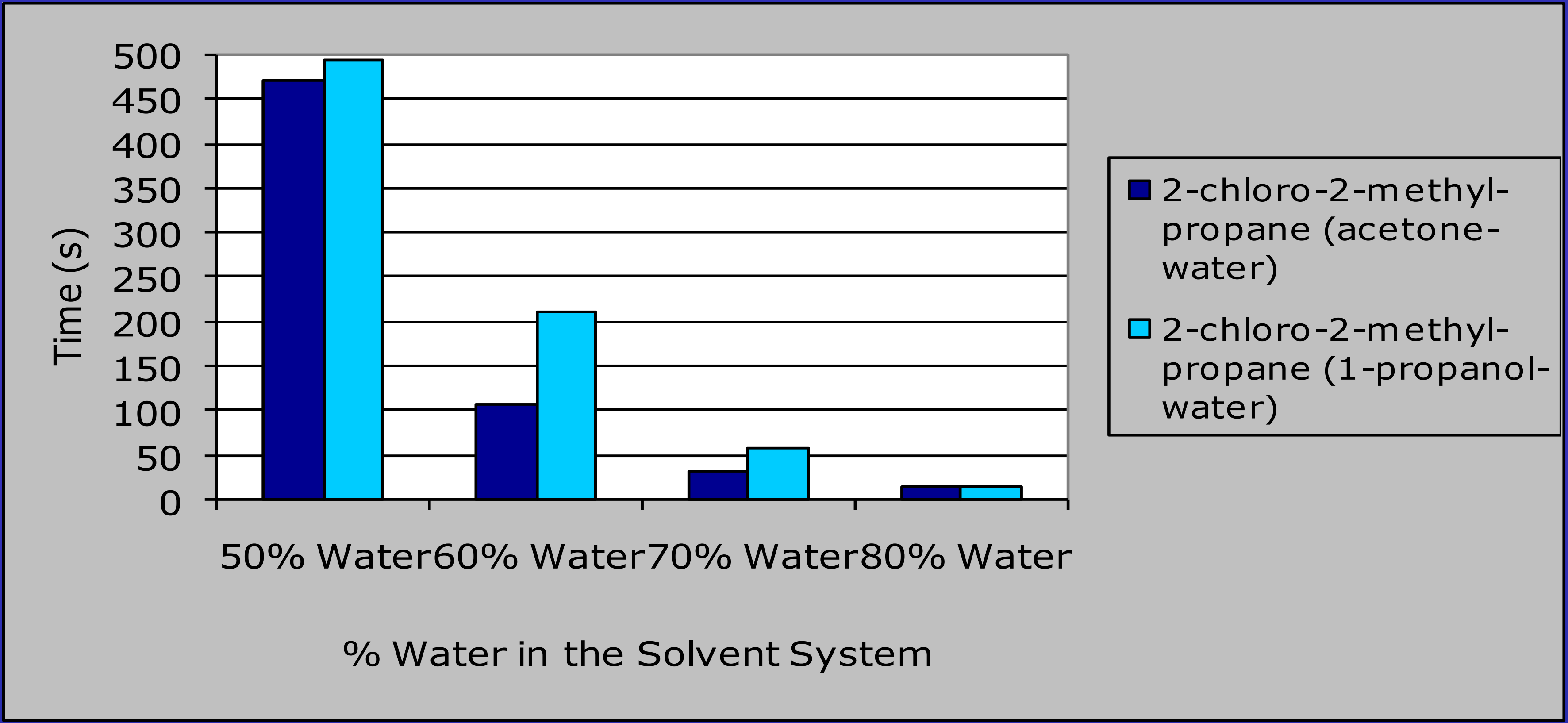


What Role Does Solvent Play In Nucleophilic Aliphatic Substitution Reactions?

