

Science/Mathematics Crime Investigation
John Graves, Mike Pierre
Monforton School, Bozeman, Montana
<http://www.opi.mt.gov/msta/bestlessons.html>

Background Story:

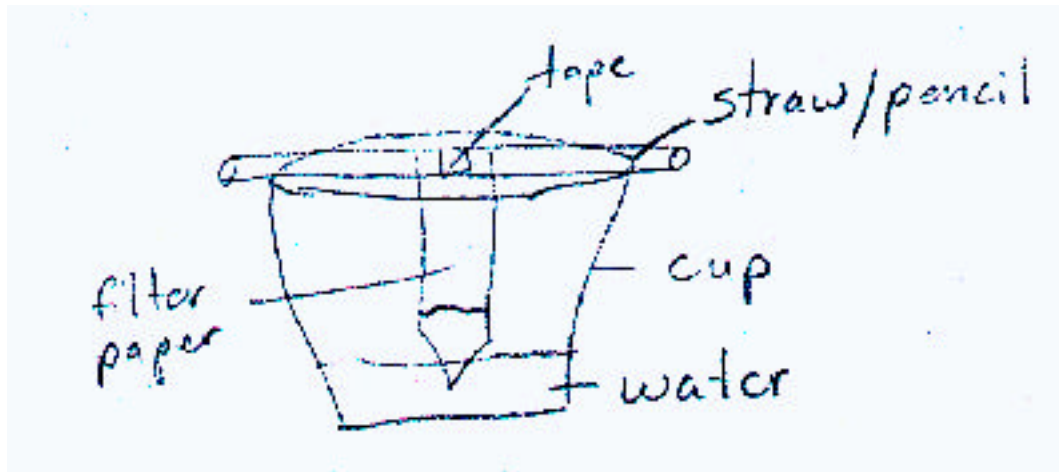
Egads! A crime has been committed. Your task is to use your mathematics and scientific skills to analyze clues, collect data, collaborate with colleagues and find the guilty party. Good luck.

You each received a colored piece of paper when you entered the room. These are your "expert" groups. Each person in the expert group will conduct one scientific and one mathematics investigation of the crime from evidence gathered from each of four suspects. After the investigation, you will take your expertise to a "crime solution team" of four members, each from a different "expert" group. The crime solution team will be given samples of evidence from the actual crime scene and you must analyze that information and come to a group consensus as to the guilty party. Remember, each person has conducted a separate investigation and brings expertise to the team.

The crime: At the Science/Math Club's Annual Dinner Meeting on the night of April 1, a bottle of priceless wine was stolen from the wine cellar. The disappearance of the wine was reported at 2:15 am by restaurant owner, L. Andersen, who had returned to his restaurant to get a bottle of wine for a picnic gathering the next day. Police were on the scene in less than 3.14 minutes. The four suspects, Ken, Cyn, Rudy and Liz, are all employees of the club and were the only ones still in the club the night of the crime. Several pieces of evidence were gathered from the crime scene. You will be given the suspect evidence first in your expert groups. Time to analyze the evidence, take notes, etc. will be allowed before that evidence is taken away and you are placed in crime solving teams. You will not be able to compare the actual samples of each suspect against the crime scene evidence, so good recording strategies are necessary. Each team will then be given evidence from the actual crime scene and the task will be to determine who stole the wine based on the evidence you've analyzed. Remember, there may not be a "perfect" match...so work carefully.

Chromatography investigation: A note was found at the crime scene. It read: "No More Whining...the Wine's Now Mine!" You have paper samples with pen marks from pens that each of the suspects had in their possession the night of the crime. Using chromatography techniques, analyze the different pens.

Chromatography setup:



Lipstick samples: Each of the suspects had lipstick smears on their clothing. Samples have been included here for analysis. As you know, lipstick, although similar in appearance in white light, may look quite different under black light conditions.

Qualitative analysis: A number of powders were found on the clothing of each of the suspects. Using vinegar, iodine solution, water and hand lenses, analyze the powders of each suspect.

Liquid Analysis: Each suspect had liquids in glasses they were carrying when the police arrived. Your task is to determine the pH of each of the suspect's liquids.

