THE USE OF DRAMATIC DEMONSTRATIONS TO ENHANCE THE MOTIVATION AND LEARNING OF CHEMISTRY STUDENTS

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Abstract

As part of the Virginia Collaborative for Excellence in the Preparation of Teachers (VCEPT) project, a series of demonstrations was incorporated into *Chemistry 100: Man and Environment*, a science course taken by non-science majors including many prospective K-12 teachers. Dramatic chemical demonstrations were first presented to the undergraduate students by the instructor, and then they used demonstration activities to teach each other during the semester. Finally, these undergraduates presented to the K-6 students in the Norfolk Statue University (NSU) Summer Children's College. The perceptions of science by the undergraduates at the beginning and end of the course were assessed using a questionnaire. The responses of the K-6 students in the Children's College were assessed through informal interviews and audience response. The use of these demonstrations seemed to change the perception of science held by the undergraduate students. In addition, this limited assessment indicated that these demonstrations may have helped more of the undergraduates consider teaching as a career option.

Introduction

Many students have the impression that science and mathematics are boring, "dry," and difficult subjects. Often these views seem to arise from a feeling that science and math are "ivory tower" subjects very much removed from applications to the "real world." Unfortunately, many of these students had a distasteful experience with these subjects during their middle or high school educational experience. College science and mathematics courses are often taught by simply using a textbook and a series of lectures to cover the required material. Chemistry teachers are like any group of people—some tall, some short; some male, some female—and some more talented and dedicated than others. It takes a very dedicated and enthusiastic teacher to give the students meaningful and motivated exposure to chemistry teaching through a traditional lecture-based course. In fact, many university instructors/professors have never had any formal instruction on how to teach and their success as educators is understandably varied. Technology can help assist in instruction, but sometimes students get "caught up" in the technology itself rather than the concepts addressed by that technology [1,2].

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Methods

A section of *Chemistry 100: Man and Environment* (*CHM 100*), an introductory survey of chemistry for non-science majors (usually predominately freshman), was taught using a variety of in-class chemistry demonstrations. Initially, the instructor gave the demonstrations and closely linked them to the current topics in the accompanying lecture. During the middle of the course, each undergraduate was assigned a demonstration to explain and give to the class. Finally, the students in teams of three gave demonstrations to several classes of K-6 students in the NSU Summer Children's College. These were followed by discussions at a level appropriate to the age group. The choice of demonstrations were made by selecting from a list provided by the instructor. The undergraduate met with the instructor one week prior to the demonstration to prepare the solutions/equipment, discuss the safety implications, and present the demonstration to the instructor. The undergraduate was awarded a quiz grade for this activity, graded on safety and presentation. The list of available activities are outlined below:

Vacuum Pump Demonstrations
- expansion of balloon/marshmallow
- boiling of water at room temperature
- lack of sound in a vacuum

Molecular Properties
- conductivity
- "electric" pickle

Chemical Kinetics
- apparent "stopping of fan" with strobe
- surface area effects of permanganate/glycerol reaction

Acid/Base
- Universal indicator changes
- Acid Rain

Oxidation/Reduction
- electrolysis of water
- hydrogen peroxide/KI reaction
- burning of magnesium
- chemiluminescence

The Demonstrations

The demonstrations were evaluated for safety concerns prior to their choice for delivery. The safety of each activity was discussed thoroughly before each demonstration (by both the instructor and undergraduate students), and the implications of waste disposal and pollution were addressed at each level. Safety goggles were worn at all times and appropriate safety measures were taken. The details of these activities are well known in chemistry and can be easily found in press and on-line [3-5]. Specific examples of two of these demonstrations, "Chemiluminescence" and "Oxidation/Reduction Reaction," are given below.

Chemiluminescence — This demonstration involves the use of a salt solution containing a molecule known as luminol, that gives off a blue light when mixed with a dilute hydrogen peroxide solution. In a dark room, the solutions are mixed in a funnel which is attached to a length of clear tubing and the glowing mixture is circulated through a field of loops and coils by a pump. The light lasts for several minutes.

Prior to the demonstration, the undergraduate student discusses :

- the safety implications (proper handling of all chemicals even in "chemistry sets," safety goggles, etc.);
- chemistry in the "lightning" bug (bioluminescence, chemiluminescence).

After the demonstration, the undergraduate student discusses:

- how it is similar to the "light sticks" that are familiar;
- how the reaction did not go on forever and why;
- what to do with the final product, leading to a discussion of recycling, chemical waste, pollution, etc.

Oxidation/Reduction Reaction — This demonstration involves putting a small amount (about ½ teaspoon) of dishwashing detergent in a graduated cylinder, and (using gloves) adding about 30ml of concentrated hydrogen peroxide (caution: this can burn the skin). Upon the addition of about ½ teaspoon of dry potassium iodide, water and oxygen gas are liberated and the gas makes the detergent foam up and out of the graduated cylinder. Brown specks of iodine are also produced in the foam. The graduated cylinder is placed in a pan to facilitate clean-up.