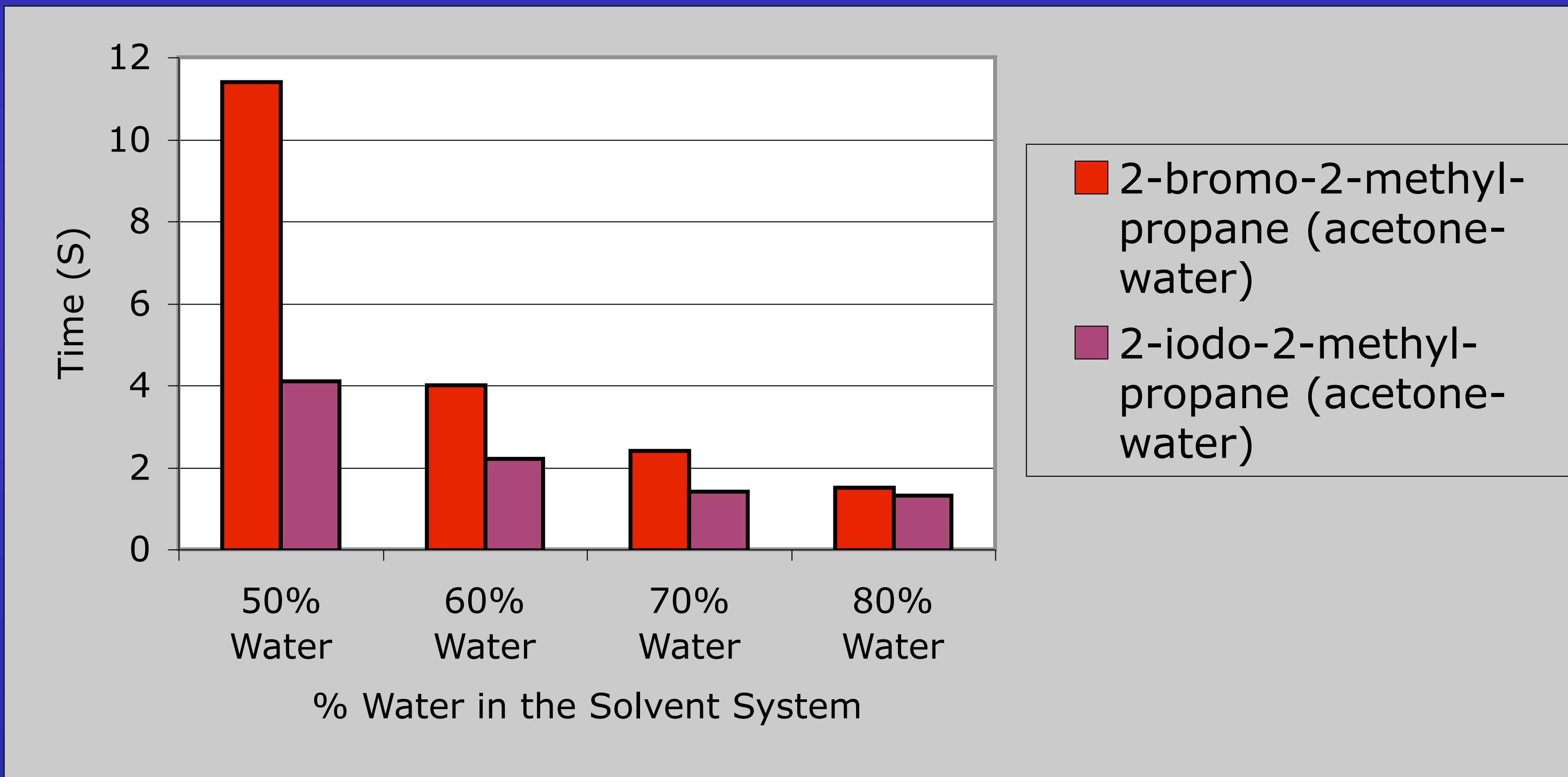
Activity 1

Typical results

Same Halide Leaving Group-Different Solvent System



Different Halide Leaving Groups- Same Solvent System



A Simple Learning Cycle

Exploration → Concept Invention → Application

Data collection
Discover patterns

Term introduction
Model

Apply model in
a new context

- Parallels the scientific method
- Ideas do not appear in your brain fully formed
- Being wrong is a stage on the way to being more right

Karplus and Thier, *A New Look at Elementary School Science,* Chicago:Rand McNally (1967). Piaget, J. *J. Res. Sci. Teach.* 1964, 2, 176; Lawson, Abraham, Renner (1989); *Inquiry and the NSES: A Guide for Teaching and Learning*. National Academy Press, Washington, DC (2000).

