Teaching Cell Biology to Nonscience Majors Through Forensics, or How to Design a Killer Course

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Nonscience majors often do not respond to traditional lecture-only biology courses. However, these students still need exposure to basic biological concepts. To accomplish this goal, forensic science was paired with compatible cell biology subjects. Several topics such as human development and molecular biology were found to fulfill this purpose. Another goal was to maximize the hands-on experience of the nonscience major students. This objective was fulfilled by specific activities such as fingerprinting and DNA typing. One particularly effective teaching tool was a mock murder mystery complete with a Grand Jury trial. Another objective was to improve students' attitudes toward science. This was successful in that students felt more confident in their own scientific abilities after taking the course. In pre/post tests, students answered four questions about their ability to conduct science. All four statements showed a positive shift after the course (p values ranging from .001 to .036, $df = 23$; $n = 24$). The emphasis on experiential pedagogy was also shown to increase critical thinking skills. In pre/post testing, students in this course significantly increased their performance on critical thinking assessment tests from 33.3% correct to 45.3% ($p = .008$, $df = 4$; $n = 24$).

Keywords: nonscience majors forensics

INTRODUCTION

Designing successful science courses for nonscience majors can be a challenge. For example, nonscience majors often have negative attitudes toward science (French and Russell, 2001). Experiential learning has been shown to overcome this obstacle (French and Russell, 2001). However, it can be problematic to design hands-on exercises that are readily done by nonscience majors yet are sophisticated enough to sustain inquiry-based learning and enhance critical thinking. I wished to design a course that would address these challenges and would incorporate cell biology. To that end, I developed a forensic science course that incorporated these three goals: enhance critical thinking, improve attitudes toward science, and introduce cellular biology concepts.

To accomplish these objectives, forensic science has many advantages. For example, it readily lends itself to interactive pedagogies such as inquiry-based learning, cooperative learning, and problem-based learning, all of which enhance critical thinking (Lawson *et al.*, 1990; Tolman, 1999; National Research Council, 2000; Cruickshank and Olander, 2002; Russell and French, 2002; Wright and Boggs, 2002; *Forensic Science in the News*, 2003; Tanner *et al.*, 2003). Forensics is also an umbrella under which almost any scientific subject can be

taught (Reddy, 2003; Zeno, 2003). Finally, students, including nonscience majors, learn more when the topic interests them (Project Kaleidoscope, 2001). Forensics fits this very well because it has an enduring appeal that predates the current frenzy of popular television shows and will likely outlive them.

Recently, forensics courses have spilled out across the academic landscape (*Forensic Science in the News*, 2003). The course described here is different because the forensic science is paired with cell biology topics such as human development, enzymology, and molecular biology.

MATERIALS AND METHODS

Forensics Laboratory Supplies and Text

Because of forensics' popularity, educational supply companies have created several forensic kits and materials (Carolina Biological, 2003; Wards, 2003). These kits are appropriate for middle school through college and I have used them successfully for nonscience majors at the college level. The kits I use cost under \$100 for a class of 30 students. For example, the blood typing kit is currently \$35.90, the one for fiber analysis is \$48, and the blood detection kit is \$30 (Carolina Biological, 2003). The kit for hair analysis, both species hair and human hair, is \$77.50 (Wards, 2003).

In some cases, I purchase individual reagents or use commonly available supplies rather than kits. For the DNA polymerase chain reaction (PCR) exercise, primers are purchased from Carolina Biological (2003) for a current price of \$21.50. These are used with PCR reagents

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already available in the lab. (Note: An Alu PCR kit with all supplies is available for \$149.) The pen ink chromatography uses Whatman No. 1 paper with solvents ethanol, acetone, and 50% methanol. The sample pens were purchased from an office supply store. This store was also where I purchased blood spatter materials—large rolls of white paper, red tempura paint, tape measures, calculators, and protractors.

