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FORENSIC UNIT: APPLICATION OF SCIENCE AND MATH IN THE JUNIOR YEAR

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Pamela M. Tejkl

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FORENSIC UNIT: APPLICATION OF SCIENCE AND MATH IN THE JUNIOR YEAR

By

Pamela M. Tejkl

THESIS

Submitted to
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in partial fulfillment of the requirements
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ASTRACT

FORENSIC UNIT: APPLICATION OF SCIENCE AND MATH
IN THE JUNIOR YEAR

By

Pamela M. Tejkl

In this thesis I have created two units which are based on forensic science. They are a thematic approach which includes, several sciences such as chemistry and biology, in addition to math and technology. Several strategies of problem solving, wait time and higher level questioning are also included. Everyday circumstances and actual forensic techniques are used. There are two units because there are two locations. One location takes place in a non traditional school environment, while the other is at a traditional high school. I saw improvement in both locations.

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INTRODUCTION

> Alarming numbers of young Americans are ill-equipped to work in, contribute to, profit from and enjoy our increasing technological society. Far too many emerge from the nation's elementary and secondary schools with an inadequate grounding in mathematics,science and technology. As a result, they lack sufficient knowledge to acquire the training skills and understanding that are needed today and will be even more critically needed in the 21st century (NRC, 83) .

As science educators, we must appropriately challenge our students. Our curriculum must develop the minds of our students and produce life long learners. Without a better understanding of science, mathematics, and technology, countless opportunities will be inaccessible for these students. We want our students to be well versed in each discipline; to become, what the majority of Americans are not, scientifically literate. Without a science-literate population, our future with a better world does not look promising. There will not be people able to address devastating global problems such as hunger and pollution. As a science teacher I want my students to be science literate.

> Scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economics productivity. Scientific literacy means that a person can ask, find or determine answers to questions derived from curiosity about everyday experiences (NRC, 96).

For individual, social, and work purposes, a scientifically literate student will understand the key concepts and principals of science and be able to use such skills as critical thinking, problem solving and analyzing and evaluating. The student also needs to be aware that science, mathematics, and technology

The student also needs to be aware that science, mathematics, and technology are interconnected. Most high school students have a difficult time making these connections, which may be a direct result of their poor attitude towards science in general and the traditional way in which these subjects are taught. As students they do not see how they will ever use science and they certainly do not see how it is used in everyday life problems and/or situations. A study conducted by the National Assessment of Educational Progress determined that "less than half of the seventh graders --and even fewer eleventh graders--perceived that science would help them to earn a living, be important to them in life or be used in many ways during adulthood" (Mullis, 88).

In order to make science genuine and to have significant value, students must participate in lab activities that mirror everyday life situations. These lab activities should incorporate and use the trio of science, math and technology. In addition, the students need to be interested and engaged in the topic. William Glasser, suggests, "The best way to teach ... is to relate what you are trying to teach to the real world. For example, all of us, including students, are interested in some of the news of the day. It is called news because we can relate it to our lives" (Glasser, 93).

These days the media is full of crimes and the accompanying investigations. The forensics science unit detailed in this document is a thematic approach to teaching and learning that engages the students from the beginning to the end of the unit.

Most people from all walks of life have an interest in and an opinion about current criminal investigation issues. Such issues range from the murders of Ron Goldman, Nicole Brown, and JonBenet Ramsey to the bombings in Oklahoma and at the 1996 Olympics, in Atlanta. The unit on forensic science, as outlined in this report, uses several procedures that are simulations of procedures used in forensic labs. Since forensics incorporates the fields of science, math, and technology, this unit also integrates the trio. Examples of lab exercises included in this unit are blood splattering analysis, hair and fiber analysis, fingerprint identification and chromatography for ink and lipstick evaluation. Forensics seems to pique the students' natural curiosity as displayed in their eagerness to bring information to me, after seeing topics related to forensic science on the news, in the paper, or even from another class. This high "outside" interest among my students reinforced my conclusions on how the students enjoyed and learned in this unit. It is because of this interest and the interconnections of science, math and technology that I chose to develop and evaluate a unit for my high school students (11th graders) on the scientific application with the basis in forensic science.

Students also require a safe and comfortable environment that emulates the "spirit" of science. This spirit can be defined as the process that encapsulates all of the following: curiosity, wonder, problem solving, and constant desire to look for answers. This classroom experience encourages students to wonder about the world around them and actively seek to understand it. It strengthens their sense of responsibility to learn, hence developing life long learners. According to John Goodlad, "most teaching, including science teaching, is dreadfully dull" (Goodlad, 91). The classroom needs to mirror the everyday-world practice of science. The teacher should be active, spend less time lecturing and more time engaging students in hands-on activities and asking open-ended questions. While "hands-on" activities are essential, they are not enough; students must also have "minds-on" experiences as well. Their minds can become engaged when the right questions are asked, whether in a discussion mode or in lab activities.

The units I have designed are based on forensics science adapted for high school students in two completely different settings. To keep things clear I will call them Unit A and Unit B. Unit A was taught in a specialized school (which will be explained later) in which the students worked in groups of four to solve a fictitious crime by completing experiments at five stations. These students used a period of two weeks, at two and half hours a day, to complete this work. Unit B is a modification of Unit A and was taught in nine weeks, for 50 minutes a day, in a traditional high school chemistry class. There was not one overall crime investigated, but several isolated ones studied.

During lectures, students often reduce passive participation to non-participation. When the lecture turns to discussion, these students can not be active participants, either, for they do not have enough prior knowledge. The forensic unit, however, immediately grabs and then holds the enthusiasm and attention of the vast majority of the students in both Unit A & B. The classroom topic and lab activities are paralleled in the media and this makes a real-life connection for them. Science becomes relevant.

The new teaching techniques that were incorporated into unit B were ones that I felt I needed to work on. These areas include Effective Questioning, Wait Time and Problem-Based Learning (PBL).

For questioning techniques, as a guide I used the article from Patricia E. Blosser on "<u>How to Ask the Right Questions.</u>" (Blosser, 91) I followed this cycle to improve my techniques:

1. Decide on one aspect of your questioning techniques (Managerial, Rhetorical, Closed or Open) that you want to improve.

2. Select a topic or activity that lends itself to the use of questions.
3. Plan key questions-and possible responses-to stimulate student thinking.
4. Teach the lesson, recording the lesson on audio tape.
5. Listen to 10-15 minute long sections of the tape, noting instances you used or could have used the technique.
6. Evaluate your success and plan a new lesson, emphasizing the same technique-or a different one.
7. Restart with number 1.

I also incorporated strategies in wait time. Wait time is the time the teacher gives the student or class to respond to the posed question before giving the answer or asking another question. When teachers ask questions of students, they typically wait one second or less for the students to start to reply. After the student stops speaking, they begin their reaction or proffer the next question in less than one second. If the teacher can increase the average length of the pauses at both points, after a question (wait time one) and, even more important, after a student response (wait time two) to three seconds or more, there are pronounced changes in student participation and student confidence. Mary Budd Rowe, (Rowe, 87) finds that wait time can really make a difference in the performance of her students. The results of her study indicate that:

1. The length of student responses increases between 300 percent and 700 percent, in some cases more, depending on the study.
2. More inferences are supported by evidence and logical argument.
3. The incidence of speculative thinking increases.

4. The number of questions asked by students increase as does the number of experiments they propose.
5. Student-student exchanges increase; teacher-centered "show-and-tell" behavior decreases.
6. Failures to respond decrease.
7. Disciplinary action decrease.
8. More students voluntarily participate in discussions.
9. Student confidence increases.
10. Achievement improves on written measures where the items are cognitively assessed.

In addition, I implemented some Problem Based Learning (PBL) activities. Donald R. Woods in Problem-based Learning: How to Gain the Most from PBL compares and contrast the basic difference between Subject Based Learning (SBL), which is basically lecturing, and PBL:

Subject Based Learning:

1. The students are told what we need to know.
2. The students learn the material presented.
3. The students are given a problem to illustrate.
4. The students are told how to use the problem.

Problem Based Learning:

1. The problem is posed for the students.
2. The students identify what we need to know.
3. The students learn the material.
4. The students apply the necessary information.

The premise of PBL is that a problem is posed that drives the learning. The students analyze the problem, define what information is pertinent to the solution of the problem, identify the new knowledge they need, learn the new knowledge and then apply it to solve the problem. Some of the needed information is obtained by investigating the problem, making observations, asking questions, testing and probing. Students determine what inquiries, observations or investigations need to be made. This learning process requires reflection, thought and deliberation and is also known as metacognition.

Some of the information needed to understand the problem or situation comes from the stored knowledge of the problem solver: the recalled facts, concepts, and prior experiences relevant to the problem. As the problem is being probed and examined through inquiry, new information is required and obtained. This new information often causes the perceived nature and extent of the problem to change, as there may be new ramifications and twists to the probe not anticipated at the outset. As before, these have to be pondered, deliberated and reflected upon. There are very few problems or situations in everyday life that present themselves with all the information that is needed to understand them well enough to make valid decisions about their causes and their resolution. More information is usually needed.

I had used problem-based learning situations a few times before in my teaching and wanted to incorporate them more completely within the forensics units A and B. Problem solving, in general, may involve the students in analyzing evidence, making quantitative considerations, presenting logical arguments, and determining unknowns. Minds that function scientifically can help people from every walk of life deal sensibly with problems. Without the ability to think critically and independently, our students as future citizens can fall prey to the practice of seeking simple solutions to complex problems. Our country and our world needs " scientific" minds, not minds that embraced the easiest solution to a complex problem.

My goal when designing these forensic units was to take all of the needs and suggestions mentioned earlier and incorporate them into Unit B. I designed both units A and B to promote learning science in favorable, applicable and yet ambitious fashion. It is for these reasons that I chose forensic science as the topic of my units.

Demographics and Educational Settings

I had the opportunity to teach for three years at a math and science center in Southern Michigan. There are twenty seven centers throughout the state of Michigan. Some of the centers have pull out programs, while others do not. They are designed to teach science and math through technology using instrumentation that many traditional high schools do not have. At the center in which I taught, It was a pull out program. Students came from fourteen schools in the region. They were selected to attend the center based on their aptitude, interviews, letters of recommendations, and interest in math and science. Students attended the center for half of the day and attended their "home school" the other half. The curriculum at the center involved only science, math and technology. The students were taught other subjects such as foreign languages, English, and music at their "home schools".

City A in which the math and science center resides (in which I used Unit A) has 53,540 residents, and the average income per household is $25,306. The region varied from city to rural, but the majority of the students came from families that had blue collar jobs at various local factories. Approximately sixty six percent of the students at the center were from the low to middle income range. There were approximately eighty five percent Caucasian, nine percent Afro-American, six percent other (Asian and Hispanic). One hundred percent of these students were planning on attending college. Since the students were selected from so many different schools, their educational backgrounds varied.

The center placed extremely high expectations on their students and the students were exposed to some integration of math, science and technology before being taught this unit. The center experimented with new and innovative curriculum so students accepted and expected different classroom procedures. The forensic science unit was taught for three years at the math and science center. The unit evolved over that time period and its development is explained in detail in the implementation section.

In comparison, city B had a population of 15,155 with an average income of $18,884. The racial makeup was 95% Caucasian and 5% Hispanic. The community is made up of a variety of business owners, doctors, farmers and blue collar workers. Sixty percent of the students go to college.

The students from the math and science center (group A) were well equipped to be successful with the forensics unit. They had the necessary math background and skills, they picked up on the technology easily and did a good job with concluding student projects. In contrast, the students from the city B or (unit B) were not as prepared as I thought they would be. The second group of students had very weak math skills, poor problem solving skills, inadequate science background and had insufficient technology framework.

The similarities that the two groups share are the similar ethnic make-up, they were eleventh graders and their very high interest level in this forensic science unit.

Because the schools are set up differently and I didn't have four colleagues to assist with this unit, as I did at the math and science center, I needed to modify the material for Unit B. Much more time was spent on teaching the necessary background and simplifying the math. However, with these modifications the students of unit B were successful. The end of the unit student project for unit B was a modification and more appropriate for this group.

The idea and evolution of the forensics unit took about three years at the math and science center. In the Fall of each school year, the teachers tried different activities to begin the year. The freshman class spent about three weeks on team building skills that incorporated both math and science. The project for the sophomore year was an in-depth research report on pond water quality. In 1993, my colleagues and I wanted to introduce something new and appropriate for the junior class, the first at the center. A detective from the local police station had spoken the previous spring at the nearby high school about the physics of hit and run accidents. This idea inspired us to design a project of solving a fictitious crime using forensics, involving math, science and technology for this class.

Implementation both Unit A and B

My research at Michigan State University occurred between my time at the math and science center and the traditional high school. Most of my time was spent preparing the evidence sacks, researching, developing and polishing labs, collecting more background information for the forensics unit at math and science center (Unit A). My job change which took me to city Boccurred at the end of my research experience. The labs were then modified for a traditional chemistry class after that time.

I spent four weeks of the summer of 1996, my research summer, working with a police officer. I was able to observe and learn various forensic technique first hand. I traveled in the crime lab van to various sites (some Breaking and Entering (B&Es), Dead on Arrivals (DOA), Domestic Assault, etc.) in which I could observe collection of physical evidence, questioning techniques, photography of tire impressions and bodily injuries, dusting and collection of fingerprints etc.

In addition, I worked with the help of the forensic department in city A to develop components for the teaching of Unit A. I prepared a matrix and the pieces of evidence for the students, such as, hair and fiber samples. This matrix was a chart that was used to determine which specific team would get positive evidence to indicate their guilty suspect. (Appendix D.) According to the matrix, Team 1's evidence was to include cotton fiber, silk fiber, a few strands of suspect C's hair, and a few strands of suspect E's pet's hair. The selected pieces were placed on a piece of carpeting and sealed in an individual evidence bag and placed in team 1' sack. This continued nineteen more times using different fibers and hairs according to the matrix. The students would then have to lift the fibers/hairs from the carpeting, make whole mount slides and then compare them to the known slides. I prepared the known slides.

