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CSI: Dognapping Workshop: An Outreach Experiment Designed to Produce Students that are Hooked on Science

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Abstract

The CSI: Dognapping Workshop is a culmination of the more than 65 Sandian staff and intern volunteers' dedication to exciting and encouraging the next generation of scientific leaders. This 2 hour workshop used a 'theatrical play' and 'hands on' activities that was fun, exciting and challenging for 3rd – 5th graders while meeting science curriculum standards. In addition, new pedagogical methods were developed in order to introduce nanotechnology to the public. Survey analysis indicated that the workshop had an overall improvement and positive impact on helping the students to understand concepts from materials science and chemistry as well as increased our interaction with the K–5 community. Anecdotal analyses showed that this simple exercise will have far reaching impact with the results necessary to maintain the United States as the scientific leader in the world. This experience led to the initiation of over 100 Official Junior Scientists.

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Introduction

Inspiring today's youth to pursue a scientific career is one of the leading critical educational challenges that face our nation today. Recent reports such as *Rising above the Gathering Storm*[1] and the Commission on Maintaining United States Nuclear Weapons Expertise, aka the *Chiles Commission Report*[2] detail the detrimental impact to the future of our economy, technology, and overall health of our country that will occur if the number of students interested in science continues its downward trend. As fewer Americans enter math, science and engineering (MS&E) fields at the undergraduate level, questions are being raised about how future generations will address global scientific issues that effect our environment, energy, and health care. Before we can increase the number of undergraduate students entering scientific disciplines that align with United States and National Laboratory critical skills needs, it is necessary to instill and nurture excitement in science as early as possible (i.e., in elementary and middle school). The alarming decline of middle school students who are considering a career in any of the science fields has raised any number of 'red flags', since reports indicate that lifetime career decisions are made at this early point in their education[3]. Other reports also suggest that career decisions are being influenced even earlier, directed by what students *believe* they are good at doing.[4] The foreboding future predicted for science and technology in the United States by the seminal reports referenced above, can be altered only by making a commitment to increase the MS&E interaction with the K – 6 community.

Why does this need to occur at such an early age? Statistics reveal that a child's early interaction and familiarity with various professions is important in directing their career choices.[3, 5, 6]

This is why most students show interest in becoming veterinarians, doctors, and lawyers — they interact with these professionals or see them on T.V. Based on these results, it is not surprising

that the majority of K–12 students have no idea what a scientist or engineer does. It must be reasoned that in order to attract more students to MS&E we must provide them an early and positive introduction — before middle school when career choices are beginning to solidify — to professionals working in these fields. Recently, an investigation on the career choices of 8th grade students tracked the careers of students who indicated they could see themselves as scientists or engineer by the age of 30.[3] From this study, it was found that these students were twice as likely to obtain an advanced degree in science as compared to those that had no expectations. This shows that by 8th grade the success of these potential future MS&E professionals was already determined by the student’s own expectations and self-confidence.

Outreach Programs

Many outreach programs have been developed to inspire and excite middle school students, however, many potential scientists and engineers are missed since they have already decided they are not good at science in elementary school. This loss of interest in science is surprising since children are naturally born experimentalists — this is how they learn about our world; however, several reasons have been cited to explain this disturbing trend, including: perceived difficulty of the subject matter, teacher apprehension concerning the subject matter, and a lack of student contact with scientists.[4, 7] To circumvent this growing problem, we believe that students *must* be inspired to follow a scientific career as early as possible which means they must be encouraged in elementary school and more important they must *believe* that they can do science. We refer to these newly attracted students as ‘hooked on science’ students or ‘HONSS’. Our CSI:Dognapping Workshop was created to improve student interactions with the scientific community in order to create HONSS by providing a forensics laboratory that:

- Targets elementary students and gets them ‘hooked on science’ (HONS) by seeing themselves as “Junior Scientists”,
- Enables hands-on experience in fundamental concepts from MS&E,
- Increases the future laboratory critical skills pipeline by exciting, recruiting, and tracking 5th graders into existing SNL student programs,
- Gives teachers a pathway forward for scientific resources (e.g., direct contact, summer fellowships through NSF, ect.) and broadens the impact of the workshop,
- Meets New Mexico K–5 Science Benchmark Performance Standards,
- Provides interaction with scientist and engineers in a laboratory setting that is not achieved in the classroom,
- Tells the students that they *CAN* do science, and
- Is FUN!

Using these concepts and issues, we have designed and implemented a workshop series to: (i) target and inspire 3rd – 5th grade level students to view themselves as “Junior Scientists” even before they enter middle school when career decisions are made; (ii) enable hands-on experience in fundamental concepts from sciences (i.e., chemistry, mathematics, materials, and engineering that support (nanotechnology) nanoscience-microsystems initiatives); (iii) increase public interaction with scientist and engineers. Our efforts have focused on the popular Crime Scene Investigation (CSI) concept used in many programs around the world to interest young minds in science.[6] The workshop promotes scientific self-confidence, and unlike typical science fairs, there are no winners or losers based on judging. The design also encourages student teamwork to solve ‘the dognapping crime’ versus competing and allows the mentoring scientists to teach, not judge. Furthermore, it was of interest to invite the students to our laboratory and introduce them to our working environment where the volunteer scientists are comfortable and minimizes the effort necessary by the volunteers.