Professional forensic supply companies are also excellent sources of material (Arrowhead Forensic Products, 2003). The paraphernalia they sell is designed for frontline law enforcement officers who may not have scientific backgrounds. Thus the protocols can be performed by laypersons such as general college students. One example is fingerprint pads. These pads cost about \$6 at this time.

No matter where the materials are purchased, I use my own instructions. This is especially true for kit instructions that direct students step-by-step through the exercise, from arranging supplies, to providing tables for data analysis, and even to interpreting results. My handouts simply summarize the experimental protocols, leaving the students responsible for arranging the experiment, organizing the data, conducting the analyses, and coming to their own conclusions.

As for a textbook, no single source covered the material I wanted to present. One text, *Criminalistics: An Introduction to Forensic Science* (Saferstein, 1997) was considered. The book is readable and presents interesting case studies. However, the text is designed for criminalistics majors and is far more detailed than is warranted for this course. Thus, I rely on lecture notes and handouts to provide basic cell biology information and to cover the laboratory aspects of the course.

Semester Schedule and Class Period Design

The course described here is worth three credits and meets once a week for 2.75 hours. In the past 3 years, I have taught five sections of forensics, with 24 students per section. In contrast, a typical nonmajors biology course at Marist is lecture-only and meets for two 1.25-hour sessions. This type of core science course has been taught dozens of times in the last 3 years by a combination of full-time professors and adjuncts. Neither forensics nor the typical nonmajors biology course has a built-in lab component. Scheduling forensics as a block class, however, allows for a laboratory to be incorporated into the lecture structure.

In forensics, the 15-week semester is divided into two parts. In the first two-thirds, the class period starts with a 45-minute lecture on a relevant cell biology topic (see Results and Discussion). The remaining class time is spent performing laboratory exercises to identify unknown specimens. Throughout the semester, students work in teams of four.

Sample Forensic Laboratory Exercises

The hands-on portion of the class period is run like a typical biology lab. First, there is a prelab session where I give instructions about the protocols, after which the students begin their lab exercise. Some examples of these laboratories follow.

Two laboratories are on forensic hair analyses. The first compares the cuticle or scale patterns from different species. To visualize the scale patterns, a mold or impression is made using nail polish. First, a thin layer of nail polish is painted onto a microscope slide. Then a single hair is gently placed in the wet polish. After the polish is almost totally dried, the hair is gently removed, leaving behind an impression of its cuticle. The second hair exercise is to compare human hairs from different people. For this test, simple wet mounts are made of each hair, which are then distinguished by such substructures as medullas (a dark stripe that runs down the middle of the hair shaft) and pigment granules. Both types of slides are examined using a compound light microscope (Figure 1).

Another exercise that students perform is the phenolphthalein test, which presumptively tests for blood. Phenolphthalein, a clear dye, immediately turns pink if oxidized by hemoglobin and hydrogen peroxide. In the lab portion, with hands gloved in latex, students are given three swatches—one with dried aseptic blood, one with a

red pigment, and one with an unknown substance. Students rub an ethanol-soaked cotton swab on each stain. The swab is then doused in phenolphthalein and hydrogen peroxide. If the swab immediately turns pink, then the stain is blood; otherwise the stain is scored as a pigment.

For fingerprinting, students first take their own prints by pressing their fingers on ink pads and rolling them onto criminal fingerprint cards. They categorize their prints into one of three standard fingerprint patterns—whorls, loops, and arches. The students then calculate the Primary Fingerprint Classification, which turns the number and location of whorls into a single fraction. This shows how fingerprint patterns can be turned into numerical data. Next students try their hand at lifting latent or invisible prints. They put a fingerprint on a glass slide or beaker and dust it lightly with black fingerprint powder. They smooth lift tape over the print, then transfer it to a print card. This part of the laboratory can be very messy, and paper towels are highly advised. Finally, students are given an unknown visible fingerprint from one of the group's fingers. (A visible print made with a fingerprint pad is used instead of a latent print because most students often do not master lifting prints sufficiently to use them as the unknown.) The students then compare the unknown print to the fingerprint cards to identify it. The last part of the task is to construct a nine-point match between the two prints. Point matches are minute similarities such as bifurcations (one ridge splits into two), short ridges, and ridge endings (Figure 1).

