## Organic Chemistry Education

My work in organic chemistry education has produced (1) hand-held devices to facilitate learning undergraduate organic and general chemistry [5-11], (2) evaluating established education protocols for undergraduate chemistry students and developing novel improvements [1-3,14], and (3) interesting ways to present research to the public [4,13]. Each of these is discussed below.

Organic chemistry is often described as a difficult discipline because there is such a large amount of information to be learned. There is a need to visualize organic reaction pathways and become familiar with the key steps in many reaction mechanisms. In order to facilitate pattern recognition and learning the reactions rather than memorizing them, we developed three teaching devices for undergraduate organic chemistry. Two were adopted by publishers for use in conjunction with organic chemistry texts [6]. The three teaching devices for undergraduate organic chemistry are: (1) the Nucleophile / Electrophile (Nu/E) Reaction Guide for the reaction of electrophiles with nucleophiles [5,6,9-11], available commercially, [5,6] (2) the Electrophilic Aromatic Substitution (EAS) Tool for learning products, reagent generation, substituent effects, and mechanisms in electrophilic aromatic substitution [7,8,12], and (3) Reaction Site Selection in Carbonyl Compounds device (Carbonyl Site Selector) with three techniques, and the rationales, for predicting the site of attack by a nucleophile or base. We have studied the effect of each of these three devices on student test performance. We found that the Nu/E Guide improved the pertinent test question performance of students using the device outside of class by 20.1% over those students who did not use the device at all, by 9.1% over those students who used the device only in class and by 8.1% over those students who used the device both inside and outside of class. We surveyed students further and gathered information which led to the conclusion that students using the device inside class were distracted from explanations and discussion being presented, which reduced learning. The EAS Tool produced analogous improvements of 17.3%, 4.4%, and 3.8% respectively. Results for the Carbonyl Site Selector are being calculated.

The large size of the undergraduate organic chemistry lecture classes was of concern. This was exacerbated by lack of teaching assistants, who had passed University English exams and were therefore able to have contact with students. Some semesters, a TA was provided who could have no contact with students, but poor English rendered them unable to do more than wash transparencies and draw figures for presentation in class. Consequently exams were multiple choice and computer graded. The question how other regional universities were staffing these courses, prompted surveying organic chemistry professors in Big 12 schools and publishing the results.[14] One school other than ours did not provide lecture TAs who could have contact with students; that school was a private school with much smaller organic class sizes.

One research project, undertaken to increase the appeal of science to the public and in particular to middle and high school students, was recently selected as the subject of a permanent exhibit in the Oklahoma Science Museum (formerly Oklahoma City Air and Space Museum) [13]. (At the time, there were only four privately funded such air and space museums in the US, one being in the Smithsonian, which also considered making our project part of its Life Sciences exhibit, but eliminated it in the final cut.) We analyzed precipitates formed in a series of reactions carried out aboard the "Getaway Special" in a project designed specifically to inspire Oklahoma high school students' interest in science. The project description, the experiment materials, and the equipment, such as the space capsule holding the remotely-controlled reaction chambers, constitute an exhibit at the Oklahoma Science Museum. Appropriately, this space project which was conceived, sponsored, constructed, and analyzed all by Oklahomans will be displayed at the museum containing the contributions of many other Oklahomans. The exhibit has been seen by thousands of Oklahoma students each year; we hope that exposure to an experiment conceived, constructed, funded, and analyzed by other Oklahomans was carried out on board the Space Shuttle, will inspire future Oklahoma students into science as well. Dr. Nelson's part in this was (1) to conceive, design, and carry out sample analysis, (2) to prepare the text, samples, and analysis photos for the museum display, and (3) to have the research published in a refereed journal [4]. It was a challenge to provide an explanation of the project which a 10-year-old would find interesting, comprehensible, and inspirational.