The Science Writing Heuristic

What is a heuristic? It is a tool, a problem-solving device.

Implementation of the Process of the Science Writing Heuristic in the laboratory work incorporates

- **collaborative inquiry activities**
- **cooperative negotiation of conceptual understanding**
- **individual writing and reflection**

Hand and Keys, **1999**; Rudd, Greenbowe, and Hand, 2001; Rudd, Greenbowe, Hand, and Legg, 2001; Omar, 2004; Hohenshell, 2004; Greenbowe and Hand, 2005; Burke, Hand, Poock, and Greenbowe, 2005; Poock, Burke, Greenbowe, Hand, 2007.

The Science Writing Heuristic

The SWH

Can be implemented universally at grade levels, including two-year community colleges and four-year colleges and universities.

Has been effectively incorporated into all types science curricula (including biology, chemistry, general science, geology, physical science, and physics), as well as pre-service teacher education programs.

Hand and Keys, **1999**; Rudd, Greenbowe, and Hand. 2001; Rudd, Greenbowe, Hand, and Legg, 2001; Greenbowe and Hand, 2005; Burke, Hand, Poock, and Greenbowe, 2005; Hohenshell, 2004

The Science Writing Heuristic

Critical Components of the Science Writing Heuristic

Creating a Successful Classroom Dynamic: Effective Instructor and Engaged Students

Writing Quality Laboratory Reports: Use the SWH Format

The SWH Format for a Practical Notebook

Standard Report Format	SWH Format
1. Title, purpose (aim)	1. Beginning questions—What are my questions?
2. Outline procedure	2. Tests & Safety-What will I do? How will I stay safe?
3. Data and observations	3. Observations—What can I see?
4. Balanced equations, calculations, graphs (Prediction and Hypothesis)	4. Claims—What can I claim?
5. Results	5. Evidence—How do I know? Why am I making these claims?
6. Discussion	6. How do my ideas compare with others' ideas (peers, text, instructor, Internet)?
	7. How have my ideas changed?

Components of the SWH Approach

Pre-laboratory: Students

- Pose their own beginning question to explore
- Summarize safety concerns
- Propose their own experimental procedure

Components of the SWH Approach

Collaborative inquiry laboratory activities: Students

- Organize their own work groups
- Decide how to divide the work among groups
- Draft appropriate data collection tables on the chalkboard

Components of the SWH Approach

Pooling and analyzing data: Students

- Enter data into pre-drafted tables on the chalkboard
- Conduct small-group and large-group analysis
- Prepare any graphs as needed and interpret them
- Examine the data to note trends or anomalies

Grading Rubric

Grading based on 30-point seven-category rubric (modifiable)

Takes the same amount of time or less using SWH rubric as traditional approach

Section of Report	# Points
Beginning Question(s)	2
Safety Considerations	2
Procedure and Tests	2
Data, Observations, Calculations, and Graphs	6
Claim(s)	2
Evidence and Analysis	6
Reading, Reflection, and Post-Laboratory Questions	10
Total	30

A Student-Centered Laboratory Environment

Effective Teacher Implementation	*Student Engagement*
Creates student-centered learning environment	Propose beginning questions, explore safety concerns
Prepares collaborative inquiry lab materials and strategies	Make observations & record data on the chalkboard, computer
Guides experimental process	Analyze data & discuss as group
Frames discussions	Propose claims
	Provide supporting evidence
	Summarize with reflective writing

Hand and Keys, **1999**; Rudd, Greenbowe, and Hand. 2001; Rudd, Greenbowe, Hand, and Legg, 2001; Greenbowe and Hand, 2005; Burke, Hand, Poock, and Greenbowe, 2005.