The last example is the PCR exercise we do in conjunction with DNA typing. In this assignment, students isolate their cheek cells using a saline mouthwash. These cells are then collected by centrifugation. The pellet is resuspended in 10% Chelex and boiled. The resultant supernatant is a crude DNA extract. This sample is then subjected to PCR using primers that test for an Alu insertion into a tissue plasminogen activator intron. The PCR product is then electrophoresed and the products compared. Students will have one of three combinations of the 100-base pair allele and the 400-base pair allele. Students then calculate the frequency of their own genotype based on the individual allele frequencies. Before the lab begins, a sample of one student's DNA is taken as the unknown. The analysis of these results is often a little tricky since the chances are high that two students will have the same genotype. Here the students learn to appreciate the practice of including and excluding suspects in the absence of an unambiguous result.

Class Project—Analysis of a Mock Murder

During the last third of the semester, the students apply their newfound skills to solve a mock murder. During week 1 of this project, the students face a simulated murder scene complete with fake victim and suspects. (The victims and suspects are volunteer administrators and faculty.) Students secure the scene, photograph it, interrogate suspects, collect known samples, and gather evidence from the crime scene (Figure 2). During weeks 1 and 2, the class is organized into six groups of four, with each group designated "experts" in one or two areas of analysis such as serology and fingerprinting. During week 3, students assemble their exhibits into Microsoft PowerPoint slides (Figure 1). During week 4, any remaining analyses and exhibits are finished and all the information is combined into one class presentation. When time permits, practice run-throughs are conducted. The actual presentation is given during the final exam period.

Student Assessment

Final grades are based on three parts. The first instrument is a set of two exams that ask for factual recall of cell biology and forensics and demonstration of problem-solving skills such as interpretations of results. These exams are 50% of the students' final grades.

The hands-on portion of the weekly sessions is worth 35% of the students' grades. Each week, the students are assessed on their general participation, how well they perform their lab exercises, and analyses of their unknowns, including a summary of their answer and

Figure 1. Sample exhibits from The Science of Forensic class at Marist College. (A) Scale cast analysis of hair to determine species. (B) Wet mounts of human hairs. (C) Fingerprint comparison. (D) Electrophoresis of simulated PCR fragments. (E) Presumptive testing of blood left at mock crime scene. (F) Blood spatter analysis.

reasoning. This 35% also includes two private presentations where students give "expert testimony" that reports their finding, briefly describes their methods, and then explicitly explains how the results support their conclusion. The students can bring only two items to the presentation—exhibits of their data and notes. The notes are graded on completeness and appropriateness of information. The exhibits

are graded on features including how easy the data are to follow, how effectively the data are organized, and how professional the exhibit looks. Essentially, the exhibits are analogous to figures from a journal-style research paper.

The last 15% of the grade is based on the final presentation, which is identical to the process built over the semester. For example,

Figure 2. Students in The Science of Forensics class. (A) Fiber analysis by burn test. (B) Recreating blood spatter patterns using red paint. (C) Blood typing. (D) Latent fingerprint analysis.

students are graded on their lab work, their presentation, and their conclusions. However, there are some differences. In this instance, the students present as groups instead of individuals. All exhibits are presented as Microsoft PowerPoint slides. Most significantly, the students present to a mock Grand Jury made up of Marist professionals, community members, suspects, and even the miraculously revived victim. After the presentation, jurors vote Yes or No to indict the suspect named by the class. The Grand Jury also provides written and verbal feedback about the class performance. The grade for the mock murder project is determined by the instructor, with input from the jurors.