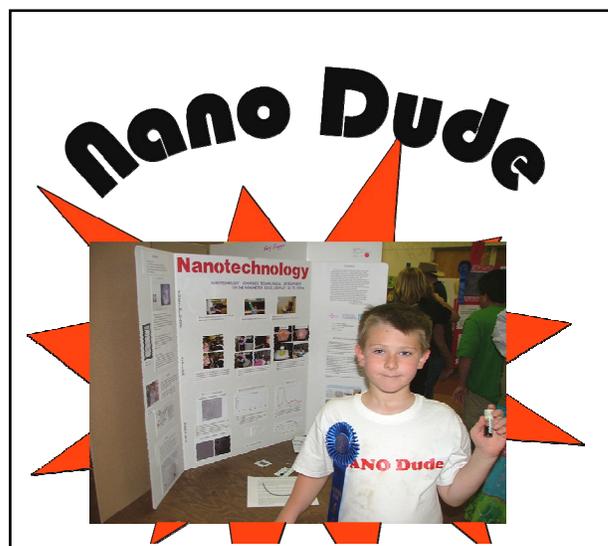
In order to verify our pedagogical methods, we initiated testing before and after the CSI:Dognapping Workshop. Specific information concerning this is detailed in the appendices, including: Appendix A. Observation & Safety Lesson Plans, Scientific Awareness Survey;

Appendix B Presentation Slides, Script, and Rewards; Appendix. C. Experimental Details and Teaching Board Posters for CSI:Dognapping; and Appendix D. Newspaper Article on CSI:Dognapping. *Note:* Lab safety is stressed throughout the entire process and the students earn receive among their many ‘rewards’ a set of safety goggles that they can take home.

Development of the CSI:Dognapping Workshop

As mentioned previously, we developed the CSI: Dognapping Workshop in response to the national competitive initiative to motivate K–12 students to become interested and proficient in MS&E fields of study.[8] Surprisingly, students indicate that CSI television programs scored unusually high as a motivating factor for choosing a science career path.[5, 6] Therefore, we elected to use the CSI concept in terms of a dognapping (CSI:Dognapping) as a platform to introduce fundamental science concepts to elementary students. The CSI:Dognapping Workshop uses scientific inquiry to solve a dognapping mystery by exploiting the natural ability of all young children (junior scientists) — observation in a play-like setting. Furthermore, the interactions with staff scientists allow elementary students (and their teachers and parents) to become more comfortable and familiar with these professionals and their surroundings.

Elementary Inspiration! The story of one W. R. Spencer Zintak and the Boyle group. The personal interaction between the K–5 and scientific community was realized to be an effective approach in exciting and retaining young scientists



based on a pre-workshop interaction with W. R. Spencer “Spence” Zintak, a 3rd grader from the local Manzano Day School (Figure 1). Spence approached us about the general subject of nanotechnology due his Dad’s injured eye (Spence had read on the internet about a future aspect of nanotechnology where ‘nanobots’ could heal injuries). Our subsequent interactions over the next couple of months led not only to him winning 1st place in his elementary school science fair based on his research concerning nanogold conducted in the Boyle group laboratory, but we also developed a very positive interaction with his parents and teachers. This initial response was as expected; however, what was surprising was the excitement that ignited in our research group of ‘jaded chemists’ concerning the introduction of Spence to research. The excitement between Spence and our group has fueled Spence’s desire to become a scientist. As Spence continued to interact with our group concerning nanotechnology (and now solar energy), it became obvious that Spence’s initial interest in science has transformed into a HONSS. This all developed from what to us was a very minimal contact.

By observing how personal interaction can excite and retain one HONSS and how his enthusiasm affected the support of his teachers and parents, we were led to consider the development of a method to excite a greater population of potential HONSS that will enhance the scientific talent pool critical to our country’s future. While 1:1 interactions are obviously the best way to stimulate new HONSS, it is not realistic to expect every laboratory or researcher to be able to accommodate their time and talents to this type of interaction. Therefore, several different ideas on how to do this on a large enough scale to make it valuable were investigated. Our solution to aid the development of elementary schools students into HONSS became the CSI:Dognapping Workshop.