Each team (a group of 4) in Unit A received a sack of evidence from the "crime" scene, all prepared by me as shown in the above example. The sack included:

1. Partial note taken from the victim's hand
2. Four cups from kitchen counter
3. Photograph of bite impression in cheese from kitchen counter
4. Photocopy of footwear impression found on newspaper on floor
5. Rug sample taken from kitchen
6. Lipstick sample taken from kitchen window
7. Swab of blood found on kitchen floor
8. Latent fingerprint from pipe found on kitchen floor

The following evidence sets were prepared and made available to each team to use for making comparisons:

9. Known fingerprint impression cards of all suspects
10. Known footwear impressions of the suspects shoes
11. Photographs of suspects dental records
12. Ink pens taken from suspects and victim
13. Portion of suspects' clothing with possible blood stains
14. Hair samples taken from suspects and their pets
15. Lipstick found in suspects' purses
16. Portion of the kitchen door with bloodstains

Overall there was about 160 pieces of evidence that were prepared for the student teams and about 60 sets of samples in which the teams would used to make their comparisons, for example fingerprint cards were made for each of the nine suspects and the victim.

The labs that were completed for Unit A during my research summer were: Fabric Examination Procedure, Thin Layer Chromatography and The Separation of Lipstick Dyes, Is it blood or not?, and Shoe Impressions. In addition, the subsequent lab experiments, were made more sophisticated for Unit A: DNA profiling, Fingerprinting, Paper Chromatography for Ink Analysis, Hair Analysis, Blood typing, and Math and Bloodstain Interpretation. See Appendix A.

While I was at Michigan State University, I also visited the Department of State Police Forensic Science Division in East Lansing. I was given permission to observe and tour the facility. I learned about how the Automatic Fingerprinting Identification System (AFIS) will be computerized so that the patrol car officer can scan the person's fingerprints right at the scene. I learned that the prisoners in various backgrounds (such as rape and child molestation) are being genetically profiled. If these individuals commit another crime, then the police will able to identify them by way of AFIS and/or the DNA data banks . I learned how some of the document analysis is done. I saw how the ballistic lab operated and how the tool marks division worked.

While I was at the State Police Post the buildings were undergoing expansion and it was clear that forensic science is a multifaceted science that is continually growing and developing. A sound scientific education is necessary to work in the field. In fact to work in the DNA labs, the wave of the future, one needs to complete graduate school. Possibly through this unit, some of my students will choose a career in the field of forensic science.

The first year of Unit A, 1993, the fictitious crime for analysis occurred at a staff party. Someone shot and injured the director of the math and science center. The bullet grazed his shoulder, but fortunately missed all major organs. The director was patched up and a sling was used to help stabilize the injury. Because of the traumatic experience, he developed some amnesia. Since the director was of no help in describing or identifying the perpetrator, the students would have to use the evidence from the scene to determine "who dunnit?"

The students were divided into five groups with approximately eighteen students in a group. Five teachers were each in charge of a different stations. At each station one or two different experiments were set up and the evidence at each station evaluated.

The original time frame for the forensics unit was two and one half hours a day for two weeks. In the first two days, a local forensic detective gave an overview of how science and math are used everyday in forensic science. Following that, the students within their groups, performed the operations at their assigned station. The groups rotated through each station over the next five days, spending a day at each station. The following brief descriptions of the various stations explain the specific techniques that are shown in parenthesis.

<u>Station I: Hair Analysis and Pen/Ink analysis</u>
(microscopes and paper chromatography).

The students, using microscopes, analyzed various suspects' hair samples and matched them with the sample found at the scene of the crime. Because a note was found at the crime scene, students performed paper chromatography to characterize the ink. The students used the note and the suspects' pens to find a match and determine which pen was used to write the note.

Station II: Fingerprints and White Powders

(matching of physical evidence and chemical analysis).

Students lifted fingerprints from a glass found at the scene, and compared the lifted print with the suspects' fingerprint cards. The student detectives had to determine who left the prints. Finally, the students examined various white powders, such as flour, baking soda, and sugar. Students used microscopes to determine their physical appearance. Sometimes white powders, which may turn out to be drugs, are found on a crime scene and criminalists need to determine the nature of the substance.

Station III: Aspirin in urine

(mass spectrophotometer)

Two of the suspects had alibis. Both said left the party early because they had a headache, went home, took some aspirin and went to sleep. The urinalysis was conducted to determine if they truly did take aspirin. Simulated urine with aspirin added to some of the samples was analyzed by the students.

Station IV: Blood splattering

(trigonometry).

The students used a prepared blood splattering sample to determine the angle of impact and the point of convergence. They determined the height of incident blood splattering using trigonometry.

Station V: Blood typing and Ballistics

(biology and matching of physical evidence).

At this station students learned about ABO typing. They determined the type of the simulated blood left at the scene of the crime and the blood types of the suspects and the victim. The next step was to compare and contrast the samples to determine a match. Simulated blood samples were used because of hazards of using real blood. Students also matched various bullets with the corresponding guns. The police department was able to provide us with photographs of several types of guns and corresponding bullets.

On paper, this plan of having student groups rotate through stations looked good. The teachers were able to handle the number of students and each student within their group had a chance to perform each test. A matrix was carefully designed so that each station would provide the evidence and clues to eliminate a staff member or two and in the end, incriminate one person. There were six staff members that were suspects.

We did not take into account, however, that the students from different groups would talk to one another and share information. At the end of the first day of "station work," each student had completed one station, but the class had completed all five stations. The students pooled the information gleaned from the different stations and all quickly learned who had committed the crime.

Since students felt that they knew who committed the crime after the first day of working at the stations, it was difficult to motivate them to complete the work and turn in an accurate report. As a result, there were large gaps in the problem solving process.

When all the students had completed the work for each station, we had a mock trial in which small groups of four students within the groups were randomly selected to present their evidence from each of the five stations. Out of about ninety students, twenty of them were involved in the mock trial. They had to be prepared, however, because we did not let them know who would be presenting. We had parents and other community members come in to serve on the jury. The evidence was presented and the jury concluded that the secretary was guilty. For dramatic effect the secretary was taken away in handcuffs. The students were graded on their participation, court presentation, and a short test over the scientific fundamentals from each station.

The following year, August 1994, we repeated the same forensics lesson but the staff didn't want to spend as much time on it as in the past year. We had similar stations, but this time each group of students only worked at one station and became the "experts" on that station. They prepared a presentation for the class with the results from the examined evidence. The six suspects were narrowed down to three. These staff members were questioned and then the students voted as to who they thought did it. They were evaluated on their results, participation, presentation, and a test covering the scientific fundamentals from each station.

In the third year, 1995, I wanted to wait until the middle of the year to present the forensics lesson. With all the media exposure about Deoxyribose Nucleic Acid (DNA) profiling, I wanted to implement it at one of the stations. By the middle of the year we would have taught genetics and DNA. It made sense to move forensics to a point where they would understand DNA profiling better. The centers' science curriculum is atypical: freshmen take physics, sophomores take chemistry and juniors take biology. That is why they did not learn genetics earlier.

We decided to have all students work at each station. We wanted the students to experience each station, and rely on their team's results. The students worked in assigned teams of four, and each team would need to analyze evidence and figure out "who dunnit." The students had to keep their lab procedures, results, observations, etc. in their lab book.

We also required the students to have their procedures for that day written in their lab books before they were admitted into any lab station. This reduced the confusion and made the students much more accountable at the stations. The rest of requirements in the third year were:

-a complete lab notebook for each student (5% of their nine week grade)

-a group presentation: the students presented their results of their evidence and their conclusions of who committed the crime. The presentation was to simulate a court appearance. (5% of their nine week grade). Half of the groups used the computer program <u>Lotus: Freelance Graphics.</u>

-an individual paper which needed to include the following: introduction, scene of the crime, analysis of evidence, decision to prosecute and a bibliography. (10% of their nine week grade)

Implementation of Unit B

Since the students in Unit B only met for about fifty minute at a time, the lab activities needed to be shortened or spread over two or three days. Also I did not have the luxury of several colleagues assisting , or the support of the local police department.

The whole premise was different in that instead of solving one "crime" as in Unit A, the students in Unit B learned the techniques and solved some "crimes" or unknowns for that particular lab activity. Unit B did not have the evidence sacks. The unit was taught more as fractional pieces. I was able to apply the necessary background information and design activities based on the ones from Unit A.

For example, while doing the fingerprint section I had the students prepare their own fingerprint cards. Also, there was an activity in which the students had to dust and lift prints. They started by attempting to lift their own. Only about ten percent were successful. I believe the dusting powder I had did not work very well. I decided not to have the students lift and identify the prints as in a "who dunnit type crime." Rather the students identified unlabeled prints from fellow classmate print cards. The print cards the students had prepared earlier provided the necessary fingerprints. I copied some of the print cards, selected clear fingerprints and prepared a worksheet in which the students were to analyze the fingerprints. (Appendix A) Most students enjoyed doing this and were quite successful. In fact, I thought that it was going to be too difficult, but they did a good job.

The shoe impression activity was very similar with the one in Unit A, except in Unit A there was one unknown impression and in Unit B there were three unknown impressions. I used the same materials for Unit A. There was a section of newspaper with several partial prints of the various suspects. I made copies and labeled them as unknowns. Then the class was provided with a set of full shoe prints for each suspects. The known sheets have been laminated in order to be used again and again. I provided different groups with three different unknowns and they had to follow the same procedure as in Unit A to identify the unknowns. If I had more time I would have had the students prepare their impressions of their shoes.

The spectrophotometer lab activities (basic techniques, breathalyzer simulation and aspirin in urine) were new to Unit B.

The procedures for the chromatography lab activities (ink analysis, lipstick analysis), blood analysis activities (is it blood?, is it human blood?; and blood typing), microscope lab activities (fiber and hair identification), and bloodstain interpretation were identical to Unit A. The difference is that Unit A was looking at specific suspects with each group having different outcomes and Unit B was solving for a particular unknown.

The electrophoresis of DNA was a simulation for Unit B because of the lack of necessary equipment and poor student technique. The students of Unit B had biology as ninth graders but did not have any experience with electrophoresis. Unit A had a procedure for electrophoresis of DNA.

The time allotted for Unit A was 2.5 hours a day for two weeks. The time allotted for Unit B was fifty minutes a day for almost eight weeks. At the start of the nine weeks forensics unit, the students were also taking the proficiency test. This test took about ten days, so I did not have the full nine weeks for teaching the unit. Since there are different type of students and circumstances in Unit A than in Unit B, the requirements differed. Unit B students completed a project and presentation, either alone or with another person, which was the basis for on a large percentage of his/her grade. The project was a culmination of the unit. The grading for Unit B in the nine week grade was based on:

30% of their grade from project/presentation

30% of their grade from participation/performance

30% of their grade from the labs/and a test

10% of their grade from homework/quizzes

Thirty percent of the students grade was on the project/presentation. The projects were designed to have the students be active learners by researching new forensics topics (ones that were not covered in class.) "Active learning is based on the belief that students learn best when they construct their own understanding by interacting with the natural world, each other and their teachers." (Kober, 1994). The students had to research the topic, interview community members and become the "expert" in order to teach the rest of the class about their topic. See the Project/Presentation rubric in Appendix C-Section 1.

Thirty percent of the grade was based on the student performance and participation. See Appendix C-Section 2 & 3 for rubrics for the participation grade. Each student was required to keep a notebook of all the class activities: lecture notes, news articles, case studies, current events, and lab activities, which counted as a participation/performance grade. Thirty percent was based on labs and tests. See Appendix A for the labs and See Appendix C-Section 4 and 5 for the evaluation forms. The last ten percent was based on homework.

The overall course and other consideration for Unit B follows. For every new topic there was either an introductory lecture or a homework assignment to read various case studies related to the topic.

I. Activities/Labs
    A. Introduction
        1. What is forensics? Discussion
        2. How does science, math and technology fit in with forensic science?
    B. Matching of physical evidence (See Appendix A)
        1. Fingerprints
            a. making a fingerprint
            b. identifying classmates' fingerprints

c. lifting prints

2. Shoe impressions

a. identifying shoe impressions

C. Spectrophotometer

a. basic techniques

b. breathalyzer simulation

c. aspirin in urine

D. Chromatography (See Appendix A)

a. ink analysis

b. lipstick analysis

E. Chemical analysis (See Appendix A)

a. fibers: synthetic vs. natural

F. Microscope (See Appendix A)

a. hair identification

b. fiber identification

G. Blood Analysis (See Appendix A)

a. is it blood?

b. is it human blood?

c. blood typing

H. Bloodstain Pattern Interpretation (See Appendix A)

a. determine the angle of impact

b. determine the point of impact

I. DNA electrophoresis

a. simulated electrophoresis

b. Case study 1-PBL

c. Case study 2-PBL

II. Individual or pair of students forensics topic project

Topics:

1. chemical analysis
    a. paint chips (especially from hit and runs)
    b. white powders (chemical analysis of aspirin, acetaminophen, ibuprofen) and poisons.
2. tool marks and tire treads
3. firearms and ballistics
4. arson and explosions
5. history timeline and background
6. forensic pathologist
7. forensic entomology
8. document analysis/handwriting
9. teeth impressions/forensic odentology

III. Guest speakers

A. local police officer-Detective Mike Imhoff

His lecture focused on several crimes that occurred locally, and how he and his department solved the cases.

B. forensic pathologist-Dr. Kyle Carr

Dr. Carr spoke about the requirements to become a pathologist, what one does in comparison to a medical examiner, and the role of a forensic pathologist.

IV. Audio-visual aids-videotapes

A. Nova: Murder, Rape and DNA

B. Fictitious murder scene at the set-up house, created with the assistance of Battle Creek Police Department

C. The Twenty-First Century: Forensics

D. Detective Van Stratton's presentation from 1996

The new teaching techniques that were incorporated into unit B were ones that I felt I needed to work on. These areas include how to ask the right questions, effective questioning, and higher-order questioning. I also incorporated strategies in wait time. Wait time is the time the teacher gives the student or class to respond to the posed question before giving the answer or asking another question.

The students in Unit B were presented with two case studies in which they were required to use the PBL steps (see introduction) to solve the problem. Two articles concerning some crime were used for these problems. The students were presented with the only a piece of the puzzle (or problem) and were asked to solve it. The students then had to figure what they needed to know to solve it. The students were to ask me for some information (without asking me for the answer to the problem) and research the information on their own. I designed my questions for the spectrophotometer activity with strategically placed wait time and timed myself. Since this technique is new to my style, I had to make a conscientious effort and make it part of my lesson. Obviously, some days are more appropriate for this technique, such as the day following a day of class discussion. I saw some improvement in the variety of student participation and an increase in their confidence. I believe that the incorporation of wait time will become more integrated in my teaching as time passes.