Course Assessment

Several sources were used to assess the forensics course. The first source was a pretest/posttest on attitudes toward science and criti-

cal thinking skills. This test was adapted from the Workshop Biology website (2003). My nonscience major course, *The Science of Forensics*, was compared to a more traditional nonscience major lecture course, *Topics of Biology*, which was also taught by a full-time biology faculty member. In both classes, the test was administered on the first and last day of the same semester. The tests were marked with identification numbers so that a student's pretest and posttest results could be compared. The results were matched and then the difference in the scores was tested using a one-tailed paired *t*-test. Any test with a *p*-value lower than .05 was considered significant.

The test began with 10 questions about scientific attitudes (Table 1). These questions were clustered into three areas—personal confidence about performing science (Questions 3, 5, 8, 10), science is like other disciplines (Questions 1, 4, 7), and science applies to everyone's life (Questions 2, 6, 9). The next test section consisted of five critical thinking questions that required no specific scientific information but

Table 1. Scientific attitude questions and pretest/posttest one-tailed, paired *t*-test results

Question	Proscience improvement, <i>p</i> value		
	Proscience answer	Hands-on forensics	Lecture-only biology
1. Science classes require very different skills than those needed in other classes.	Strongly disagree	.006	.288
2. People need to understand the nature of science because of its effect on their lives.	Strongly agree	.314	.394
3. Even if the class is interesting and the teacher tries to help, I don't learn science very quickly and often get discouraged.	Strongly disagree	.024	.385
4. Many people don't do well in science classes because science lacks creativity.	Strongly disagree	.213	.107
5. In general, I feel good about my ability to learn science.	Strongly agree	.001	.500
6. I resent having to take science instead of something more useful.	Strongly disagree	.412	.067
7. People who are good in science can be good in other areas as well.	Strongly agree	.154	.302
8. With enough effort, I can understand many unfamiliar scientific concepts.	Strongly agree	.036	.065
9. Scientific ways of thinking are applicable in many areas of life.	Strongly agree	.332	.314
10. Scientific work would be too hard for me.	Strongly disagree	.009	.085

Answers range from strongly agree (1) to strongly disagree (5). Attitude 1—personal confidence in performing science (Questions 3, 5, 8, 10). Attitude 2—science is like other disciplines (Questions 1, 4, 7). Attitude 3—science applies to everyday life (Question 2, 6, 9).

*Critical *p* value = .05. Forensics course, *df* = 23 and *n* = 24. Lecture-only biology class, *df* = 21 and *n* = 22.

relied on familiarity with the scientific process. A sample question can be found in Table 2.

Two additional sources were written comments from student evaluations and comments from the mock Grand Jury. Students were also asked general background questions such as year in school (Workshop Biology, 2003). Finally, my own observations were used.

RESULTS AND DISCUSSION

Major Objective Met—Cell Biology Is Incorporated into a Forensics Course

The first objective of this course was to link basic cell biology to applied forensics. One example is cell structure and function, which is taught as a prelude to hair analysis. Similar to what would be covered in a lecture-only biology class, the forensic cell structure lecture includes the names and functions of cellular organelles, cell shape, and cell structure proteins such as keratin. Students also learn how cells differ among tissues, individuals, and organisms. This basic ma-

terial is then linked to forensics. For example, students learn that forensic molecular biologists get excited over sheathed hair roots because these structures are rich in nuclear DNA. The students also learn about different types of microscopy that are common to both forensics and cell biology. In forensic laboratories, mammalian species can be differentiated by hair scale patterns using scanning electron microscopy. Similarly, human hairs can be matched using a comparison light compound microscope.

Enzymology, another cell biology topic, is covered in conjunction with blood detection. The basic science lesson focuses on enzymatic reactions including reactants, products, cofactors, and coenzymes. Students concentrate on oxidative/reductive or redox reactions and the difference between an enzyme (e.g., peroxidase) and an enzyme activity (e.g., oxidative activity of hemoglobin). This catalytic property of hemoglobin is used to relate enzymology to forensics since it forms the basis of the presumptive blood detection technique described in *Materials and Methods*.

