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Creation of an Introductory Forensic Science Grant for Non-Majors

2/07-5/08

Award amount: \$5000

1. The original goals and objectives were to create a course for non-science majors focused on forensic science in which forensic techniques were used as the vehicle for the introduction of scientific concepts. The focus was to be on those related to chemistry: spectroscopy, chemical reactions, and chromatography, but the course also included topics from biology, like DNA analysis, and anthropology, such as forensic anthropology and determining sex from bones. The second goal was to involve students in an examination of the quality of the data, asking what level of “accuracy” was necessary to convict. The final goal was to deliver the course in a studio format, in which the laboratory portion of the course occurred primarily during the lecture period, although there were also two Saturday morning experiments in the chemistry laboratory.
2. The only change in the goals was that instead of inviting a guest lecturer from biology to talk about DNA, I did those lectures myself because I needed to make sure that I was knowledgeable about the material and so that I could present the material in a PowerPoint presentation that would serve as a partial textbook for the course, see below. I also sacrificed the visit to the forensic laboratory in favor of additional laboratory work. It was also difficult to organize a visit to the forensic lab for such a large class, 30 people, and because the Bexar County Crime lab was involved in an extensive accreditation process.
3. I have tabulated the experiments and the chemical/scientific principles covered to demonstrate the variety of chemical/scientific principles used to illustrate techniques of forensic science.

Experiment	Chemical/scientific principles
Measuring a gun with different types of rulers	Uncertainty in measurement and how this is conveyed to the reader
Analysis of inks by paper chromatography	Intermolecular forces, electronegativity, ionic and covalent bonds
Drug analysis by spot tests	Acids, bases and the relationship of acidity to structure, chelation (Fe^{3+} with the phenolic group in analgesics)
DNA analysis	DNA and heredity, structure, replication, types of DNA (nuclear, mitochondrial), biochemical techniques such as PCR and gel electrophoresis
TLC of drugs	Thin layer chromatography, use of two analytical methods on the same sample
Fiber analysis	Fourier-transform infrared spectroscopy, comparison of data to determine whether it is possible to determine an exact match or simply

	identify a class
Blood spatters	Use of trigonometry to determine angle of impact
Blood analysis	Use of luminol, reduced phenolphthalein, and Hematest tablets to identify a sample as blood, false positives
Arson analysis	Gas-chromatography/mass spectrometry, fragmentation patterns
Fingerprint analysis	Pattern recognition
Fingerprint development	Additional pattern recognition
Gunshot residue	Combustion, precipitation reactions

I was most pleased with the fiber analysis lab which was completely new. We have an attenuated total reflectance Fourier Transform Infrared spectrometer which is able to take solids and easily obtain their infrared spectrum. In the past, difficult sample preparation was required. I knew that IR spectroscopy had been used for the analysis of fibers but that it was frequently unsatisfactory because of the difficulty of sample preparation. I thought that this technique might be appropriate. However, rather than develop the experiment myself to confirm that it worked, I provided the 7 student groups with sets of known fibers (silk, nylon, acetate, cotton, polyester, and polyester/cotton) from a number of different fabrics and asked them to obtain the spectra and then to decide whether they could identify specific fibers by this technique or whether they could just determine the type of fiber. Then they were given an unknown fiber and asked to identify its type. Because it was a “real” experiment, in which the answer wasn’t known, the students really became involved in the laboratory. (And this was on a Saturday morning at 8:30 AM). The DNA analysis, another Saturday experiment, was a favorite. Using a BIO-RAD kit, the students mixed samples from 4 “suspects” and the “Crime Scene” and amplified the DNA using polymerase chain reaction (PCR). The samples were then loaded on a gel that the students had helped to make and separated by electrophoresis. Again, the students were really interested in the lab and captivated by the fact that they were working with DNA.

The second goal was to have the students deal with data and the issues associated with the analysis of data. We did this in two ways. Most of the experiments had an unknown component (a ransom note written with one of the pens used in the ink chromatography, an unknown analgesic in the drug analysis labs, four samples that contained blood or fake blood for the blood analysis lab) which required the students to begin to understand how a scientist draws conclusions from data. In all cases, there were at least 6 data sets so that at most two teams of students might have the same unknown, so the students couldn’t use the data of neighboring teams to identify their own unknown, so they learned how to work properly in a lab. My favorite experiment asked them to determine the best method of visualizing a fingerprint and then to apply that method to a fingerprint of one of their group. The second way that I approached this topic was to have several class discussions on topics in forensic chemistry such as whether fingerprints have the necessary scientific validity to be introduced in court, and how does the search for “truth” in science differ from the search for “truth” in legal proceedings.