Now that I am more comfortable with PBL, I will continue to use this method when appropriate throughout my teaching because I like the PBL outcomes. The students become actively engaged in critical thinking and problem solving.

The chromatography lab activities and spectrophotometer lab activities allowed me to ask higher level and open ended questions. There was some improvement in the student's higher level thinking with my new questioning techniques, and I believe this also will continue with time.

Evaluation

The evaluation of Unit A is anecdotal while the evaluation of Unit B is more in depth. The forms of evaluation I found to be most effective were student surveys, discussions and interviews. Since the material in this unit is not presented or taught in any other course that is offered at either location I did not use a pre test. From previous experience, I have learned that pretests aren't very effective when there is no or very little knowledge of the subject. However, I did conduct a survey for students in Unit B to have them report their prior knowledge. The students rated their perception of their knowledge in the following categories from document evaluation to paint analysis. This is a student self-evaluation survey and was enforced with results of interviews of 15% of my students. There were thirty seven students in my two chemistry classes. See Table 1 for prior knowledge survey results. See Appendix B-Section 1 for the survey instrument.

TABLE 1 PRIOR KNOWLEDGE SURVEY RESULTS

The scale is 1 through 5. One means there is no knowledge while a five means that they fully know and understand this topic.

	1	2	3	4	5
1. document evaluation	47%	9%	22%	22%	0%
2. forensics anthropology	67%	15%	9%	9%	0%
3. forensics paleontology	75%	13%	9%	6%	0%
4. forensics entomology	72%	13%	6%	13%	0%
5. fingerprinting	16%	13%	31%	13%	16%
6. fiber analysis	50%	12%	25%	13%	0%
7. hair analysis	44%	15%	19%	13%	0%
8. blood and body fluids	47%	12%	16%	16%	9%
9. DNA evidence	47%	16%	16%	12%	9%
10. arson	29%	12%	24%	26%	9%
11. crime scene procedures	31%	17%	22%	14%	17%
12. lipstick dyes	75%	13%	9%	6%	0%
13. water based ink dyes	75%	13%	9%	6%	0%
14. thin layer chromatography	67%	14%	8%	8%	3%
15. paper chromatography	73%	20%	3%	0%	3%
16. stereo microscopy	31%	14%	11%	19%	25%
17. light microscopy	73%	20%	3%	0%	3%
18. Spectrophotometer 20	67%	14%	8%	8%	3%
19. Blood stain analysis	50%	8%	21%	13%	8%
20. Blood typing	43%	5%	22%	19%	11%
21. footwear impressions	38%	15%	18%	21%	8%
22. Paint analysis	45%	13%	21%	13%	8%
Average:	**53%**	**13%**	**15%**	**12%**	**6%**

In summary, most students had little prior knowledge about these twenty two categories. The topics in which a small percentage of students believed they knew the topics well were fingerprinting, blood and body fluids, DNA evidence, arson, crime scene procedures, blood typing. Students that gave a rating of five for prior knowledge, had learned some of the material probably through the media. However I would rate their knowledge closer to a three or four, but not a five. One of the students that I interviewed gave a few fives in this survey. I questioned the student in these categories and I would have rated their knowledge as a three.

Since the students had a biology course two years earlier, I gave them a survey on blood to determine their prior knowledge and to ascertain where to begin the forensic curriculum on blood.

After Unit B was completed, I used the same survey to determine how much change had occurred in their self-reported knowledge of these topics. Several students were asked similar questions in one-on-one interviews. These students were the same ones as in the pre-unit interview. See Table 2 for post forensic unit survey results (change in knowledge). See Appendix B-Section 4 for interview questions.

TABLE 2 POST FORENSIC UNIT SURVEY (Change in Knowledge)

scale: 0 = no change, no increase — 1 = increased slightly
2 = increased some — 3 = increased a lot

	0	1	2	3
1. document evaluation	0%	13%	57%	30%
2. forensics anthropology	0%	17%	48%	35%
3. forensics paleontology	0%	13%	57%	30%
4. forensics entomology	0%	13%	57%	30%
5. fingerprinting	0%	4%	30%	65%
6. fiber analysis	0%	17%	48%	35%
7. hair analysis	0%	17%	48%	35%
8. blood and body fluids	0%	17%	48%	35%
9. DNA evidence	0%	4%	29%	68%
10. arson	0%	17%	48%	35%
11. crime scene procedures	0%	4%	29%	68%
12. lipstick dyes	0%	4%	29%	68%
13. water based ink dyes	0%	4%	29%	68%
14. thin layer chromatography	0%	17%	48%	35%
15. paper chromatography	0%	13%	57%	30%
16. stereo microscopy	0%	17%	48%	35%
17. light microscopy	0%	17%	48%	35%
18. Spectrophotometer 20	0%	4%	29%	68%
19. Blood stain analysis	0%	4%	29%	68%
20. Blood typing	0%	17%	48%	35%
21. footwear impressions	0%	17%	48%	35%
Average:	**0%**	**12%**	**44%**	**46%**

These student responses indicate that they all learned something about all of the topics. Most of the topics were taught through laboratory activities. The topics in which the students learned the most were fingerprinting, DNA evidence, crime scene procedures, lipstick dyes, water based ink dyes, spectrophotometer 20, and blood stain analysis. Some of the topics that students thought they knew a lot about were also the ones that they gained the most amount of knowledge. They did not know as much as they thought. I believe this is due to the fact that, as I stated earlier, when students are interested in the topic at hand they pay attention more and have the desire to learn what the lab is trying to show.

Students in Unit B seemed very interested throughout the whole forensics unit. However, as with anything new, I wanted to know from the student's perspective their interest level and determine where I could improve my teaching. Therefore, I asked the students to complete an interest level survey. The survey and results follow: See Table 3 for interest level survey results. See Appendix B-Section 3 for the instrument.

TABLE 3 INTEREST LEVEL SURVEY RESULTS:

0 = no interest
1 = a little interest
2 = moderate interest
3 = high interest

	0	1	2	3
1. document evaluation	0%	17%	50%	33%
2. forensics anthropology	4%	35%	39%	22%
3. forensics paleontology	0%	17%	50%	33%
4. forensics entomology	4%	35%	39%	22%
5. fingerprinting	9%	0%	43%	48%
6. fiber analysis	0%	9%	45%	45%
7. hair analysis	0%	9%	45%	45%
8. blood and body fluids	0%	9%	45%	45%
9. DNA evidence	0%	17%	48%	35%
10. arson	4%	35%	39%	22%
11. crime scene procedures	0%	17%	50%	33%
12. lipstick dyes	0%	17%	52%	30%
13. water based ink dyes	0%	17%	52%	30%
14. thin layer chromatography	4%	35%	39%	22%
15. paper chromatography	4%	35%	39%	22%
16. stereo microscopy	22%	39%	39%	0%
17. light microscopy	39%	39%	22%	0%
18. Spectrophotometer 20	25%	25%	42%	8%
19. Blood stain analysis	0%	17%	52%	30%
20. Blood typing	0%	9%	26%	65%
21. footwear impressions	0%	9%	35%	57%
Average:	**5%**	**21%**	**42%**	**31%**

The interest levels were highest in the topics of blood typing, footwear impression, and fingerprinting. The topics with the least level of interest were the light microscopy and the spectrophotometer 20. Again, this group of students had never been exposed to the equipment used to implement science lab activities before. I underestimated their ability to effectively use the microscopes and spectrophotometer.

Results of student interviews:

The following comment is one from a student who graduated from the math and science center during the last year I was there in (1995). This student is currently a freshman at Hope College studying Forensic Pathology: "It was a great opportunity to meet the members of the community. It resulted in a great mentor relationship between a forensic detective and myself. In fact, the mentoring then led to me changing my career plans to that field of study. The forensic unit was probably the most life-changing experience that the MSC offered me." See Appendix B-Section 5 for the interview questions.

Comments from unit B students based on interviews of eight students and the surveys of forty four students:

"I loved it, because it was interesting and we did labs on it. I liked the fingerprints and blood labs."

"It was successful because it was a change from the normal. It made us wonder more about things we hear on the news."

"I really like the projects, because they allowed us to be more creative."

"The videos that were used were very much on topic and interesting."

"I didn't know a lot about forensics as a whole when we started. I learned a lot throughout this chemistry unit....."

"My interest level was real high through the whole unit. I liked the non-traditional, non-book stuff. We could stay with forensics all year long."

"The whole unit was better, the labs were better, you see the stuff all the time on the news and it is real interesting. I was more interested, everything is more clear."

"Doing the end of the unit projects was a nice way to end. I had fun putting together the slides and information together."

"I liked getting the hands on.....studying blood splattering, doing labs to figure things out."

"I liked making my own fingerprints. I liked it because it was "hands" on."

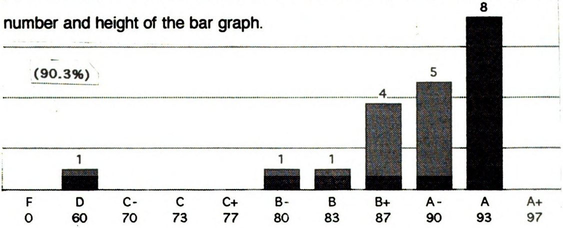
"The activities made it fun because a chance was given to us to use hands on experience. Given real life cases made it fun."

Based on the surveys their prior knowledge about most areas of forensics was low. A few students felt they had some knowledge in fingerprinting, blood typing, DNA evidence, footwear and crime scene procedures. Their knowledge level increased as reported by all students. The greatest increase in knowledge occurred with fingerprints, DNA, crime scene procedures, lipstick chromatography, paper chromatography, spectrophotometer 20 and footwear.

The students liked the blood typing, footwear impressions and fingerprinting sections the most. I believe it is because each one of these labs can be individualized, meaning they exhibit these characteristics themselves.

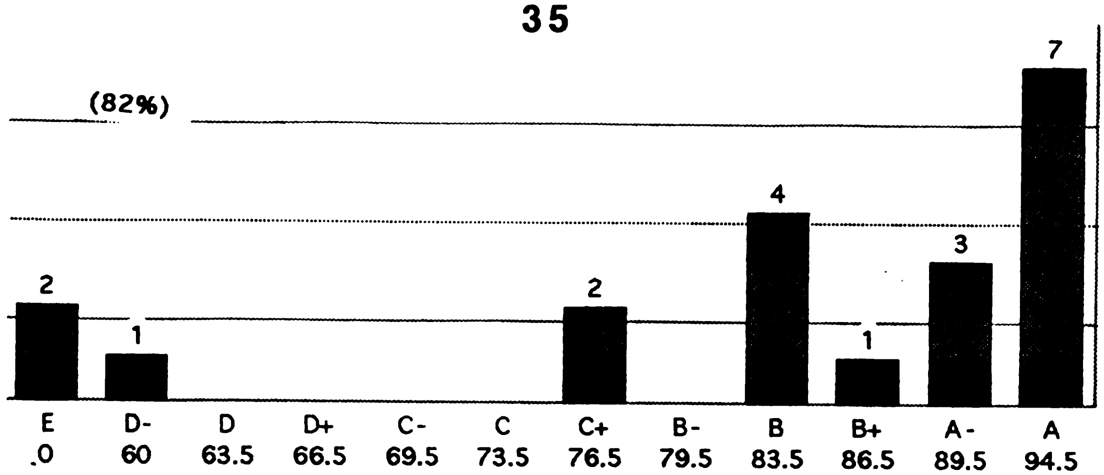
The activities that were failures were those requiring spectrophotometers. I did two labs using them. One was the alcohol breathalyzer test and the other was determining the amount of aspirin in urine. I had prior success using spectrophotometers with students from the math and science center so I was not prepared for the lack of ability that I saw from the second group of students. I will be more prepared next time! The topics were interesting to the kids: it was the technology that was out of their league.

The success of forensic unit B is evident in the information shown in the following tables. Tables 4 and 5 represent students' performance for one class with table 4 as the forensics unit and table 5 as general chemistry.classes, while Table 6 and 7 represent a different class, with table 6 for the performance during the forensic unit while table 7 is for the general chemistry unit. The topics that were covered in the non-forensic unit were: moles, stoichiometry and the gas laws. The classes show an increase up to 12% for the forensics term verses the basic chemistry term in the brackets. The letter grade and percentile are on the X-axis while the number students is represented by the number and height of the bar graph.



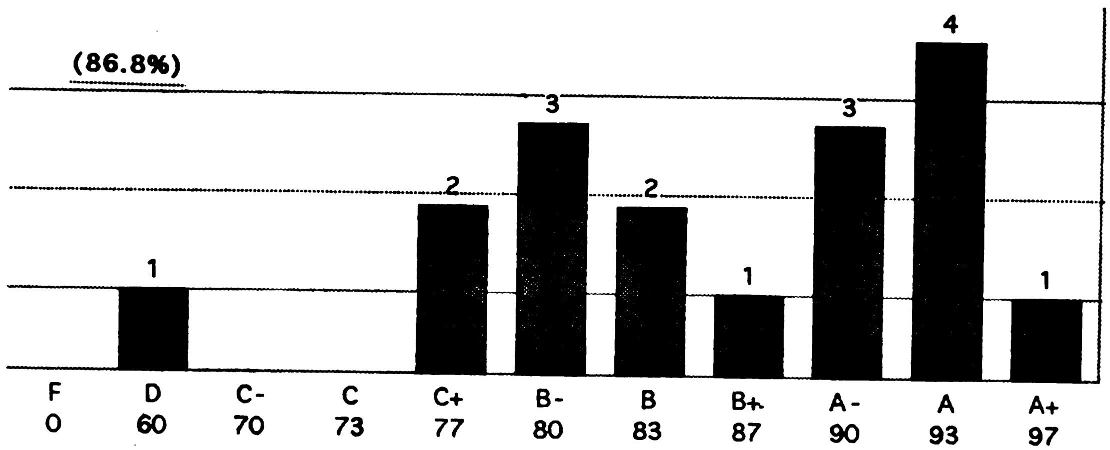
5th Hour Chemistry Class Performance for the Forensic Unit

Table 4



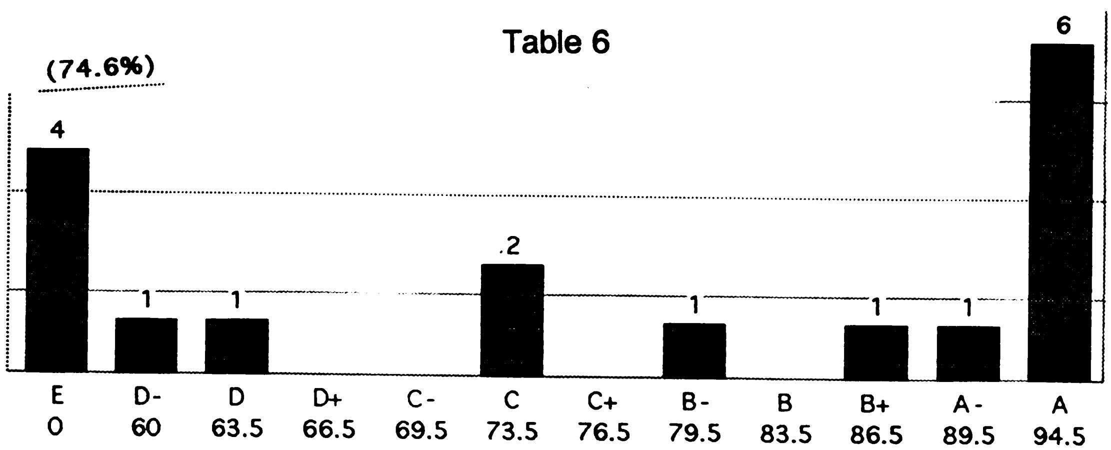
5th Hour Chemistry Class Performance for the Non-Forensic Unit

Table 5



7th Hour Chemistry Class Performance for the Forensic Unit

Table 6



7th Hour Chemistry Class Performance for the Non-Forensic Unit

Table 7

The following is my evaluation and comments from the teaching of the Unit A. I do not have formal data from this group of students. However, informally, I can say that years later, students still talk about the forensics unit, and what an incredible learning experience it was for them. They said that it was the most enjoyable project that they participated in while at the center. As far as this teacher is concerned, it was the most successful topic I have ever used that incorporated science, math, technology and members from the community.