With fingerprinting, I cover developmental biology, specifically fetal development and the interaction of environment and genetics. In the case of fingerprints, the pattern is controlled largely by genes. However, uterine movements also influence pattern development, which is why even monozygotic twins have different fingerprints. From these scientific concepts, the lecture turns to forensics including the history of fingerprinting and fingerprint identification patterns such as whorls, loops, and arches.

Because of the students' limited chemistry background, one of the most challenging topics is DNA typing. Because of this situation, DNA typing is divided into two lectures. The first covers the basics of DNA structure, replication, and structural features such as the double-helix, nucleotides, sugar-phosphate backbone, and base-pairing. Replication includes DNA polymerase, priming, and elongation. These basics are drawn on to understand the polymerase chain reaction, or PCR. In the second lecture, the forensic applications of molecular biology are taught. This lecture focuses on loci such

Table 2. Critical thinking sample question

Tom decided to investigate if the tips of germinating daisies bend in response to light by somehow sensing the direction of the light source. To test this, he covered the tips of several growing daisy plants with black tape and compared them to a group of plants with no tape on them.

In order for this setup to work, what is Tom assuming?

- The tape allows a small amount of light to reach the tips.
- The presence of tape does not prevent the plant from bending.
- Plants can bend toward a light source when their tips are not covered.
- The tip of the plant can sense the direction of a light source.
- As a scientist, Tom is making no assumptions.

Table 3. Selected basic science concepts paired to forensics techniques

Featured cell biology or other scientific topic	Forensic exercise
Solvent chemistry	Document analysis—chromatography
Cell structure & microscopy	Hair analysis
Chemistry of polymers	Fiber
Tissues & human development	Fingerprints
Physics of gravity	Blood spatter analysis
Enzymes, immune system	Blood detection, blood typing
Molecular biology	DNA typing

as VNTRs, STRs, and SNPs and detection techniques such as horizontal gel electrophoresis, capillary electrophoresis, and DNA microarrays. This basic cell biology technique is then connected to the hands-on lab where students perform PCR on themselves.

Table 3 lists the forensic topics with their matched scientific subjects, which are principally drawn from cell biology. This list is hardly comprehensive and many forensic topics can be used to explore other scientific disciplines (Reddy, 2003; Zeno, 2003). For example, blood spatter reconstruction requires geometry and physics.

Major Objective Met—Pretest/Posttest Establishes that the Forensic Science Course Improved Students' Self-Confidence About Science

In addition to adding a cell biology component, one objective of this course is to improve students' attitudes toward science. In the pretest/posttest, students in the forensics class showed significant improvement in their scientific self-confidence,

while the lecture-only class did not (Table 1; Questions 3, 5, 8, 10). An example of this is Question 3, "... I don't learn science very quickly and often get discouraged." Students were asked to agree or disagree with this statement on a scale of 1 to 5 (1 being strongly agreeing and 5 being strongly disagreeing). The average response for the forensics class went from 3.292 ± 1.197 in the pretest to 3.667 ± 1.007 in the posttest. This is a net attitude improvement of 0.375, which is statistically significant by the one-tailed paired *t*-test ($p = .024$, $df = 24$; Table 1). The topics class, however, did not show improvement. The average response in that course went from 3.227 ± 1.232 to 3.273 ± 1.077 , which represents a statistically insignificant improvement of 0.045 ($p = .385$, $df = 22$; Table 1). The other questions in this category showed similar results (Table 1; Questions 5, 8, 10).

I propose that this response was due to three factors. The first was that students took pleasure in the class. In their course evaluations (Table 4) and in personal comments to me, most students shared how much they really enjoyed the course. Another mark of their enthusiasm was the excellent attendance. In fact, students who were unable to attend class due to illness, etc., expressed great disappointment at missing the experience and were grateful for the makeup sessions arranged with my teaching assistant. Also, the positive energy in our class was palpable, as many passing faculty and administrators noted. I believe that the students' goodwill toward the class was translated into goodwill toward science. This phenomenon has been noted by others (Project Kaleidoscope, 2001)

The second factor that better disposed students toward science was the rigor of the course (Table 4; personal communications). Several students stated that this was the hardest class they had taken. They commented on the amount of time devoted to this class between projects and studying for exams. The inclusion of cell biology greatly enhanced this aspect.