The Process of the Science Writing Heuristic ...

Back Forward Stop Refresh Home AutoFill Print Mail

Address: http://avogadro.chem.iastate.edu/SWH/homepage.htm go

Live Home Page Apple Apple Support Apple Store .Mac Mac OS X

Favorites History Search Scrapbook Page Holder

Department of Chemistry
IOWA STATE UNIVERSITY
Science Writing Heuristic

- SWH Homepage
- Background
- View Laboratory Video Segments
- SWH Lab Report
- Instructor Role
- An Instructor's View
- Resources

The Process of the Science Writing Heuristic Homepage

This web site will help you to become familiar with the process of the Science Writing Heuristic, SWH, and will provide you with an opportunity to view it in action. These are real students and their instructor (a teaching assistant). The session was not scripted nor was any portion rehearsed. What you will see is a spontaneous interaction among the students with their instructor.

To watch the video segments, you will need the latest free version of RealPlayer. Follow this link to theRealMedia site and follow the installation instructions. If you already have RealPlayer and are having difficulty playing the video clips, try re-installing the latest software.

Some help with RealPlayer problems (particularly with Mac OSX) may be found at Northwestern University. For additional problems, contact your system administrator.

This web site is partially funded by the Hayden-McNeil Publishing Company. The Hayden-McNeil Publishing Company supports innovative educational projects that emphasize active student learning.

HAYDEN HM McNEIL

Internet zone

SWH Publications About Teaching College Chemistry

- Rudd, Greenbowe, Hand, & Legg. (2001). Using the science writing heuristic to move toward an inquiry-based laboratory curriculum: An example form physical equilibrium. *J. Chem. Ed.,* 78, 1680-1686.
- Rudd, Greenbowe, & Hand. (2001). Recrafting the general chemistry laboratory report. *J. Coll. Sci. Teach.,* 31, 230-234.
- Greenbowe & Hand. (2005). Introduction to the Science Writing Heuristic. In Cooper, Pienta, Greenbowe (Eds.) *Chemists' Guide to Effective Teaching Volume I (pp. 140-154).*
- Burke, Hand, Poock, & Greenbowe. (2005). Training chemistry teaching assistants to use the Science Writing Heuristic. *J. Coll. Sci. Teach.* 35, 36-41.
- Burke, Greenbowe, & Hand. (2006). Implementing the Science Writing Heuristic in the General Chemistry Laboratory. *J. Chem. Ed.* **83**(7), 1032-1038.
- Rudd, Greenbowe, & Hand. (2007). Using the Science Writing Heuristic to enhance student understanding of general equilibrium. *J. Chem. Ed.* **84**(12), 2007-20012
- Poock, Burke, Greenbowe, & Hand. 2007). Using the Science Writing Heuristic to Improve Students' Academic Performance. *J. Chem. Ed.* **84**(8), 1371-1379.

Marks by Instructor Ratings

TA Rating	N	Average	SD
ACS CAL (Pre)			
H	79	61.6	16.0
M	145	58.5	14.2
L	63	60.6	11.6
ACS Exam (Post)			
H	66	73.5*	13.4
M	118	66.8	16.5
L	54	64.8	19.6

Marks by Student Ratings

Student Rating	N	Average	SD
ACS CAL (Pre)			
H	64	62.8	15.9
M	145	58.7	13.5
L	78	59.4	13.8
ACS Exam (Post)			
H	57	74.8*	12.1
M	120	66.6	17.2
L	61	65.3	18.2

Result from the ACS General Chemistry Examination (Fall 2006)