The second activity to associated with this goal involved a research paper on some aspect of forensic science, with an emphasis on a critical evaluation of the

forensic data. There were papers on forensic anthropology, entomology, ethical issues associated with a DNA database, an examination of the books and film "In Cold Blood" and its effect on the actual trial, art forgeries, counterfeit currency, the detection of banned drugs in athletes (by a soccer player), etc. The papers were varied and reflected each student's interests and were almost universally very good to excellent.

The final goal was to do a substantial amount of lab work within a 75 minute class period. This required that I make sure that everything necessary for the lab be in place before the class began. In a normal lab, it is possible to go to the stockroom for a missing solution, or more filter paper, etc., but there simply wasn't enough time to do that. One experiment, the analysis of drugs by spot tests, was too long, but if the samples of analgesics are ground up ahead of time, the experiment will be the correct length.

4. Three evaluation/assessment processes were used. The first was a mid-term questionnaire that asked whether they felt that the amount of chemistry covered was appropriate, asked whether the method of providing background for the chemistry (PowerPoint presentations and sample problems) was sufficient, whether they liked the textbook, whether Saturday labs should start later than 8 AM, and to describe what they liked and disliked about the course. They universally felt that there was too much material on the mid-term exam and they would have liked two exams. They were split on the question of background material and I have identified a chemistry review book that appears to provide appropriate background at a reasonable cost. They felt that the textbook was too expensive. And, they wanted the Saturday labs to start a little later, like 8:30, but they liked having them in the morning. The second assessment process had them write a summary of an episode of CSI on the first day of class. They then watched the same episode on the last day of class and wrote a critical summary. The summaries were much more thoughtful about the evidence, the lack of controls in the spectroscopic analysis, and in the way that crime scenes are handled. Of value to me was also the recognition in many of the summaries of the amount that the students had learned in the class. They tended to be more skeptical about the conclusions from the data. In the episode we watched one of the protagonists said "Evidence is truth" and the students felt that "truth" in forensic science was more nuanced than portrayed in CSI. Finally, the course evaluation document used at Trinity University was used. The numerical scores on all of the questions were very positive. On the statement, "This course stimulates creative or critical thinking" 59% of the students strongly agreed, and 33 % agreed. Ninety-seven percent agreed or strongly agreed with the statement, "I am learning a great deal in this course." The written comments that were most informative about the course (as opposed to the professor) were: "Great class, interesting, good for Pre-law. This was a great way to fulfill my CC (common curriculum science requirement)"; "Thoroughly enjoyed the class. I had high expectations and it exceeded them."; "I learned a lot. I feel confident about Forensics- glad because I want to study law and this seems like a must"; "This class was great for assessing the validity of scientific data which is important no matter what major or career"; "Considering the range of scientific background in the class, I think we

- learned enough chemistry to critically assess techniques and data which will come up in our professional futures”; “I am able to analyze data more effectively now”.
5. Changes that I would make, and that are going to be implemented by Dr. Michelle Bushey when she teaches the course next fall while I am on leave, are:
Having two mid-term examinations. The amount of hard-core science on the midterm exam made the exam a very scary one for many students, so breaking it into two examinations would make the material easier to master.
Providing supplementary material on the chemistry content. As mentioned above, I wrote extensive PowerPoint lectures and made them available through Blackboard to provide background for the students. A supplementary text would be an improvement on this.
Providing homework assignments. Although the population was juniors and seniors, who should be savvy about how to succeed in college, they didn't work on the material if it wasn't due.
Cleaning up the language in some of the handouts. When I wrote the handouts, I was not clear enough in the directions.
 6. I have not yet shared the results. My intent is to put the syllabus and experiments on the web, but I need to check with my co-authors for their permission. (I modified some experiments developed by a faculty member at Pima Community College. I had his permission to use the experiments, with his attribution, but I need to confirm that he is willing to have them go up on the web. If that is a problem, I will give an outline of the course on the web and will then offer to discuss the course and provide materials to faculty who are interested. I will also explore presenting the course material at an upcoming American Chemical Society national meeting.
 7. Dr. Michelle Bushey is offering the course next semester because the level of interest in the course was so high. I had 85 people on my waiting list, for a course that can hold only 30 because that is the size of our largest lab, and this was before the course had ever been taught. Dr. Bushey had 105 people on her waiting list. So, it appears that the course is meeting an important need. By having Dr. Bushey teach the course next semester, we are demonstrating a departmental commitment to the course, rather than having it be the “baby” of a specific faculty member. In addition, because she is teaching the course and I will be on sabbatical leave in Oregon, I have a great incentive to make sure that the materials are as clean as possible. Finally, having her teach the course will expose any additional flaws in the course so that we can continue to improve it.
 8. A complete financial statement, showing original budget (the breakdown of the amount awarded) and expenditures.

I give ACS permission to post my original proposal and the results of my work on the ACS Science Reform website.