Discussion and conclusion

Initially in 1993, the forensic science unit was used as a unique and innovative way to start the school year off for the junior class at the math and science center. The major problem with this unit was that it was the first time that we had done something like this so we were somewhat "green" about the forensic information. The student groups were too large (there were about 18 students in a group) and individuals need not do much. There was only one true suspect and all the evidence was the same for each group. So if they knew what the group before them found, students felt that they didn't have to complete or do the lab. We were not prepared to hold each student accountable. In summary, our expectations of the students were not challenging enough.

The positive points for the first year were many. First, we actually got the project off the drawing table into the classroom. Students were able to actively participate in the unit and not just hear about it. Secondly, the students were very interested in the topic and this interest inspired participation and discussion. Thirdly, most of the staff was involved. When the staff works together the lines of communication were open and it really allows the staff to become a team. Finally, as a science teacher I am interested in incorporating other subjects and making connections or helping my students to make these connections

When we taught the unit during the second year, 1994, some of the staff were somewhat disappointed with the outcomes from the first year, so we decided to make changes. We had the students in the same size groups. However, each student participated in only one of the stations. For example, the students in a particular group would only perform the blood splattering lab. That group of students would then become the experts on this lab and then a few of these students were selected to present their lab, how it worked, and what the results were. Everyone in this group was suppose to help out with the posters and necessary visual aids for the presentation. The positive things that happened the second year were that not as much time was used (one staff member wanted less time spent on forensics), there was better integration of science, math and technology, and the students were highly interested. The down side of teaching this unit this way was that a majority of the students did a careless, negligent job. For example, the students in the fingerprinting section did a poor job of collecting the prints, lifting the prints and therefore drew incorrect deductions.

From this experience we surmised that if the students are to get more out of this type of lesson it is better to complete all the stations. Again, some students could sneak by without doing much. The expectations needed to be individualized and raised. For the first two years the students were divided into groups alphabetically, no group dynamics were considered.

By the time the forensic science unit was taught the third year, 1995, much had been done to improve the unit. I began to consider the development of my forensic science unit for my thesis project. I had taken the Cellular & Molecular Biology Course that summer at Michigan State University and many other teachers were there working on their research for their thesis. I began to think about what I wanted to do and the forensic unit seemed ideal. I saw how this "fun" introduction week to the junior fall year could be turned into a very good unit.

First of all, we wanted to change and correct the negative aspects of what we had accomplished so far and improve the positive ones. One of the things that I worked on was the group dynamics. Students within the groups were selected by their ability. Students that were the "non-workers" were singled out and placed together. The center does a lot of group work so previous experiences allowed us to selectively group the students. This worked well, because they had to depend on each other and a leader did emerge. The groups were made up of four students. Also each group or team had a number and along with this number the team got a corresponding sack of evidence. There were only six suspects again and with 22 teams some would have the same suspect to prosecute in the end. The teams had different evidence in their sacks.

Some of the experiments at the stations became more sophisticated. Our expectations of the students increased. By having each student keep a lab notebook throughout the unit they were held more accountable. We required the students to record the experimental procedures in their lab book before they came to do the lab. By doing the procedures in their books , the students came into the stations more prepared to do the lab and usually the lab work went much smoother. They were more apt to participate in the lab and not let their teammates do all the work. There was plenty of work at each of the stations and a time limit was set, so the students really needed to work as a team.

In the end each team had to present their evidence, results and deductions to the staff and the class as to who should be prosecuted . Each member of the team was required to do part of the presentation. In addition, to the above assignment an individual paper was required. The paper was made up of five parts: an introduction, a description of the crime scene, an analysis of the evidence, the decision to prosecute and a bibliography. This was an excellent way to have each student tie the unit together. They also had to turn in their lab notebooks for a grade. The notebooks needed to include all the lab procedures, any corrections and/or adaptations to the procedures, the data and observations of the evidence, their results and the summation of what this piece of evidence and lab indicated.

As I stated earlier, I changed teaching positions and moved my forensic science unit to city B, and many modifications were necessary. I was unable to be at the math and science center for it's fourth year of the forensic unit, but I was told that it was a success.

In city B, I was to teach chemistry at a traditional high school. One of the modifications for my forensic science unit B was to change the stations into individual labs, since I no longer had the luxury of working with four colleagues. The labs needed to be simplified and either reduced or split because the time available went from one hundred and fifty minutes to fifty three minutes. Unit A was completed in about two weeks, while unit B was completed in about eight weeks. In the allotted time I was able to complete only some of the labs, which are indicated in the implementation section of this thesis.

Even though some adaptations were necessary, the second group of students mastered the material and enjoyed studying chemistry through forensics. In addition to the chemistry, various other sciences such as biology and physical science were introduced or expanded, along with math and technology. I feel the unit was very successful.

Proper implementation of Unit B will require more time. If I had twelve weeks instead of eight, I would have the students make their own shoe casts and solve a fictitious crime. I would have had hair, paint, handwriting, and document analysis done as labs and not by projects. I would require computer generated or video presentations. I would like to add field trips, but that was a budget restraint. I would plan to incorporate journal writing. I would have liked to have a guest speaker for the topic of arson. However I had a student do an incredible job on this for her project, so it was fine this year. Overall, the unit has been beneficial for all my students, mostly because of their high interest throughout the unit.

The projects allowed the students to be creative and teach the class about their topic. All the lab techniques can be applicable to a typical high school chemistry lab. The least effective lab activities were the lipstick analysis because of technological difficulties and the spectrophotometer lab. The difficulties for the lipstick analysis was that we did not have proper capillary tubes. Consequently, the separate dyes overlapped as they were chromatographed. The spectrophotometer lab did not work well because the students were not very careful when adding the reagents. Most of my students did not have the sophistication to understand how the spectrometer works and they had weak analytical skills. I believe if the students were exposed to the technique more and we did several labs throughout the year that they would develop this sophistication. I had to borrow the spectrophotometers from Michigan State University so it made it difficult to use them at other times.

Students love to do lab activities; the hands-on activities are always appreciated. It is the minds-on part that they struggle with, as they do not always understand the 'what" or the "why" of the lab activity. As a teacher I also have difficulty with this. I will gladly try to lead them through to the conclusion, but I do not want to spoon feed them. In my professional opinion the second group of students (Unit B) have only been spoon fed and therefore drawing their own conclusions, or "so whats" as I call them, is extremely difficult. I call them "so what" in order to get the students to think about why we did this particular lab, etc. Yet, in this forensic science unit the students had enough interest and desire to learn that when it came time to put it all together, they were quite successful. For example, when the students wrote their conclusions for the ink chromatography, they were able to connect the concept of chromatography to it's application.

The down side of teaching Units A is that it is very time consuming, requiring the teacher to prepare, sort, label and collect the evidence for over twenty teams; design the procedures for the various labs/activities, set up the stations, run the stations, etc. Most schools are not able to devote this much time on a unit such as this, (2.5 hours a day, each day for two weeks). The staff of five also worked together as a team to share the work load.

Three new teaching strategies that I addressed in this unit were ones that I wanted to improve. I worked on my questioning strategies, wait time and problem-based learning activities. I believe my questioning technique and wait time have improved and will continue to improve with time and more teaching experience. Forensics had several opportunities to have some problem-based learning situations. The students are presented with a problem and they need to find the information out on their own to solve it. This worked quite well, even though the students really struggle with the fact that I did not help them by giving them the answers, I did help them by facilitating the situation.

Unit B was also very time consuming because I had to prepare everything by myself, I did not have help from Battle Creek police department or the local police department. However the time commitment and modifications could be spaced out more over the nine weeks verses having all the evidence in bags and team sacks.

I feel that this unit was successful because the students welcomed the idea that the science in this unit had direct application to what was happening in the world around them. The media at the time was flooded with the second trial for OJ Simpson and JonBenet Ramsey murder investigation.

I would like to see the unit taught as a semester course, as the students would be able to explore the topics in much more detail and other areas that were only covered as projects. I would also add soil and glass analysis and serial number restoration. I will also continue to work on my teaching style by incorporating more problem based situations, improve my questioning techniques and increasing my wait time.

Success where I didn't expect it was that I thought I'd have high interest through some of it but, not necessarily throughout the whole unit. I hope that I will be able to incorporate strategies such as how chromatography is used in industry and other everyday things that worked well in the forensics unit, into my regular chemistry class in other topics.

In summary, my analysis of the past four years is as follows:
The first year, the students had their results at the end of the first day as mentioned earlier. The students felt that they did not have to complete the rest of the labs. They had figured out the "who dunnit", without doing all the required work. Consequently they did not learn as much as they could have from the rest of the stations.

The second year didn't work as well as expected either, the students only did one station, and therefore only learned a segment of the workings of a crime lab.

The third year worked quite well. Since we had learned from the previous two years, we knew how to make the students more responsible for their own learning. One improvement I would have recommended for the third year was to have every group present their case by using Lotus Graphics.

Lotus Graphics was to be used as computer generated presentation. Only half of the groups were able to use Lotus Graphics because we ran short of time. Another improvement would be to use more math in the labs that are currently used.

The modified unit or unit B was very successful for its debut. The atmosphere of a typical chemistry class was very positive as attested to by the comments made by my students and their overall performance in the evaluation section of this thesis.

The forensics unit will be a model for the teaching of future units. The students interest level was high throughout the entire unit. I will use the concluding projects as an assessment tool again. Since I did not use a formal tool of evaluation, I do not formal results for wait time, PBL, and higher level questioning. However in my professional opinion and eight years of teaching experience I believe that the effectiveness of wait time was good. I saw an increase in student confidence, more students participated in discussion and there were fewer failures to respond. I am constantly learning and polishing my skills. Now, I am more conscious of the time I give students to respond and I will become more skilled as the years continue.

In my opinion the PBL technique was ineffective with this group of students. My students struggled with problem solving and this type of assignment was difficult for them and not very effective. More assignments need to be developed to teach students how to problem solve in smaller simpler steps. .

I believe that the effective of my questioning techniques were somewhat positive. I taped myself and was able to evaluate and adjust my performance and technique. Meanwhile my students struggled with some of the questions, yet with more practice and training they will get better. As I develop these skills and techniques I will become a better teacher and therefore have more of my students achieve higher level thinking. Teachers need to tape and self-evaluate their own performances in order to make the necessary improvements.

I thoroughly enjoyed teaching this unit, my students were engaged and actively learning throughout it and I highly recommend teachers to bring everyday life situations into their classrooms and they will be successful too. I believe that this unit increased scientific literacy, promoted the scientific mind and demonstrated the value of an interdisciplinary approach to teaching and learning. By mirroring the everyday world, our classrooms become successful learning environments and promote problem solving. Math, science and technology are interconnected in the everyday world and must, therefore be interconnected in our classrooms.

Appendix A
Lab activites and Handouts for Unit A & B

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Section III: Fabric Examination Procedure....56

Section IV: Hair Examination Procedure....57

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Section VIII: Blood Analysis....71

Section I

LIFTING FINGERPRINTS

BACKGROUND

Fingerprints, the most common form of physical evidence found at the scene of a crime, are among the most reliable means of identifying suspects. No two people's fingerprints are exactly alike, and fingerprints do not change. The FBI classifies fingerprints into three main types: loop, arch and whorl (see below). When experts compare two fingerprints, they usually require 10 to 12 points of similarity between the two to establish that the prints are identical.

MATERIALS:
Newspapers
Scotch Tape
Brushes (1 per group)
Aluminum or carbon powder
Index cards
Camera (optional)

PROCEDURE

1. Spread out newspaper in the area in which you will be working
2. Obtain a brush for dusting the prints. Make sure it is clean and the bristles are separated from each other, Use a different brush for each different powder.
3. Use either carbon black or aluminum powder to dust for the print.
4. Place a small amount of the loose powder in a labeled beaker. Dip the brush in the powder and lightly dust the area of the evidence.
5. Distribute the powder evenly over the surface that contains the print. If possible pick up the object and tap the edge of the object to uniformly distribute the dusting powder.
6. After all the print is developed, remove the excess poser by blowing the dust from the surface. Be careful not to inhale any of the dust.
7. If a camera is available, try to photograph it
8. To lift the print from the evidence to an index card, unroll about 5" to 6" of tape and place the end to the right of the thumb print and allow the tape to cover the whole print. Slide a thumb over the tape and smooth it down over the print to force out all air bubbles.
9. The print can be removed by pulling up on the roll end of the tape and then placing it on the fingerprint card in the same manner as the tape was over the latent print. Make sure the tape is secure. Cut the tape from the roll.
10. Observe the print under a dissecting scope and compare it to the prints given. Identify the owner of the print.
11. RECORD ALL THE NECESSARY INFORMATION IN YOUR LAB BOOK

References:

Battle Creek Police Department

Revised by Pam Tejkl

Section I

FINGERPRINT DEVELOPMENT LAB

Background:

Many times fingerprints are left behind yet there are can not be detected because of the surface of the container in which they are left. Also they may not be seen with the use of the Al or carbon powder. Using the super glue or iodine method many fingerprints that otherwise may have been left unnoticed can be made visible. Fingerprints are nonpolar skin oils and such, will absorb nonpolar vapors. The vapors from both iodine and super glue are toxic so the use of a hood is necessary. The teacher may just want to do this as a demonstration or photos/slides may be obtained from your local police forensic department.