Table 4. Selected responses from student evaluations and "Grand Jury" comments

A. Selected student comments to evaluation question, "What were the best things about this course? Explain."

- "I enjoyed the group labs and the final project. This was a fun, challenging way to fulfill my science requirement."
- "The lab sessions were a great way to learn all of the subject matter."
- "Class was interesting in every aspect, especially hands-on. Probably the best and most beneficial class that I've taken here."
- "Trying to solve the crime kept my attention and made it easier to retain information."
- "It was an interesting approach to teaching. It was very hands-on."
- "The mock murder. It was an incredible learning experience."
- "The lab—we were more involved than just being in lecture."
- "Hands-on labs. Group work. Crime scene project."
- "Bringing it altogether with the crime."
- "The labs were useful in order to put new knowledge into practice."

B. Selected Grand Jury comments on mock murder project

- Juror 1 (a science education instructor)
 - "Excellent overview of what blood spatter pattern can tell you. Outstanding interpretation of spatter patterns."
 - "Outstanding explanation of process for interpreting DNA. They really knew their stuff."
 - "This [grand jury presentation] was a *really awesome* way to ask students to apply their knowledge and skills."
- Juror 2 (local judge whose daughter was in the class)
 - "Their presentation was as professional as some I've seen on the stand." (personal communication)
- Juror 3 (chief college relations officer)
 - "Excellent documentation—obvious result!"
- Juror 4 (criminal justice professor)
 - "Great job! Outstanding."

Having to tackle concepts such as DNA structure and human development really ratcheted up the rigor of this course. By mastering complex material, the students became more confident in their own abilities.

The third factor for improving the scientific self-confidence of students was the interactive structure of the course (Table 4; course evaluations; personal communications). Indeed, 61.7% of the written course evaluation comments included positive remarks about the hands-on nature of the forensics class. Students indicated that they learn better by actually doing science. Every time these nonscience majors successfully carried out an experiment, their faith in their own scientific abilities increased. This sense of mastery is especially true for the mock murder, where students, working together, solved a large multitask problem on their own. Many others have seen this same response (National Research Council, 2000; Cruickshank and Olander, 2002; Tanner *et al.*, 2003).

In contrast to the gains in "scientific confidence," the two other attitudes showed no substantial change for either the forensics class or the lecture-only class. These two attitudes were "science applies to everyday life" (Table 1; Questions 2, 6, 9) and "science is similar to other disciplines" (Table 1, Questions 1, 4, 7). (Note: Question 1 did show a statistically significant change for the forensics class but the shift was a negligible $-.04$.) The failure to affect these two attitudes underscores the need for deliberate course planning. In this case, the forensic course did only what it was designed to do, that is, improve self-confidence. To change the other two attitudes, explicit exercises would need to be incorporated into the course. Similarly, the lecture-only course was designed around content only and showed no change in any of the attitude parameters.

Major Objective Met—Critical Thinking Scores Increase

The third objective of this course was to increase critical thinking skills. Again, the forensic class showed a statistically significant improvement on answering critical thinking questions, while the lecture-only biology course did not. In a one-tailed paired *t*-test, the forensics class rose significantly, from 33.3% correct to 45.3% ($p = .008$, $df = 4$; $n = 24$). The lecture class also increased from 36.5 to 39.4% correct, but this change was not significant ($p = .100$, $df = 4$; $n = 22$).

I believe the increase in critical thinking in the forensics class was because the format of the forensic class parallels the methods of science, as should all science courses (DeBurman, 2002). This course met the criterion even though forensics is primarily an applied science. Indeed, other instructors have used applied topics in a similar way such as exercise physiology (DiPasquale *et al.*, 2003), fly fishing (Ulanski, 2002), and emerging diseases (Fass, 2000). Like basic scientific research, the forensic course required students to perform controlled and experimental trials, keep good notes, examine the results, come to a logical conclusion, and report their findings.