Notes to the Teacher

Science Setup

- Design a crime to fit your setting. Use people in your school and make it as realistic as possible. I actually had one of the secretaries come in one time and report the crime, taking the kids totally by surprise. A follow-up to the activity would be to have the students share with the class who they think is the guilty party, have the suspect come to the class and hear the evidence and get a "confession" to the crime. I also had a police officer in once to talk about criminal investigation and the science/math/language arts/problems solving skills necessary for such a position. A further extension would be to work with a social studies teacher and hold a trial and use the evidence gathered in this activity in the trial. This is a great activity to stress the need for accurate data collection.

The following suggestions are listed to assist you in setting up the science investigation component of your crime. The initial setup is a bit time-consuming, but with planning and an effective organization/management system, materials can be saved from year to year and it will take very little time to get things ready for future use.

- Chromatography. Locate a number of different water soluble black pens. Write a message or simply put a mark on a piece of coffee filter paper. Cut the paper into strips and place them in each suspect's envelope. Make enough so that every group can have the suspect evidence at once. Do the actual "crime scene" evidence at the same time. I make up enough crime scene packets so that every group can have a complete set. I purposely "mislead" students by including a few "wrong" pieces of evidence in the crime scene packets. This eliminates the temptation for groups to look at one or two pieces of evidence and draw a conclusion as to the guilty party.

- Powders. Use powders available to you. Choose the number of powders you want the students to analyze. Place small amounts in the suspect packets, enough for every group to work on at the same time. Decide what tests you will allow students to perform. Possible tests include water, vinegar, iodine, heating, pH, etc. Prepare the crime scene evidence at the same time. Again, I have the majority of the crime scene evidence of powders point to one suspect, but some "misleading" clues are also included. I keep a record of what crime scene packets have which misleading clues so I don't end up with a second suspect.

- Liquids. This is done the same as the powders. I use liquids with a wide variety of pH's. Clear liquids work best so students can't distinguish due to color.

- Lipstick. This one is actually very difficult. It is one in which I often allow the students to "match" the crime scene lipstick smear with the suspect smears. Analyze under black light.

- Refraction gradient of glass. Pyrex glass has the same refraction gradient as

vegetable oil, therefore the glass will disappear in the oil. I use baby food jars of broken glass for each suspect. Glass from pop bottles, windows, Pyrex test tubes, etc. is used. This can be very dangerous due to the possibility of students getting cut. Use good judgment with this one.

- Fingerprints. Have students analyze fingerprint samples from the suspects. Again, actual samples may be needed to match up with the crime scene evidence.
- Hair. I think you get the idea.
- Bits of clothing. This is especially good if you can get different fabrics of the same color. Students use magnifying glasses or hand lenses.
- Soil samples. Students can analyze these for color, content, pH, etc.

The task of the crime solution teams is to determine which of the suspects is most likely the criminal. After completing your investigations, be prepared to give a report to the group stating the following:

- who you think is the guilty party
- the pieces of evidence that your group feels gives support to your claim

Sample Matrix for Setting Up Crime Material--Science

Powders

Cyn: corn starch	Rudy: corn starch	Liz: powered milk	Ken: milk
Cyn: baking soda	Rudy: baking soda	Liz: corn starch	Ken: borax
Cyn: borax	Rudy: borax	Liz: baking soda	Ken: corn starch

Crime Scene: baking soda, corn starch, borax

Liquids

Cyn: hydrochloric	Rudy: hydrochloric	Liz: vinegar	Ken: hydrochloric
Cyn: sod. hydrox.	Rudy: sod. hydrox.	Liz: sod. hydrox.	Ken: vinegar
Cyn: vinegar	Rudy: hydro. perox.	Liz: hydro. perox.	Ken: water

Crime Scene: hydrogen peroxide, sodium hydroxide, hydrochloric acid

Lipstick

Cyn: type 1	Rudy: type 3	Liz: type 3	Ken: type 4
-------------	--------------	-------------	-------------

Crime Scene: Type 3

Chromatography

Cyn: pen 3	Rudy: pen 2	Liz: pen 1	Ken: pen 2
------------	-------------	------------	------------

Crime Scene: Pen 2

Mathematics Setup

Broken Plate Investigation: Each of the suspects had a piece of broken plate in his or her possession. You have samples of the broken plates from the suspects. Tape the broken plate to the bottom of a piece of paper with the smooth edge facing down. Find the center of each plate by bisecting two chords drawn on the broken plate. You may use paper folding or a compass to complete the bisecting. The center of each plate is the point where the two perpendicular bisectors from the chords intersect. Use the center and the edge of the broken p piece to complete the ci rcle of the original plate. Finally, measure the diameter of the plate in centimeters.