	Pre-test	Post-test Final Exam	National Fall 2005	Chemistry TAs
N	634	648	3,458	42
Average	21.9 (31%)	49.8 (71%)	36.3 (52%)	50.7 (72%)
Standard Deviation	7.90	10.85	11.30	10.64
Median	21.0	52.0	35.0	51.5
Min.	3	17	10	21
Max.	51 (70)	69 (70)	67 (70)	65 (70)

Components of the SWH Approach

Points students ponder during their reflective writing:

1. If I made a prediction prior to the activity, what was it and was I correct? Why or why not?
2. Have I identified and explained sources of error and assumptions made during the experiment?
3. How have my ideas changed, what new questions do I have, or what new things do I have to think about?

Components of the SWH Approach

Points students ponder during their reflective writing:

4. How does this work tie into concepts ` about which I have learned in class?
5. To what can I refer in my text, my notes, some reading that I have done, or some real life application to make a connection with this laboratory work?

Discussion

- During the lab, sources of error may have come from contamination, not observing obvious reactions, other human errors, and the data table not being complete. Throughout the lab, my ideas changed as to what my unknown was when new evidence came in. In class we are learning about solutions, and this lab ties in very well with that.

- Claim: I believe the chemical composition of my substance is K_2CO_3.
- Evidence: I compared results of my unknown with the results of the class data table. I had the mostly the same results for the known substance. Only 5 of the reactions did not match my results, which could be due to error.
- Discussion: Since this lab ran long, I have no idea what my unknown really is. There's a good chance it is one of the known substances we worked with. When I first started the experiment I had no idea how all of this was going to tie together, but after awhile it became clear.

- My unknown is Na_2CO_3 because the tests for my unknown solution matched up very well with the tests for the known solution of Na_2CO_3.

- In this experiment we explored the identity of an unknown aqueous solution by comparing how it reacts to known solutions. We also used pH, flame tests, and electrical conductivity as tests. By doing some detective work and making comparisons it is possible to eliminate what your unknown solution is not.

- "After conducting this experiment, I believe my beginning question is poor. I would like to change it to: What is the balanced chemical equation of the compound formed and what is the percent yield of the reaction? This question is much more applicable to the lab. Before the lab I predicted the product would be ZnI_2. The results of our class varied greatly. We were all able to conclude the chemical equation but our own % yields were very different, they ranged from 243% to 58%. Other groups did not dry their product enough and the moisture added to their products final mass. This is why some results are so high."

"After finding the mass of the product, which we know was Cu from the observation, we calculated how many moles of Cu were in our product. Since we knew our limiting reactant was our unknown and the mole ratio was 1:1, we could then find the molar mass of the unknown and compare it to those on the periodic table. By this method, we found our unknown to be zinc. We backed up this evidence by comparing it to the reaction of Zn $+CuCl_{2,}$ which produced a copper (s) product and aqueous $ZnCl_2$. Also the appearance or our unknown metal was that of Zinc."

Visit the POGIL and SWH Web Sites

To learn more about POGIL
http://www.pogil.org

To learn more about the SWH

http://avogadro.chem.iastate.edu/SWH/homepage.htm

- Background about the SWH
- Video segments to view components of the SWH
- A typical laboratory report written in the SWH format
- Resources for

The SWH	Collaborative Learning
Inquiry	Write-to-Learn Strategies

Acknowledgements

Brian Hand, University of Iowa; Frank Creegan, Washington College; Rick Moog, Franklin and Marshall College

Kathy Burke, James Rudd, Jason Poock, K. A. Burke, Nihal J. Kaissieh, Jacob Schroeder, Han-Chin Liu, Rohini Vanchiswaran, David Cantonwine, Marge Legg, Tanya Gupta

- http://avogadro.chem.iastate.edu/SWH/homepage.htm

Funding: National Science Foundation DUE CCLI EMD 0088709; NSF DUE CCLI EMD Phase II 0618708; ISU Miller Faculty Fellowship

The views of the author of this presentation do not necessarily reflect the views of the NSF.