MATERIALS

iodine crystals or Super Glue (contains cyanoacylate)
objects which will fingerprint (light and dark)
sealable glass containers with metal lids (without a plastic or metal liner)
[a peanut butter jar works well]
candle

PROCEDURE:

1. Grab objects with fingertips to produce the fingerprints. Do not smear.
2. Place the object in the container.
3. For light colored objects place a few crystals of iodine, (the fingerprints will appear brown)

   For dark colored objects place a few drops of Super Glue (the fingerprints will appear white)
4. Seal the container tightly.
5. Light the candle and gently heat the lid of the container. Vapors should be visible and then the fingerprints should be come visible. Do not open the container until it has cooled and then open only in a swell-ventilated place (like a fume hood).

Safety and Clean-up

Be sure that the container has cooled before opening it and do so only in a well-ventilated area. Excess iodine can be reduced with sodium thiosulfate

References:

Battle Creek Police Department, VanStratton, Mike Det.
Bratton, Professor Raymond, University of Virginia, 1990
Fundemental of Criminal Investigation Sixth edition, Charles O'Hara, Gregory O'Hara, Charles C Thomas, Springfield IL 1994

Revised by Pam Tejkl

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Section I
IDENTIFYING FINGERPRINTS
AND
MAKING YOUR OWN FINGERPRINT CARD

Background

The search for a valid identification medium has been a constantly recurring quest in the history of investigation. Tattooing, branding, physical descriptions, measuring and photographing have had their successive vogues. The latter of the three methods are still in current use.

Humans have an intricate set of ridges on the palmar surfaces of their hands and the soles of their feet. These ridges appear to be non-skid adaptations like a tread of a tire. Along these ridges are irregular scattered ends of tiny ducts that discharge perspiration from sweat glands a millimeter or so down in the dermal layer. Formed in the third or fourth fetal month, these ridges persist from birth to death. They change only in size with growth.

Fingerprints remain unchanged through life. The experts look for ten to twelve points of similarities as a comparison.

IDENTIFYING FINGERPRINTS
Part 1

Fingerprints may be resolved into three large general groups of patterns, each group bearing the same general characteristic or family resemblance. The topology includes: the arches (see figure 1), the loops (see figure 2 and the whorls (see figure 3).

The patterns may be further divided into sub-groups by means of the smaller differences existing between the patterns in the same general group. The divisions are as follows:

1. Arch
    a. Plain arch
    b. Tented arch
2. Loop
    a. Radial loop
    b. Ulnar loop
3. Whorl
    a. Plain whorl
    b. Central pocket loop
    c. Double loop

Plain Arch

Tented Arch

Figure 1

Radial Loop

Ulnar Loop

Figure 2

Plain Whorl

Central Pocket Loop

Double Loop

Figure 3

Section I

MAKING YOUR OWN FINGERPRINT CARD
Part 2

Procedure:

1. Pair up with another student
2. Obtain materials. (index card, ruler, pencil, ink blotter)
3. Make a chart on your index card for all ten digits. Label each box for each specific digit.
4. Ink the bottom of each digit of the other person's hand
5. Gently roll the digit on to the index card in the corresponding box.
6. Wash your hands
7. Repeat for the other student.
8. Identify the major points of the prints and the type of each fingerprint.
9. Note these characteristics
10. Record all the necessary information in your notebook
11. Look at other student's prints. Try to become an expert. You will have to identify unknown prints at a later date.

References:

Battle Creek Police Department, Battle Creek, MI

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Section I

FINGERPRINT IDENTIFICATION WORKSHEET

THE FOLLOWING PRINTS ARE OF FELLOW CLASSMATES.
FILL IN A, B, AND C FOR THE FOLLOWING PRINTS
A = IDENTIFY THE TYPE OF PRINT
B = IDENTIFY WHO IT BELONGS TO
C = IDENTIFY WHICH FINGER IT IS

1.
A_______________
B_______________
C_______________

2.
A_______________
B_______________
C_______________

3.
A_______________
B_______________
C_______________

4.
A_______________
B_______________
C_______________

5.
A_______________
B_______________
C_______________

6.
A_______________
B_______________
C_______________

7.
A_______________
B_______________
C_______________

8.
A_______________
B_______________
C_______________

9.

A________________

B________________

C________________

10.

A________________

B________________

C________________

11.

A________________

B________________

C________________

12.

A________________

B________________

C________________

13.

A________________

B________________

C________________

14.

A________________

B________________

C________________

15.

A________________

B________________

C________________

16.

A________________

B________________

C________________

17.
A________________
B________________
C________________

18.
A________________
B________________
C________________

19.
A________________
B________________
C________________

20.
A________________
B________________
C________________

21.
A________________
B________________
C________________

22.
A________________
B________________
C________________

23.
A________________
B________________
C________________

24.
A________________
B________________
C________________

Pam Tejkl

Section II

SHOE IMPRESSIONS

BACKGROUND:

Often times overlooked at the crime scene are footwear impressions or tire marks. In some cases, the impressions are visible and identifiable without the need of further enhancement. In other cases, the impressions are not as easily identifiable and must be enhanced through chemical means in much the same manner as fingerprints. Impressions whether coming from shoes or tire treads may not necessarily prove that a person committed a crime, but it can place a person at the crime scene. Shoe prints and tires have characteristic trend patterns. If a depression, print or skid marks may be match up with the various suspects.

A cast can be made of the shoe depression, or of a tire depression, and this is one way in which to have to students match up the original with the cast. Another way is that a foot impression was left at the scene of the crime. The students will match up the known shoe impressions with a partial print that was left at the scene of the crime on newsprint.

MATERIALS:

Newsprint from crime scene with partial shoe print
known prints from the suspects and the victim's shoes
ruler
magnifying glass
copy machine or camera

PROCEDURE:

1. Obtain the newsprints found at the scene
2. Compare it to the known prints
3. Identify 4 to 5 similarities, note the similarities
4. Determine from the known prints which footwear impressions is a match with the ones found at the crime scene.

DATA:

Your results

newsprint 1 belongs to ________ which shoes? _____
newsprint 2 belongs to ________ which shoes? _____
newsprint 3 belongs to ________ which shoes? _____

EXPLAIN YOUR REASONING:

REFERENCES:

Van Stratton, Detective Mike, Battle Creek Police Department
Revised by Pam Tejkl

Section III

FABRIC EXAMINATION PROCEDURE

BACKGROUND:

In violent crimes, clothing is a source of valuable clues. The fibers from the clothes may adher to the person or the victim. In hit-and-run cases there may find fibers in the grille, radiator, or tires of the vehicle.

Different fabric is made up of different threads. Under microscopic examination the threads are structurally different so hence fabrics can be identified.

types of fibers

animal: wool, silk, camel's hair, and fur
vegetable: cotton, hemp, and ramie
mineral glass wool and asbestos (these fibers are in safe insultation)
synthestic: rayon, nylon, and dacron

PROCEDURE:

1. Prepare a slide for each thread from each fabric.
   a. check the viscosity of the mounting medium. It should be the consistency of thin maple syrup. If it is too thick add small amount of xylene.
   b. wet a small area on the surface of the slide with mounting medium.
   c. place a few strands of thread on a clean microscope slide to the mounting medium
   d. holding the coverslip horizontally in one hand add the mounting medium to it. Use about 1 - 2 drops,
   e. quickly invert the cover slip onto the slide starting at one edge and pivoting the other edge down as illustrated below. This helps eliminate air bubbles.
2. Observe the prepare slides under a compound microscope. Make the necessary comparisons and recordings.
3. Obtain photos of the slides for your case/ presentation may be helpful

References

Van Stratton, Michael, Detective of Forensic, Battle Creek Police Department

Revised by Pam Tejkl

Section IV

HAIR EXAMINATION PROCEDURE

BACKGROUND:

The stray hair found at the scene of the crime has long been considered one of the classic examples of physical evidence. At best the expert can say that two specimens of hair are similar, in this present state of knowledge he may not say that they are identical in source. Nevertheless hair specimens provide valuable exclusion and may help narrow the field of suspects.

Human hair is readily apparent because of the relative diameter of the medulla and the location and distribution of pigment. SEM (scanning electron micro) are used to determine surface characteristics of hair such as scale count, hair shape, scale structure and physical and/or chemical damage. Drug testing: hair will absorb any drug the is ingested, it is an excellent medium for determining long-term drug use. DNA can be analyzed if the root of hairs are left at the scene of the crime, perhaps in the clutched hand of the victim.

Forensic scientist may analyze strands of single hairs using microscopic morphological examination of the internal structure of the hair. The analysis of a suspect hair from a crime scene involves the determination of whether or not the object is a hair or a fiber, if it is hair, which species of animal it belongs to and what degree of association can be made between the crime scene hair and hair from a known source. Hair is a protein substance that grows out of a hair follicle. Hair is shed all the time and humans shed about 250 hairs per day.

Although it is not possible to individualize a single hair (or even a whole group of hairs) to a particular person (or animal), it is possible to associate the unknown hair to an individual to very high degree. This is accomplished by a careful morphological examination which will determine a number of physical characteristics.

The major parts of the hair shaft are the cuticle, cortex and medulla. (See Figure 1.) The cuticle is the outermost or external part of the hair. It is composed of a series of overlapping scales. The patterns are specific to species (Figure 2). The cortex is inside region. The cortex contains the pigment granules of the shaft, the distribution of these granules are helpful in determining the racial origin of the human hair. The medulla is the central portion of the hair shaft. There are three categories: fragmented, interrupted and continuous (see Figure 3).

The cortex of the hair shaft varies from species to species as seen in Figure 4. And Figure 5 represents samples of the roots of hair and their species for example for the root of human hair there is one that has been shed and one that has been pulled out of the scalp.

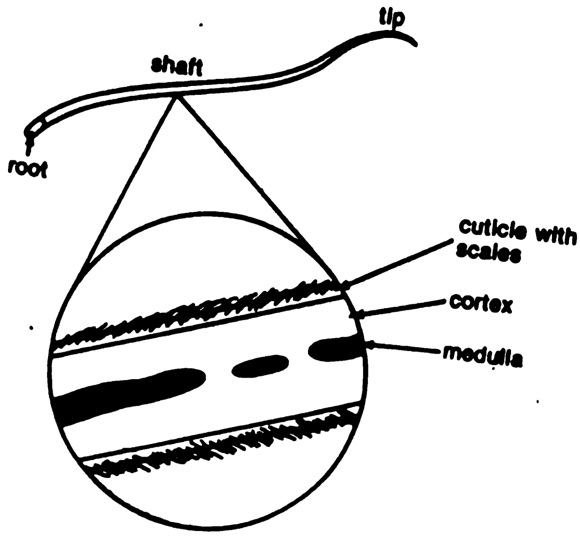


Figure 1

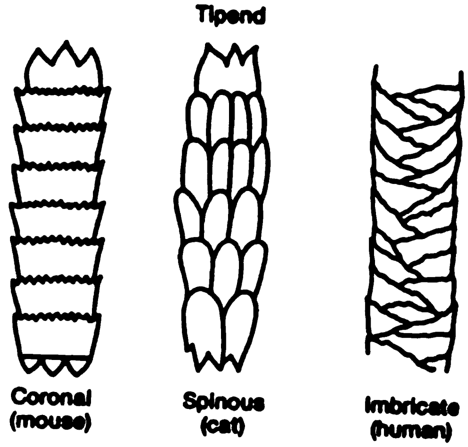


Figure 2

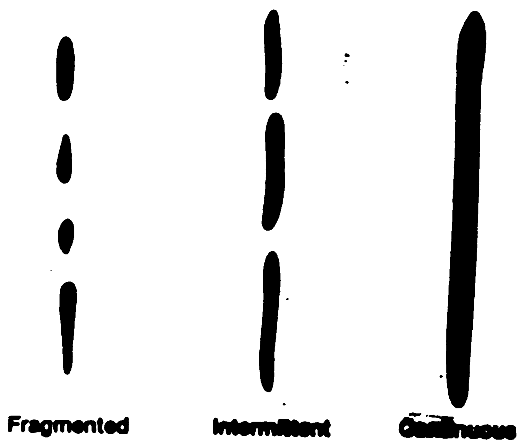


Figure 3

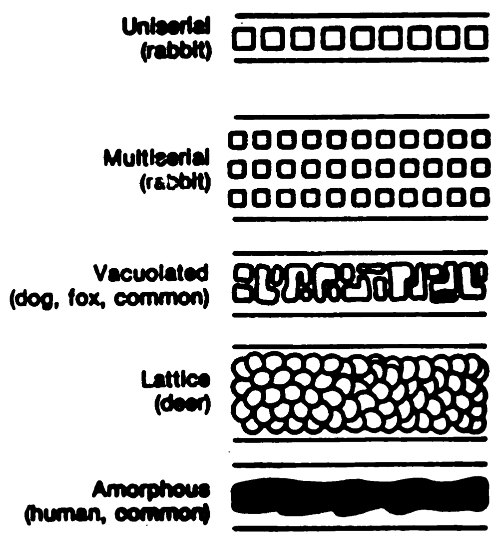


Figure 4

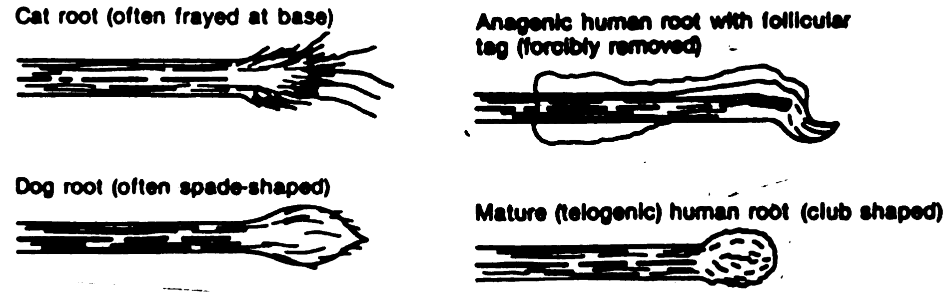


Figure 5

PROCEDURE

1. Prepare a slide for each suspect.
    a. check the viscosity of the mounting medium. It should be the consistency of thin maple syrup. If it is too thick add small amount of xylene.
    b. wet a small area on the surface of the slide with mounting medium.
    c. place a few strands of hair on a clean microscope slide to the mounting medium
    d. holding the coverslip horizontally in one hand add the mounting medium to it. Use about 1 - 2 drops,
    e. quickly invert the cover slip onto the slide starting at one edge and pivoting the other edge down slowly. This helps eliminate air bubbles.