Blood spatter is a good example of this approach. To begin, the students design control tests that show how blood behaves when spattered. The first experiment reveals how a blood drop's shape can reveal the angle of impact. (If the shape is like a teardrop, the direction of impact is from the larger end

to the smaller end.) By dropping blood from different heights, students determine that the elevation of a blood drop causes the spatter diameter to increase up to the point where terminal velocity is reached. By spattering blood at different velocities, the students discover that low-velocity impacts give larger rounder drops with little secondary spatter, medium velocity drops give medium-sized teardrop drops with some secondary spatter, and many small secondary drops are characteristic of high velocity. All of these relationships are determined by control experiments designed by the students and carefully documented in detailed notes.

In the experimental part of the exercise, students are given a mocked-up spatter from a crime scene and a suspect's story. By using information from their control experiments, the students have to apply analytical reasoning to determine if the story is false. Finally, they have to explain their reasoning in a written statement.

The mock murder added two more points of similarity to "real-life" science experiences. First, the final project is designed with a multiweek approach, which has been used successfully by Grant (1998). By conducting their project over several weeks, the students perform science as it is really done—they begin their analysis, go down wrong roads, correct their course, and, finally, produce a coherent project. The Grand Jury trial also provides a mock version of actual events, which is a technique used by Harwood *et al.* (2002). The mock trial makes the students take the assignment very seriously. It focuses their investigation and causes them to think out exhibits and develop ways to explain their science to the layperson. The widespread community involvement and feedback also contribute to the mock murder's success (Table 4; and footnote 1).

Strictly speaking, the lecture-only class is not a perfect control for the forensics course. The two classes, which were similar in all other parameters, differed in year-in-school. The forensics class was unavoidably mostly juniors and seniors, while the lecture-only class was mostly freshman and sophomores. Despite this difference, I believe suggestive information can be drawn for three reasons. First, the students in this study were compared against themselves in the pretests and posttests, not to each other. Second, the pretest attitude scores and the pretest critical thinking scores were similar between the classes (data not shown). Third, the number and type of previous science courses were similar between the two groups.

Transferability

The cell biology/forensics course described here has been successfully transferred to another setting. Through an articulation agreement with Marist College, this course has been taught for college credit for 2 years at Brewster High School (Kosloff, 2001). This means the students take the same class given at Marist but with a different instructor using the same syllabus and the same materials.

¹Media on BIOL240 The Science of Forensics (2000): one national article (*Chronicle of Higher Learning*, November 3, 2000); four local articles (*Poughkeepsie Journal*, September 20, December 20, and January 1, 2001; *Hyde Park Herald*, December 2000); three local television news shows (WRGB, September 20 and December 20, 2000; WRNN, September 20, 2000), and one regional radio program (WHUD, September 18, 2000).

Caveat to Mock Murders

Despite its obvious educational potential, mock murders are deemed inappropriate by some groups, who instead suggest more benign scenarios such as lost backpacks (Carton, 2001; Court TV Forensic Curriculum, 2003). Not everyone agrees (Palevitz, 2002). For one, the comments contraindicating mock murders were directed at high schools, not colleges. College students have sufficient judgment to tell the difference between real violence and fictional scenarios. Additionally, I carefully explain that our fake homicide is similar to whodunit games like *Clue* and must never be confused with actual violence. To further distance real homicide from our pseudomysteries, I make our scenarios as preposterous as possible such as a dean being done in by a professor who was made to teach all 8 AM classes.

Postscript

The format described for forensics can be applied to any non-science major science course. Perhaps the best indicator of this comes from the professor of the lecture-only course that was analyzed here. After seeing the success of the forensics course, my colleague developed a nonmajors course on exobiology that incorporates cell biology and hands-on activities. The topic appeals to nonmajors and it also taps into his own research program involving life in extreme climates. Based on their remarks to the professor, his students have responded positively to the change.

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