Prior to the demonstration, the undergraduate student discusses:

- the safety implications of this demonstration and cautions the audience not to try any demonstrations without proper training and supervision;
- the use of a baseball — the demonstrator becomes the "baseball pitcher" and a volunteer as a "baseball catcher," as the demonstrator tosses the baseball to the catcher — to relate these familiar **terms** to "oxidation" and "reduction" with the baseball serving as the electron.

After the demonstration, the undergraduate student discusses:

- was there a reaction? if yes, how can you tell?
- how the iodide ion was converted to iodine and relates this to the iodine solution that is used to disinfect skin;
- how the reaction did not go on forever and why;
- how a battery is also an oxidation/reduction reaction with **an electron** being transferred (and why batteries do not last forever);
- what to do with the final product, etc.

Results

The *Chemistry 100* students' perceptions about science were evaluated with a pre- and post-course questionnaire (Appendix A). The data obtained from this questionnaire were compared to a *CHM 100* section taught by the same instructor without using these demonstrations. However, the "regular non-demonstration" [R] course was given during the fall semester and the "demonstration-based" [D] course was given during the previous summer semester. The results of the pre- and post-course questionnaires for both classes are given in Table 1.

Table 1

Average Responses to Pre- and Post-Course Questionnaire for *Chemistry 100*

		GROUP			
		Regular		**Demonstration**	
		Pre-	**Post-**	**Pre-**	**Post-**
1	"Chemistry is a boring, hard, and often 'dry' subject."	4.52	3.30	4.21	2.80
2	"My dislike of math makes science hard for me."	3.91	3.80	3.82	3.52
3	"I would consider teaching science or math as a career."	2.33	2.60	2.52	3.51
4	"It is hard to relate science to the 'real world.'"	4.02	3.66	3.76	2.48
5	"Boys are naturally better at science than girls."	1.80	1.80	1.82	1.86

(scale: 5=strongly agree, 4= agree, 3= neutral, 2= disagree, 1= strongly disagree)

The pre-course results for the demonstration based group [D] were similar to that for the "regular" non-demonstration based group [R], indicating that as far as the questionnaire could measure, both groups were initially composed of a similar population of students. The perceptions of chemistry appear to improve in both groups, but the demonstration-based group seemed to become more "excited" about chemistry, as evidenced by the response to question #1 (concerning how boring chemistry is) and question #4 (relating chemistry to the "real world"). Some of the undergraduates were very excited about the demonstrations, especially those given to the younger students in the NSU Children's College. These feelings may be expressed in the different post-course answers in the [R] and [D] groups to question #3, (re: considering teaching as a career). Question #5 (boys versus girls in science) was included as a non-related inquiry to assess the questionnaire. The comments collected from the K-6 students in the NSU Children's College after the demonstrations were overwhelmingly positive. Examples of these comments include: "Science is cool!"; " I want to be a scientist and play with stuff like that"; and simply, "Wow!" Several times the students spontaneously burst into applause after a demonstration.

The undergraduate students in the summer section [R] had higher grades than those in the section held during the academic year [D]; however, this is usually the case for this course at NSU. Based on the distribution of grades earned in these course sections, the use of demonstrations did not seem to have an effect on the ability of the students to understand

concepts in chemistry. However on the course evaluation in the [D] section, over one-quarter of the undergraduates commented that the course was more fun than they thought it would be and the demonstrations helped them stay focused. Example comments included: " I dreaded taking chemistry, but this course turned out to be sort of fun"; "I wish I had done this sort of thing in high school"; and, "Thanks for making the subject more interesting by including the demos." No such similar comments were given for the [R] section. Since the number of students in these sections was low (28 and 18 students in the [R] and [D] groups, respectively) and the differences in response to the questions relatively small, the results of this study can only be viewed as pilot data suggesting possible trends. Based on this *limited preliminary study*, demonstrations conducted by the instructor, as well as the student, should be considered for implementation in these courses and further studied as an integral part of the teaching strategy for science courses. Additionally, demonstrations should be evaluated for use in showing undergraduate students that teaching science can be an exciting, rewarding profession. ■

References

[1] A. Hobson," Combating Science Anxiety," *APS News*, **7**(9) (1998).

[2] J.A. Craven and J. Penick, "Preparing New Teachers to Teach Science: The Role of the Science Teacher Educator," *Electronic Journal of Science Education,* **6**(1) (2001).

[3] R. Schriener, B. Shakashiri, E. Scott, J. Bell, and M. Testen, *Chemical Demonstrations*, University of Wisconsin Press, Madison, WI, 1990.

[4] The Department of Chemistry, University College London Website, Internet: http://www.chem.ucl.ac.uk/demonstrations/

[5] *Science is Fun in the Lab of Shakhashiri*, University of Wisconsin-Madison, Internet: http://scifun.chem.wisc.edu/

APPENDIX A

Please express your feelings to the following questions using the scale at right. Circle your answers.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Chemistry is a boring, hard, and often "dry"subject	5	4	3	2	1
2. My dislike of math makes science hard for me	5	4	3	2	1
3. I would consider teaching science or math as a career	5	4	3	2	1
4. It is hard to relate science to the "real world"	5	4	3	2	1
5. Boys are naturally better at science than girls	5	4	3	2	1