2. Prepare slides of the evidence found at the scene following step one.

3. Observe the prepare slides under a compound microscope. Record your observations.

4. Compare the prepared slides of the suspects to that of the ones found at the scene of the crime.

5. Obtain photos of the slides for your case/presentation.

References:

Van Stratton, Detective, Battle Creek Police Department

Revised by Pam Tejkl

Section V

Paper Chromatography and Ink Analysis Lab

Background:

Chromatography is an important tool of forensic scientist in solving crimes. Using chromatography, ink manufacturers can quickly determine if a competitor has stolen their "secret" formula. Ink chromatography (using paper chromatography technique) is often used in questioned document identification. It is a method of determining the brand of ink used to write the document in question. This is done in conjunction with handwriting comparisons to the suspects. Because each different brand of black ink is a unique mixture of colored molecules, each pattern on the paper or chromatograph is characteristic of the brand of pen used determine the mixture of dyes to make the particular color ink we will use the paper chromatography technique.

Paper Chromatography is a method of separating mixtures by using a piece of absorbent paper. In this process, the solution to be separated is placed on a piece of dry filter paper. This is he stationary phase. A solvent (the moving phase) is allowed to travel across the paper by capillary action. As the solvent front moves, the components of the mixture separate. The components of the mixture that are most soluble in the solvent and least attracted to the paper travel the furthest. The colored molecules that make up the black ink mixture will be distributed by the solvent.

At the scene of the crime a partial note was found in the clutched hand of the victim. You are to determine which pen was used to write the note.

MATERIALS:
Filter Paper
Petri Dishes
Pens
Pencils

Procedure A: <u>For the piece of evidence</u>

1. Obtain the partial note from the evidence bag.
2. Use only a sample of the evidence in case an error is made and the ink is not water soluble.
3. Place the sample of note in the appropriate beaker.
4. Determine the amount of water it will take in order for the paper to make a good wick. (so that the writing is not in the water)
5. Attach the paper so the water can travel up the paper evenly.
6. Remove the paper from the water, just before it reaches the top.
7. Make the solvent front (the water line). Allow it to dry and mark all significant colors.
8. Draw the chromatograph in you lab book and record your results.

* If the ink does not move or separate, this means hat the ink is not water soluble. Try the same procedure using isopropyl alcohol instead of water.

Procedure B: For each of the pens of the suspects

1. Use a pencil to sketch a circle about the size of a quarter in the center of a piece of filter paper.
2. Cut a 1 cm wide wick at one edge of the filter paper.
3. On the circle make a dot with Suspect A's pen and write the letter A next to it with a pencil. Repeat for all other pens, so be sure you space the dots out to accommodate all the pens.
4. Concentrate the dots nine more times keeping track of the pens.
5. Allow the dots to dry before another application.
6. Fill the petri dish about 1/8 of the way full with water. Set the wick of the filter paper into the water. Do not allow your black dots to become submerged into the water.
7. Remove the paper from the water for the inks leave the paper and allow it to dry.
8. Draw the chromatograph and record the colors that have separated from each of the pens in your lab books.

Questions:

1. What procedures did you use to identify the ink from the note?
2. Some components of ink are slightly attracted to the stationary phase and are very soluble in the solvent. Where are these located on the filter paper during chromatography?
3. What can be said about the properties of a component ink that travels only half the distance to the final solvent front?
4. Predict the results of forgetting to remove the chromatogram from water in the petri dish until the next day.

References:

Pawloski, Karen. (1996) Forensic Science in the High School Classroom. Michigan State University, East Lansing.

Van Stratton, Detective, Forensic Department, Battle Creek Police, Battle Creek, MI

Revised by Pam Tejkl

Section VI

Thin Layer Chromatography and Lipstick Dye Analysis Lab

Background:

Lipstick stains left on clothing, glass, napkins and cigarettes provide valuable clues as to the identification of a suspect. Lipsticks are composed of fats, oils, waxes, coloring, perfumes and flavorings. The color of a lipstick in concentration between 15% to 20% is mainly due to aluminum, calcium or barium dyes. A forensics scientists can separate the dyes using thin layer chromatography.

Procedure:

1. Obtain the evidence envelope containing the lipstick smear collected from the window at the crime scene.
2. Cut a 1 x 2 cm section from the evidence. Place it into a spot plate. Cut this piece up further into smaller pieces keeping the pieces within the wells.
3. Now make lipstick smears on kim wipes from the four suspects' lipstick.
4. Prepare them like you did in step 2.
5. Add 5 drops of methanol. (be sure that the pieces are wet and there is some liquid in the well)
6. Prepare the chromatographic plate by notching the end as shown in figure 1. This notching forces the solvent to move through a narrow space, which in the results the dyes will appear as thin bands of color will appear.

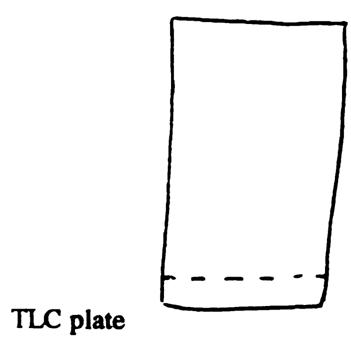


Figure 1

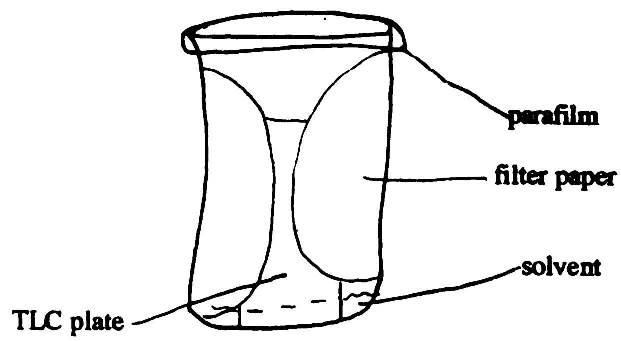


Figure 2

7. Using a capillary tube transfer 10 drops of the lipstick solution onto the thin plate between the notches allowing each drop to dry
before adding the next drop. In this activity there is five samples to compare so there should be five separate slots used.
8. Prepare the developing solvent. Mix 5ml of isoamyl alcohol, 5 ml of acetone, 3.2 ml of distilled water and 0.1 ml of ammonium hydroxide in a 250 ml beaker. Stir with a stirring rod to ensure mixing.

9. Place two pieces of filter paper into the beaker. The filter paper should be leaning against the wall of the beaker with a small portion submerged in the solvent. The paper will absorb some of the solvent and make the entire atmosphere of the TLC chamber. Cover the beaker with parafilm. See Figure 2.
10. Hold the prepared plate next to the chamber and check to be certain that the colored spots are above the solvent line. (rather than immersed within)
11. Uncover the chamber and place the TLC plate into it. Replace the parafilm and allow to stand undisturbed until the solvent reaches the end of the plate.
12. Remove the plate and mark the solvent front by making a notch in the TLC plate.
13. Allow the plate to dry and compare the dyes on each.
14. Measure each band from the point of application.
15. Measure the solvent front from the point of application.
16. Calculate the R_f value:

$$R_f = \frac{\text{distance of sample band from application point}}{\text{distance of solvent front from application point}}$$

17. Compare the evidence with the four known chromatographs.

Data:
Draw and label each of the chromatographs. Show the distance moved and calculate the R_f values.

Conclusions:
State which lipstick was used to write the note and why.

Questions:
1. Why did the lipstick extracts move to different places on the TLC plates?
2. Does this evidence unequivocally prove who wrote the note?
3. Suggest another scenario that might utilize this forensics technique.

References:

Pawloski, Karen (1996) Forensics Science in the High School Classroom. Michigan State University, East Lansing.

Van Stratton, Michael, Detective of Forensic Science, Battle Creek, MI

Revised by Pam Tejkl

Section VII

Mathematics of Bloodstain Pattern Interpretation Analysis

One of the most important aspects in bloodstain pattern interpretation is the ability to determine the location of a point of impact by the angles of a bloodstains' pattern on a target surface. To understand how this is accomplished it is necessary to understand the mathematical functions of right triangles. Many of you will remember functions of the sine, cosine and tangent from high school geometry or trigonometry. Some of you will understand this better than others, but it will not prevent anyone from using the formulas involved and arriving to the proper conclusions.

We have previously mentioned the importance of the viscosity and surface tension as it relates to blood. Depending upon the volume of blood, in particular a drop, it will assume the smallest size and area possible, a sphere. This spherical shape allows that drop of blood to travel in one plane. You could say its ballisticaly true. Its this round spherical shape that allows us to determine the angle of impact of a bloodstain of a target surface.

To better understand the relationship between the target and the spherical shape of a drop of blood it is necessary to understand a little about right triangles and their functions. We will discuss only those functions that relate to determine point of impact and origin of impact. These functions fro a right triangle are defined as follows; (Figure 1), triangle ABC has a right angel (90 degrees) at C and sides of length *a, b, c*. The trigonometric functions of angle A are;

sine of A = sin A = a/c = side opposite/hypotenuse
tangent of A = tan A = a/b = side opposite/side adjacent

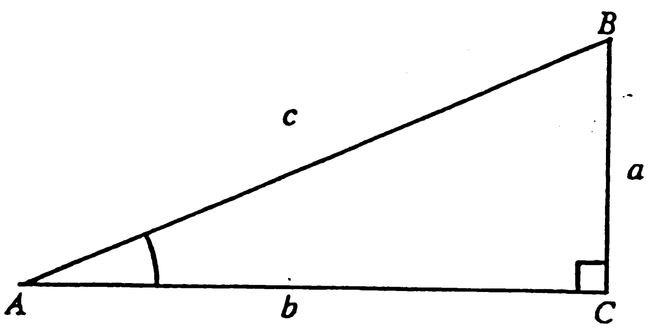


Figure 1

To better understand this relationship between a drop of blood and target surface, examine Figure 2. Here the drop of blood has taken the shape of a sphere. The opposite sides of the sphere are designated as A-B. In a sphere all sides are symmetrical. For that reason A-B is equal to C-D.

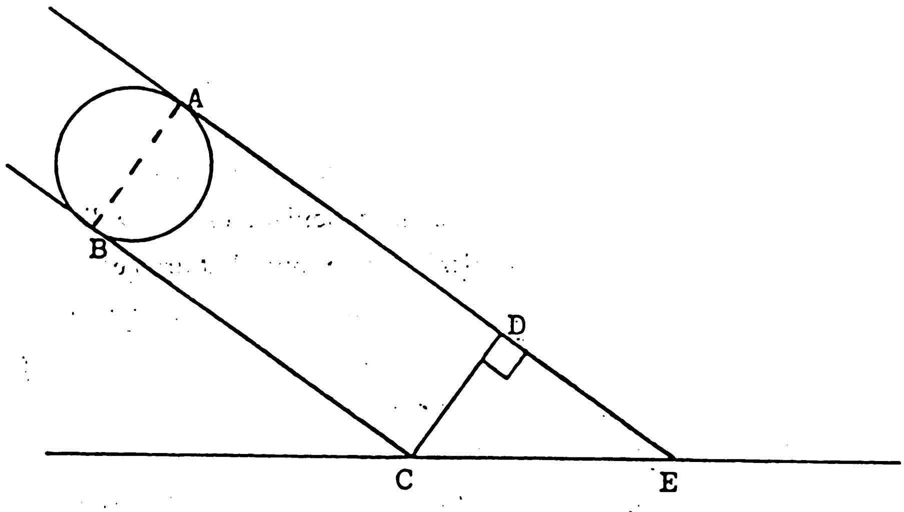


Figure 2

At this point we can see the relationship of C-D, D-E, and C-E. We have formed a right triangle. Point A-B and C-D represents the diameter of the bloodstain, which is also equal to Aa-Bb in Figure 3. The length of the bloodstain is C-E in Figure 2, is represented as Cc-Ee in Figure 3.

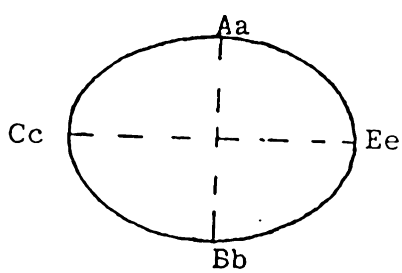


Figure 3

By measuring the width and the length of the bloodstain we can determine the sine of the angle E which is:

$$\text{sine of angle E is} = \frac{\text{side opposite (the width of the bloodstain) Aa-Bb}}{\text{hypotenuse, Cc-Ee}}$$

This formula can then be applied to determining the angle of impact of a bloodstain.

$$\text{sine of the angle is} = \frac{\text{Width}}{\text{Length}} \qquad \text{therefore,}$$

Example:

Width = 12 mm
Length = 24 mm

Sine = 12/24
= 0.500

= 30 degrees

Using your calculator, simply divide the width of the bloodstain by the length, then push the INV(invert) button and then the SIN(sine) button and the angle of impact will be displayed.

Determining Origin of Impact

There are certain steps that must be followed in determining the origin of impact of a bloodstain pattern.

STEP 1: The first thing to do is identify our bloodstain pattern by the size, shape and distribution of the bloodstains. If there is a sufficient amount of impact stain present we can determine the location from which the bloodstains originated. First of all we use only those bloodstains which show the same directionality and have not been acted upon by gravity. Only through practice, experimentation and actual field work, will you be able to make accurate observations and conclusions. Mark each bloodstain you are using and measure the width to length ratio to determine the angle of impact. (Figure 4).