**Publications / References**

14. Survey of Teaching Resources and Responsibilities of Organic Chemistry Professors at "Big 12" Research Universities. Brammer, Christopher N.; Hallman, Lauren; Nelson, Donna J. *Chemical Educator*. **2007**, *12*, 1-6.
13. Formation of Inorganic Precipitates in Microgravity on the Getaway Special STS-40. Frates, Rodman A.; Nelson, Donna J.; Friedrich, Craig; Rubowitz, Mark; Collins, Clay. Oklahoma Air and Space Museum **2000**, permanent exhibit.
12. An Organization Device for Visualizing Mechanisms and Regiochemistry Rationales in Electrophilic Aromatic Substitution. Nelson, Donna J. *Chemical Educator*. **2001**, 6, 142.
11. The Effect of the Nucleophile/Electrophile Reaction Guide on the Performance of Undergraduate Organic Chemistry Students. Nelson, Donna J. *Chemical Education Journal* **2001**, *4*,17.
10. Teaching Devices to Make Undergraduate Organic Chemistry Easier. Nelson, Donna J. *Proceedings of the Oklahoma Academy of Science*. **2000**, *80*, 71.
9. Teaching Devices to Make Undergraduate Organic Chemistry Easier. Nelson, Donna J. *Proceedings of the 26th National Triennial Convention of Iota Sigma Pi*; Iota Sigma Pi Promethium Chapter: Portland, OR, **1999**.
8. Gillham, O. Nelson: Professor develops, markets teaching aid. *The Norman Transcript*, May 5, **1998**, p. 1A.
7. Stills, S. "Slide rule" helps in teaching electrophilic aromatic substitution. From the ACS meeting. *Chemical & Engineering News* **1998**, April 13, p. 47.
6. Study Guide and Solutions Manual to Accompany Organic Chemistry, Second Edition. Marye Anne Fox, James K. Whitesell, and Donna J. Nelson; Jones and Bartlett Publishers, Inc.: Sudbury, MA, **1997**.
5. Nucleophile / Electrophile Reaction Guide for Organic Chemistry. Nelson, Donna J.; Jones and Bartlett Publishers, Inc.: Sudbury, MA, **1997**.
4. Formation of Inorganic Precipitates in Microgravity on the STS-40. Frates, Rodman A.; Nelson, Donna J.; Friedrich, Craig; Rubowitz, Mark; Collins, Clay. *Proceedings of the Oklahoma Academy of Science*. **1996**, *76*, 75-82.
3. Creativity and Science. Nelson, Donna J. *Creativity in Action*. **1992**, *215*, 5.
2. A Rule Based Expert System for Gas Chromatograph Troubleshooting. Nelson, Donna J. *Proceedings of the First Oklahoma Symposium on Artificial Intelligence* **1988**, 103-110.
1. A Safe Convenient Method of Generating Bromine for Qualitative Analysis. Do, Thuy H.; Smiley, Kimberly Y.; Nelson, Donna J. *J. Chem. Ed.* **1987**, *64*, 368.

**Presentations**

11. Issues in Teaching Organic Chemistry. McGraw-Hill Organic Chemistry Symposium, Austin, TX. Sep 24, 2004.
10. A Device to Make Balancing Simple Equations Easier. Nelson, Donna J.; Brammer, Christopher N. 220th ACS National Meeting, Washington, DC. **CHED 31**, Aug. 20, 2000.
9. A Device to Make Balancing Simple Equations Easier. Nelson, Donna J.; Brammer, Christopher N. 45th Annual ACS Oklahoma Pentasectional Meeting, Stillwater, OK. **Poster 11**, Apr. 15, 2000.
8. Developing, Testing, and Marketing Devices which Facilitate Learning Organic Chemistry. Nelson, Donna J. State Regents Economic Development Day, Norman, OK. **Paper No. 28**, Nov. 12, 1999.
7. Teaching Devices to Make Undergraduate Organic Chemistry Easy. Nelson, Donna J. 26th National Triennial Convention of Iota Sigma Pi, Portland, OR. **Scientific Paper No. 14**, June 24, 1999.
6. Device to Clarify Reaction Site Selection by Nucleophiles and Bases in Carbonyl Compounds.

Nelson, Donna J. 216th ACS National Meeting, Boston, MA. **ORGN 212**, Aug. 23, 1998.

5. A Device for Visualizing the Mechanism and Regiochemistry Rationales in Electrophilic Aromatic Substitution. Nelson, Donna J. 215th ACS National Meeting, Dallas, TX. **ORGN 126**, Mar. 29, 1998.
4. A Device for Demonstrating the Basic Patterns of Reactivity of Nucleophiles and Electrophiles in Organic Chemistry. Nelson, Donna J.; Ashley, Derrick; Patel, Rina. 40th ACS Oklahoma Pentasectional Meeting, Norman, OK. **No. 40**, Apr. 29, 1995.
3. Analysis of Inorganic Chemical Precipitates Formed Aboard the Columbia on the STS-40. Frates, R. A.; Nelson, Donna J.; Friedrich, C.; Rubowitz, M.; Collins, C. 40th ACS Oklahoma Pentasectional Meeting, Norman, OK. **No. 39**, Apr. 29, 1995.
2. Analysis of Inorganic Chemical Precipitates Formed Aboard the Columbia on the STS-40. Nelson, D. J.; Vitense, K. R.; Bench, T. 205th ACS National Meeting, Denver, CO. **CHED 156**, Mar. 29, 1993.
1. A Rule Based Expert System of Gas Chromatograph Troubleshooting. Nelson, Donna J. First Oklahoma Symposium on Artificial Intelligence, Norman, OK. Nov. 2, 1987.