Shoe Size Investigation: At the crime scene, the police were able to measure the size of a shoe print that was very faint. To calculate the approximate height of each suspect, set up a scatter plot using height and shoe size as your two variables. To do this you will need to measure the shoe size and height in centimeters of every person participating in this sectional. Once this data has been compiled, plot the information on a piece of graph paper, using height as the y value and shoe size as the x value. When your scatter plot is complete, draw a line of best fit.

Stride Length Investigation: Luckily for the police, they were also able to measure the stride length of the perpetrator. To calculate the approximate height of the suspect, set up a scatter plot using height and stride length as your two variables. To do this, you will need to measure the stride length and height in centimeters of every person participating in this sectional. Once this data has been compiled, plot the information on a piece of graph paper, using height as the y value and stride length as the x value. When your scatter plot is complete, draw a line of best fit.

Grappling Hook Toss: Police found that the perpetrator entered the building by tossing a grappling hook up to a window on the third floor (9.6 meters up). Police were able to determine the initial velocity with which each suspect could toss the grappling hook into the air. Use the velocities given with the vertical motion model to determine which of the suspects could indeed toss the hook up to the third-floor window.

Vertical Motion Model: $0 = 4.9 t^2 - vt + h$

h = height

t = time

v = velocity

*For example:

$$4.9 t^2 - 15t + 10$$



a value



b value



c value

Next use the discriminant formula $b^2 - 4ac$

Example: $(7)^2 - 4(4.9 \cdot 10)$
 $49 - 196 = -147$

** If the answer is negative, then the hook could NOT make it up to the window.

Setup Ideas for the Mathematics Component

Broken Plate Investigation: You may want to use the broken plates we used or you can make up your own. This investigation works best when two or three of the diameters are fairly close to each other. The broken plate investigation is completed during the "expert group" portion of the workshop.

Equipment needed: compasses, meter sticks, rulers, tape

Data used in this investigation: Rudy 33.2 cm., Cyn 35.6 cm, Ken 20.4 cm., Liz 28.0 cm

Shoe Size and Stride Length Investigations: These two investigations are also completed during the "expert group" portion of this activity. They are the most time consuming of the mathematics investigations. We have found that they work best when matched with a science investigation that takes less time. If you won't have a large group to work with, you might want to bring some extra data to insure that the lines of best fit are fairly accurate. In the crime scene envelope, place the shoe size and stride length of the guilty party. Both activities give you the opportunity to incorporate the use of a graphing calculator.

Equipment needed: meter sticks, tape, graph paper, rulers, calculator

Data used in this investigation:

Heights: Rudy 186 cm, Cyn 158 cm, Ken 184 cm, Liz 175cm

Rudy's shoe size: 30.75 cm.

Grappling Hook Toss: Place the hook velocities of the four suspects in the expert group envelopes. An example of how to work through the equation would be helpful to the participants. The participants working in this group will know quickly which of the suspects was able to get the hook to the window. There is no need for additional evidence to be placed in the crime scene envelope. The investigation works best if three of the suspects have the ability to throw the hook 9.6 meters.

Equipment needed: calculator

Data used in this investigation:

Hook velocities: Rudy 14.72 m/s, Cyn 12.82 m/s, Ken 14.42m/s, Liz 14.1 m/s

To Be Provided with the Crime Scene Evidence:

Data gathered from the actual crime scene:

Stride length: 74 cm

Plate size: 33.2 cm

Shoe Print size: 30.75 cm

Suspect heights:

Rudy: 186 cm

Cyn: 158 cm

Ken: 184 cm

Liz: 175 cm