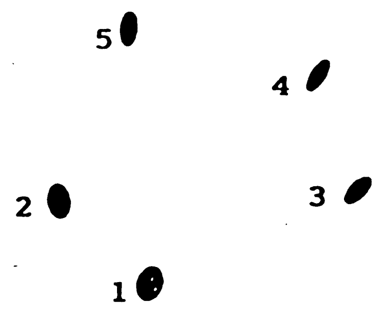


Figure 4

STEP 2: Once you have identified the stains you are going to use, place a piece of string through the center of the long axis of the stain. This string should be long enough that when other bloodstains are marked accordingly they converge at a common location. This point is referred to as the point of convergence. You may find that not all of the stains will converge on the same location. This may indicate overlapping impact bloodstain patterns which would be consistent with the victim being struck numerous times in the same general area. See Figure 5.

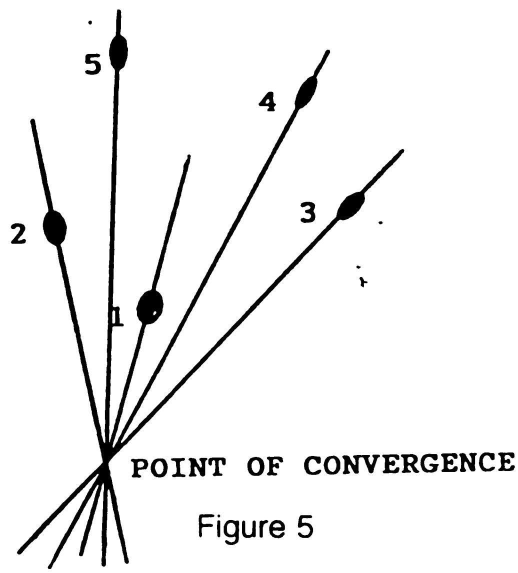


Figure 5

STEP 3: Lets assume that the bloodstains in Figure 5 are located on the vertical surface of a wall. From our point of convergence we can project a perpendicular line. Its on this line that we will be able to determine the location (distance from width and height above the floor) that the impact occurred. See Figure 6.

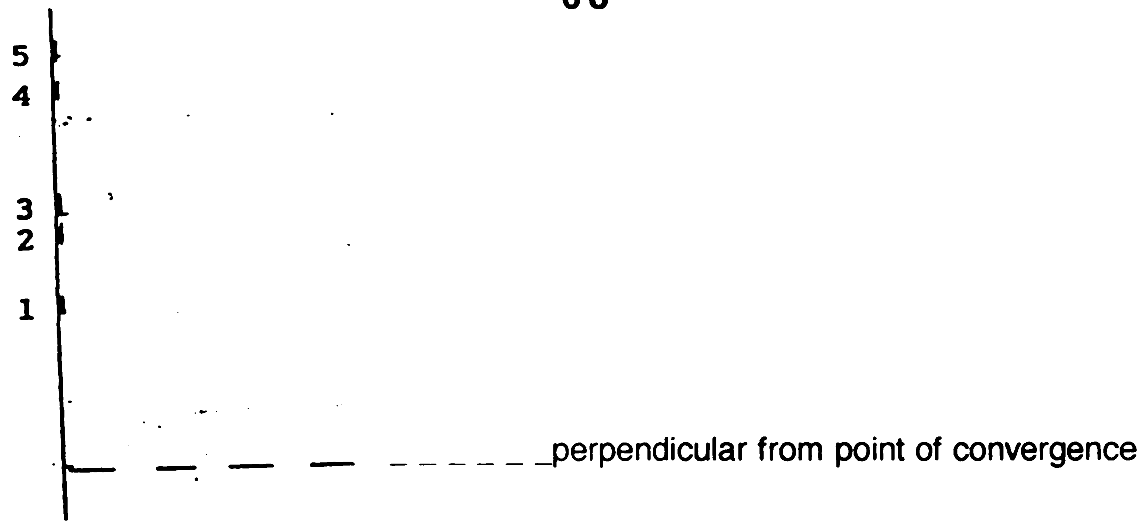


Figure 6

<u>STEP 4: </u>Next take a piece of string, the length will depend upon he distance form the bloodstain to the point of origin, and tape one end of the string to the center of the bloodstain. Place the center of your protractor onto the center of the bloodstain next to the string which you just attached. Next move the string along the surface of the protractor which is parallel to the major axis of the bloodstain. When the angle of the stain is reached on the protractor, the opposite end of the string should be attached to an object, such as a ring stand, which is perpendicular form the point of convergence. This procedure is followed with each of the bloodstains. Its at this point or proximity that the impact bloodstains originated. See Figure 7.

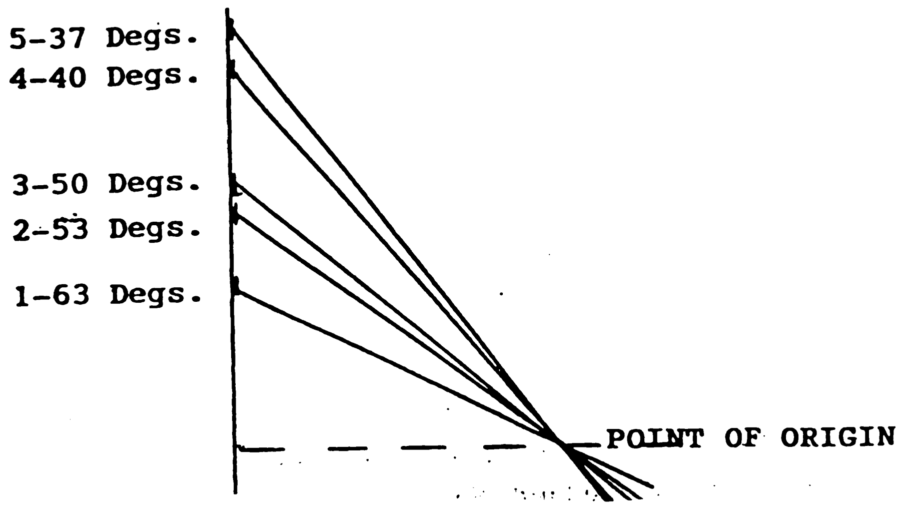


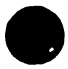
Figure 7

Practice Sheet for Determining Angle of Impact

W = width of the drop of blood

L = length of the drop of blood

sine of W/L = degree for angle of impact

1.  W _______/L _______ Degrees ________

2.  W _______/L _______ Degrees ________

3.  W _______/L _______ Degrees ________

4.  W _______/L _______ Degrees ________

5.  W _______/L _______ Degrees ________

More Bloodstain Mathematics

In the beginning it was stated that there were two formulas relating to right triangles which we would be using. The one concerning the sine of an angle has been explained. The other formula pertains to determining the origin of impact. This is a much quicker way of finding the origin of impact then the previously stated steps. Keep in mind that you should use more than one or two angle of impact when using this formula because you may have overlapping bloodstain patterns. To use this method you must have two bloodstains. A string should be placed through the major axis of each bloodstain. These strings must converge to use this formula.

To determine the point of origin we must know the angle of impact of one of the two bloodstains (A) and the distance from the center of that bloodstain to the point where the two bloodstains converge (D). In our trigonometric functions of a right triangle we know that the tangent of angle A is expressed like this:

tangent of A = tan A = *a/b* = side opposite/side adjacent

If you know angle A, the distance of the side adjacent, that being the distance between angle A and the point of convergence. We need to know is the height of the side opposite of angle A, which in our case is the point of origin of the impact bloodstain. Since we know two of our values we can determine the third. See Figure 8 .

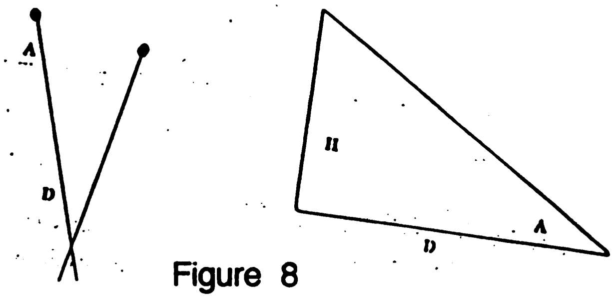


Figure 8

Summary:
formula: the tan of an angle is = H/D
where angle A = known angle of impact
D = distance of the first intersecting stain
H = Unknown distance above the target

References:

Van Stratton, Detective Forensic Science, Battle Creek Police Department, Battle Creek, MI
Revised by Pam Tejkl

Section VIII

Is It Blood? Is It Human Blood?

Red stuff left at the scene of the crime

Blood is often left at the scene of a crime. The criminalist must be prepared to answer the following questions when examining the red stuff left at the scene of the crime.

1. Is it blood?
2. Is it human blood?
3. If it human can they characterize the blood type?

Is It Blood?

By treating a stained area with phenolphthalein and hydrogen peroxide it can be determined whether or not a stain is blood. A deep pink color will develop when the blood's hemoglobin reacts with the hydrogen peroxide and phenolphthalein.

(Obtaining blood from a local veterinarian clinic can be used safely in the classroom lab. A mixture of ketchup and coffee can give an appearance of blood without the hemoglobin)

Is It Human Blood?

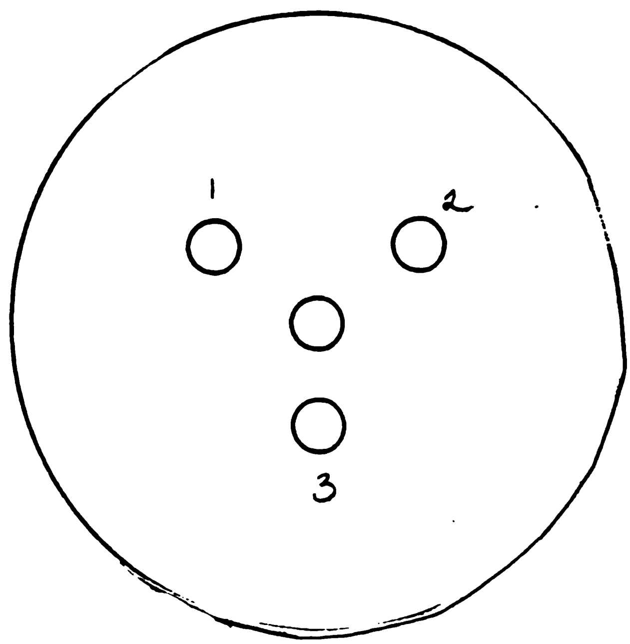
Once the stain has been characterized as blood the technician must determine if the stain is human.

The test is based on the fact then when animals usually rabbits are injected with human blood. The animal produces antibodies as an immune response to the invading human blood cells. The technician can then recover these antibodies from the rabbit (or other animal used) by bleeding the animal and isolating the sera. This serum will contain antibodies that specifically bind to human antigens. For this reason the serum will be known as human anti-serum. In the same manner, by injecting rabbits (or other animals) with other known animal blood other antisera can be produced.

Using an ouchterlony diffusion method is helpful in the determination using the process of gel diffusion and taking advantage of the fact that antigens and antibodies will move toward each other on a gel plate. Here, the extracted bloodstain (simulated) and the human antiserum are placed in separated wells opposite of each other on the gel. If the blood is of human origin, a line of precipitation will form where the antigens and antibodies meet. This test is extremely sensitive and require only a small thread if blood soaked material. Human bloodstains dried as long as 10-15 years still provide positive results. Extracts from mummies 4000-5000 years old have given positive results.

Procedure:

1. Put goggles on.
2. Use a straw to bore four holes (see pattern) into the agar with your petri dish.
3. Remove the agar plugs carefully. Using a toothpick.
4. Label the wells (agar openings) 1, 2, 3
5. Fill each well with the corresponding solutions. Fill the center hole last.
   solution 1 (well 1) = anti-sera for rabbit
   solution 2 (well 2) = anti-sera for bovine
   solution 3 (well 3) = anti-sera for human
   solution 4 (center well) = crime scene blood sample



What can you conclude?

Pam Tejkl

Section VIII

TEACHER'S GUIDE

BLOOD TYPING

Among various types of evidence, blood has a good chance at being left at the scene of the crime.

History of blood transfusion: Before the discovery of the glycoprotein antigens on the surface of erythrocytes in 1900, medical transfusions have been a possible life-threat because they did not understand. Since 1900, medical transmissions have been carried out safely without fear of patient rejection.

With the prevalence of serious blood-borne transmitted diseases-the use of human blood in laboratory is prohibited. This lab is a simulation to represent the related concepts of human blood grouping, antigens, and antibody reactions.

Materials:

Type A:	200 ml of 5% skim milk (10 ml milk diluted with water to a volume of 200 ml) Keep refrigerated when not in use.
Type B:	200 ml white vinegar
Type AB:	200 ml of %1 skim milk & enough vinegar (drop by drop) to the point just before they "agglutinate" this needs to be done minutes before the students use it.
Type O:	200 ml water

(Add approximately 20 drops of red food coloring to give the appearance of blood)

Anti- sera A white vinegar
Anit- sera B 5% skim milk

A preliminary classroom discussion on the role of blood typing, antigens and antibodies and population studies, paternity suites, etc. is necessary. The gradual clumping of milk particles by the vinegar is the bias for evidence for agglutination of incompatible types i.e. the anti serums. The acetic acid in the vinegar chemically precipitated milk protein casein) into partially insoluble curdles.

References:

Arico, Anthony (1995). Blood Type Compatibility. *The American Biology Teacher,* 57(2), 108-110.

Appendix B

Survey Forms

Section I: Pre-Unit Survey....................................75

Section II: Pre-blood Survey.................................76

Section III: Interest Level Survey.........................77

Section IV: Post-Unit Survey.................................78

Section V: Interview Questions..........................79

PRE-UNIT SURVEY

The following is a survey that I will be using as part of my thesis. Please take the time to answer the questions completely concerning the content. Respond by circling the numbers between 1 and 5.
(1 = very little knowledge and 5=a lot of knowledge)

Please read the subject area listed at the left, and rate the level of knowlegde you for each topic. **If you do not know very much in any or all these topics, do not worry about it.**

1. document evaluation	1	2	3	4	5
2. forensiccs anthropology	1	2	3	4	5
3. forensics palenotology	1	2	3	4	5
4. forensics entomology	1	2	3	4	5
5. fingerprinting	1	2	3	4	5
6. fiber analysis	1	2	3	4	5
7. hair analysis	1	2	3	4	5
8. blood and body fluids	1	2	3	4	5
9. DNA evidence	1	2	3	4	5
10. arson	1	2	3	4	5
11. crime scene procedures	1	2	3	4	5
12. lipstick dyes	1	2	3	4	5
13. water based ink dyes	1	2	3	4	5
14. thin layer chromatography	1	2	3	4	5
15. paper chromatography	1	2	3	4	5
16. stereo microscopy	1	2	3	4	5
17. light microscopy	1	2	3	4	5
18. Spectr 20	1	2	3	4	5
19. Blood stain analysis	1	2	3	4	5
20. Blood typing	1	2	3	4	5
21. footwear impressions	1	2	3	4	5

a. Did you follow any of the evidence presentation during the O.J Simpson? Explain what you understood. (CONT. ON BACK IF NEC.)

b. Do you remember what you didn't understand? Please write them here.

Pre-blood/forensic survey

Please answer the following questions the best you can, you are not going to receive a low grade if you do not know the answers.

1. Do you know your blood type? If you do, what is it?

2. Have you ever received a blood transfusion? (if you have had surgery, you may have)

3. What does blood type mean? As a human can we receive any human's blood?

4. What is in blood?

5. What is the difference between RBC and WBC? RBC: red blood cells. WBC: white blood cells (besides the color)

6. What is an antigen?

7. What is an antibody?

8. If an expecting mother has type A blood and the father has type O, what are the possible blood types that the baby will have? Explain

INTEREST LEVEL SURVEY

Now that we have completed the forensic science unit, please indicate your interest level for the following area while we were studying them.
0 = no interest
1 = a little interest
2 = moderate interest
3 = high interest

1. document evaluation	0	1	2	3
2. forensiccs anthropology	0	1	2	3
3. forensics palenotology	0	1	2	3
4. forensics entomology	0	1	2	3
5. fingerprinting	0	1	2	3
6. fiber analysis	0	1	2	3
7. hair analysis	0	1	2	3
8. blood and body fluids	0	1	2	3
9. DNA evidence	0	1	2	3
10. arson	0	1	2	3
11. crime scene procedures	0	1	2	3
12. lipstick dyes	0	1	2	3
13. water based ink dyes	0	1	2	3
14. thin layer chromatography	0	1	2	3
15. paper chromatography	0	1	2	3
16. stereo microscopy	0	1	2	3
17. light microscopy	0	1	2	3
18. Spectr 20	0	1	2	3
19. Blood stain analysis	0	1	2	3
20. Blood typing	0	1	2	3
21. footwear impressions	0	1	2	3

1. How did you like this unit? What did you like about it? What didn't you like about it?

2. For the areas in which you have a 1 or less, please let me know how it could be done to increase you interest level.

3. Other comments/suggestions. (use back if nec.)

POST-UNIT SURVEY

The following is a survey that I will be using as part of my thesis. Please take the time to answer the questions completely. Respond by circling the numbers between 0 and 3.

My knowledge for the following has
- 0 = not changed
- 1 = increased slightly
- 2 = increased some
- 3 = increased a lot

1. document evaluation	0	1	2	3
2. forensiccs anthropology	0	1	2	3
3. forensics palenotology	0	1	2	3
4. forensics entomology	0	1	2	3
5. fingerprinting	0	1	2	3
6. fiber analysis	0	1	2	3
7. hair analysis	0	1	2	3
8. blood and body fluids	0	1	2	3
9. DNA evidence	0	1	2	3
10. arson	0	1	2	3
11. crime scene procedures	0	1	2	3
12. lipstick dyes	0	1	2	3
13. water based ink dyes	0	1	2	3
14. thin layer chromatography	0	1	2	3
15. paper chromatography	0	1	2	3
16. stereo microscopy	0	1	2	3
17. light microscopy	0	1	2	3
18. Spectr 20	0	1	2	3
19. Blood stain analysis	0	1	2	3
20. Blood typing	0	1	2	3
21. footwear impressions	0	1	2	3

Please list the three lab activities in which you have learned the most.

Please list the three lab activities in which you have learned the least.

Interview Questions
(Many times more questions would be asked to probe the students' understanding.)

What does forensic science mean to you?
How has that changed from before we started this unit?
Does science relate to forensics? How?
Does math relate to forensics? How?
Does technoloty relate to forensics? How?

Did you like this forensic science unit?
What did you like about it? Specially what worked for you? why?
What could be improved?

I would check for understanding my asking them specific questions about the activities and sometime would have them map out their understanding.

Appendix C

Assessment Forms

Section I: Spec20Quiz..81

Section II: ForensicsTest..82

Section III: Worklog...86

Section IV: ParticipationRubric....................................87

Section V: Presentation and Poster Rubric..........88

Spec 20/Forensics Quest

1. Explain using an illustration what a serial dilution is.

2. What can a spec 20 be used for? (As far as a chemist or a forensic scientist is concerned)

3. What does the spec 20 measure and how does it do this?

4. **Graph** absorbance vs. wavelength of methylene blue for the spec 20 lab. Use the data table provided below.

cuvette =	1	2	3	4	5	6
wavelength(nm)						
380	.95	.50	.54	.37	.19	.19
420	.80	.47	.48	.33	.17	.08
460	1.40	.55	.52	.37	.17	.08
580	2+	2.00	1.50	1.35	1.20	1.10
660	1.20	1.10	.80	.80	.50	.30

absorbance (above)

5. a. What is the peak wavelength? Why?
b. If the concentration for cuvette #1 was 0.125 mg of methylene blue, figure out the concentrations for the other cuvette:
number 2 = ______mg
number 3 = ______mg
number 4 = ______mg
number 5 = ______mg
number 6 = ______mg

c. Graph absorbance vs. concentration for the values for this peak wavelength.

d. Determine the concentration of the following unknowns with the following absorbencies.
a. #7 has absorbance of 1.8, therefore the concentration is _______.

b. #8 had absorbance of 1.45, therefore the concentration is _______

Forensics Test

Choose the best answer, use the answer sheet and justify your answers.

1. A lab technician conducted an experiment to see if the red stuff on some bib overalls was blood. With the reaction using phenolthalin and hydrogen peroxide the sample turned _______ to indicate that the sample was blood.
a. green b. blue c. pink d. yellow

2. When an experiment was conducted with different sera, the _____________ reacted with the sample, meaning the blood was determine to be rabbit.
a. anti-human b. anti-rabbitc. anti-bovine d. anti-canine

3. Determine the angle of impact for the following blood stain

a. 24 b. 26 c. 30 d. 34

4. This red blood cell has no antigens on it's surface.
a. type A blood b. type B c. type AB d. type O

5. This blood type doesn't have antibodies for A or B.
a. type A blood b. type B c. type AB d. type O

6. This blood type has anti-A antibodies.
a. type A blood b. type B c. type AB d. type O

7. This blood type is sometimes called the universal donor.
a. type A blood b. type B c. type AB d. type O

8. What kind of pattern does this fingerprint represent?

a. arch b. whorl c. loop

9. What kind of pattern does this fingerprint represent?

a. arch b. whorl c. loop

10. If a child is born with type B blood and the mother has type A blood, what type of blood does the father need to be?

11. T or F There are tiny sweat glands between the groves that form our fingerprints.
a. true b. false

12. The forensic project is worth how much of your grade?
a. 20% b. 30% c. 40% d. 50%

13. T or F It really doesn't take much time to collect the evidence and determine what is evidence and what isn't.
a. true b. false

14. What are the first insects to the scene of a crime?
a. maggots b. killer bees c. flesh flies d. black flies

15. What does a forensics pathologist do?
a. they study tissues
b. they study body fluids
c. they study blood stains

16. What happens when you stand up quickly?
a. Your blood goes directly to your head as soon as you stand up.
b. Your blood goes directly to your head as quickly as it can but is delayed somewhat.

17. What is the purpose of using a spec 20?
a. to determine the concentration of an unknown
b. to analyze unknown substance and determine the concentration
c. to show how a mini-breathalyzer works
d. all of the above

18. Why is it important that you use the peak wavelength?
a. to get the highest wavelength
b. to determine the best wavelength
c. to figure out the concentration

19. Why is it important to label graphs and data tables
a. to know what it stands for later on
b. so others can follow
c. so you can follow
d. so the teacher can grade it easier
e. all of the above

20. How many times does a person have to be hit with a blunt object in order to have blood splatter walls?
a. once
b. twice
c. more than twice

21. How is a DNA fingerprint like a grocery bar code?
a. because we all can be scanned to check out net worth
b. because of the cells look like it
c. because the DNA fragment are separated similarly to a bar code

22. Who was Tommie Lee?
a. He was the first guy in England that they used the DNA technique on and sent him to jail.
b. He was the wood chip murder.
c. He was a blood stain expert.
d. He was none of these above.

23. What is a serial dilution?
a. a breakfast dilution
b. a dilution that is 1/10 of the original and continues
c. a dilution that is 1/2 of the original and continues

24. Why did we use black paper when we lifted fingerprints?
a. to contrast the carbon powder
b. to contrast the aluminum powder
c. the tape worked best with it

25. Who was Dr. Lee?
a. He was the first guy in England that they used the DNA technique on and sent him to jail.
b. He was the wood chip murder.
c. He was a blood stain expert.
d. He was none of these above.

26. Name two deja vu items from the second article (this doesn't pertain to the first article). You need two answers here.
a. the author
b. the source
c. the date
d. the case study

27. Which of the following is not part of a nucleotide?
a. water
b. phosphate
c. sugar
d. base

28. What are restrictive enzymes analogous to?
a. probes
b. scissors
c. gels
d. ladders

29. Which of the following is not a DNA base?
a. adenine
b. cytosine
c. guanine
d. uracil
e. thymine

30. How might PCR be a problem in a forensic lab?
a. If there is a contamination then that will be replicated again and again.
b. PCR doesn't always work.
c. The results may be misinterpreted.

Short answer section

1. What does DNA stand for?
2. How are insects used in forensics?
3. How is chromatography used in forensics science?
4. Name four reasons why we study blood?
5. Explain the main steps (at least 5) of gel electrophoresis
6. Explain how are shoe impression are useful in forensic even if there are 4 people with the exact same type of shoe and are the same size.
7. Summarize one of the two assigned articles

LOG FOR 3/18: TO BE TURNED IN AT THE END OF THE DAY.

1. RECORD TIME ON TASK

   STARTING TIME: ENDING TIME:

2. WHAT ARE YOU WORKING ON?

3. HOW CLOSE ARE YOU TO COMPLETION?

4. WHAT ELSE NEEDS TO BE DONE?

5. YOU NEED TO TURN IN AN OUTLINE OF YOUR PRESENTAION AT THE END OF THE HOUR. STAPLE IT TO THIS FORM.

6. IF YOU HAVE A PARTNER. DESCRIBE THE WORK LOAD THAT YOU AND YOUR PARTNER HAVE DONE SO FAR AND HAVE LEFT TO DO.

7. HOW MUCH TIME DO YOU NEED FOR YOUR PRESENTATION?

PARTICIPATION RUBRIC
FOR 3/18 THRU 3/21

Everyone is starting on 3/18 with 100% of the total points possible (there is a different participation grade for before 3/18)

How does one lose points?

1. By not being on task
2. By not being cooperative
3. By not working the whole class time
4. By not listening when others are presenting
5. By not listening when the teacher is talking
6. By not grading the presentations fairly/accurately when asked.

PRESENTATION AND POSTER RUBRIC

Presenters: Grader:

Rate with 1 being the lowest and 5 the highest

1. Are the presenter(s) making it interesting?

   1 2 3 4 5

2. Is the presentation .....presented well? (DOES IT LOOK LIKE IT HAS BEEN PRACTICED?)

   1 2 3 4 5

3. How well do they answer the overall questions?

   1 2 3 4 5

4. Is the poster neat and complete?

   1 2 3 4 5

5. Is the space used well on the poster (ie so it isn't all text)

   1 2 3 4 5

6. How well did they teach it?

   1 2 3 4 5

7. Were they creative?

   1 2 3 4 5

Total points ______________

Appendix D

Matrix

Section I: Matrix for Unit A 90

Section II: Matrix Explanation 91

Crime Matrix for Unit A

teams	fprts	incm fprt	DNA	BLOOD type	cloth	HAIR	FIBER	foot wear	INK	lip STICK	bite MARK	SUSPECT
1	E, F, G, I	A	V	O	-	A, V	CO/W	A	C	A	D	A
2	A, B, C, H	E	V	O	-	E, A	R/CO	G	E	C	A	E
3	B, F, G,H	-	C	A	-	C	S/R	H	G	C	E	C
4	A, B, C, D	-	V	O	+	B, V	W/N	B	A	F	F	B
5	E, I, B, H	-	A	A	-	A, V	R/CO	E	I	A	B	A
6	C,H,A, E	-	G	O	-	G	R/W	F	B	E	I	G
7	E, H, C, F	-	V	O	+	H, D	R/N	H	E	C	F	H
8	F, B, D, G	F	V	O	-	F, V	S/N	D	D	F	G	F
9	F, H, C, D	-	C	A	-	C	S/W	C	V	A	C	C
10	B, I, G, A	-	V	O	+	B	W/S	B	F	F	G	B
11	C, G, I, A	-	D	A	-	D	CO/W	A	C	C	H	D
12	D, I, A, H	C	V	O	-	C, V	S/W	G	H	E	C	C
13	E, F, B, G	-	I	O	-	I	R/W	I	V	C	D	I
14	F, B, C, H	-	V	O	+	B, V	W/S	B	F	E	E	B
15	H, I, D, E	G	V	O	-	G	R/CO	C	H	C	H	G
16	E, A, C, G	-	D	A	-	D	R/CO	E	G	A	B	D
17	F, D, B, C	-	V	O	+	H	N/R	F	V	A	A	H
18	A, I, E, H	F	V	O	-	F	R/S	A	I	A	A	F
19	G, C, F, B	-	V	O	+	H	S/N	H	B	C	I	H
20	F, G, AH	-	I	O	-	I	W/CO	G	V	E	B	I
21	E, I, H, D	A	V	O	-	A	CO/S	C	A	F	C	A

FIBERS:
- CO: COTTON
- S: SILK
- R: RAYON
- N: NYLON
- W: WOOL

FOR A-V REFER TO SUSPECT SHEET

Crime Matrix Explanation:

There were twenty two teams. There were eleven categories in which the evidence would be postive for the suspect or victim. For example, team 1 had four fingerprints for the suspects (E, F, G, I) and the DNA evidence was for suspect A, while the hair was the victim's, etc. The matrix was used in setting up the evidence producing the correct suspect.

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