How the CSI:Dognapping Workshop Is Conducted

The general premise of the workshop is to invite students to Sandia with the idea that they will attend a chemistry magic show (presentation slides and script, Appendix B). Again, we strongly feel it is critical that these future HONSS and their supporters visit the scientist's

laboratory setting to learn that it is not as foreign environment as they might have envisioned — it's a fun place! In the laboratory setting, stereotypes are broken and the overall process concerning safety and setup is simplified. Upon arrival, the students learn that the magic show was cancelled since the 'Magic Chemistry Dog' Beaux (Figure 2) who helps make glowing nanomaterials was dognapped. The students are then 'accused' of dognapping Beaux, but use science (fingerprints) to prove their innocence. They are then

'deputized', given safety goggles and asked to help evaluate the 'crime scene'. Five unusual aspects of the scene are identified and the students then visit different analytical stations to uncover the 'who-dun-it' mystery. The analytical stations involve: (a) nanogold – purple water found in the dog bowl; (b) pH – three bottled liquids (water, ammonia, or lemonade?) found along with a clear spill at the scene; (c) milk rainbow – white spill (milk or glue?) found at the scene; (d) fiber analysis – three types of fibers found (dog hair, nylon – colored and white), and; (e) secret message – blank index cards found at the scene. Additionally, pen ink analysis (paper chromatography) is conducted on the ransom note. The script that is used is presented in

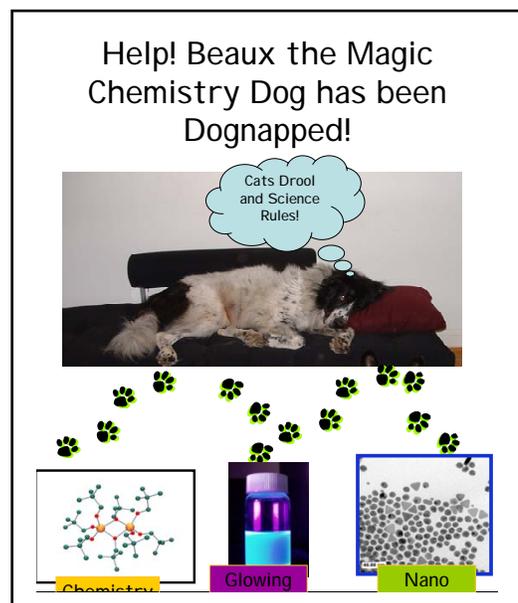


Figure 2. Beaux the Chemistry Magic Dog.

Appendix B. The experiments are described in detail here and have been gathered together in Appendix C. Below is a general summary of the workshop.

General Workshop Process. Upon arrival, the students sit down and are briefed on important facts concerning safety. The ‘host’ then arrives and informs the students that the magic show has been cancelled since the ‘Magic Chemistry Dog’ Beaux has gone missing. The ‘host’ then informs the students that he has looked around the building and cannot find Beaux and has arrived at the conclusion that the students took him. Since some fingerprints were found at the scene, the students can use their own fingerprints, if they are willing, to prove they are innocent. This scenario is designed to get the students involved immediately, to act together to clear their names, and want to use science to prove their innocence.

Fingerprints. The students must pass a fingerprint test. A Photo of this activity is shown in Figure 3. The students are taught how lift their own fingerprints with a pencil, paper, and tape, analyze them by deciding which type of fingerprint they have, and then compare them to the ones found at the crime scene. The students must “pass” a fingerprint test before they are allowed to investigate the crime scene and move on to the analytical stations.

Equipment needed: regular pencil, scotch tape, and 3x5 card.

Procedure: The students are called up to the table which has a pencil for everyone and a 3 x 5 card. The students are asked to write their name on the card. They are then told to draw a box on the right hand



Figure 3. Fingerprint Analysis

side of the card and color it in as dark as possible. After the students roll their thumb in the box until it has been covered in graphite. The students also get a piece of tape. The tape is placed over their thumb and they lift off their fingerprint and tape it to the left hand side of the card. A series of fingerprint types (i.e., whorls, swirls, etc.) are then shown and the students are asked to identify what type their fingerprint is and to write it down. The cards are then collected to be analyzed.

An incentive for passing their test is that these students will be sworn in and honorably badged as “Junior Scientists”. Of course, the students are all cleared and the four suspects turn out to be: (i) the school’s principal, (ii) a beloved manager at SNL, (iii) and (iv) are two scientists at SNL. In addition to learning about fingerprints, this aspect of the workshop is designed to introduce the idea of collecting, analyzing, and interpreting data.

A slide detailing the basic information concerning the characteristics of these suspects is presented. Their “biographies” must contain the various clues described below. One aspect of performing this workshop is that all of the logic does not have to be perfect, but the story line *must* be maintained. The students are asked – with no data – to decide who did it. They base their opinions on what the guilty the suspects look in their mug shots. Once a consensus is reached, by the group, they are asked to prove it. Since they cannot, they are asked if they’d like to use science to solve the crime and get on with the chemistry magic show. Once the students agree, they are *all* given ‘Official Junior Scientists’ badges.

(2) Observation. Once badged, the students then use their power of observation to study the crime scene. This was performed as a group activity emphasizing that some things belong and some things are out of place. Figure 4 shows the students investigating the crime scene.

Crime Scene: Must consist of things that a dog would have (i.e., water bowl, bed, chew toys, dog treats, leash, etc.). In addition, it is critical that the clues for the crime be present. For this

case, several critical clues must be present (i) clear liquid spill, (ii) white liquid spill, (liquid spills are placed on top of transparencies to protect floor) (iii) several fibers or strings, (iv) two white 3x5 cards, (v) purple water in the dog bowl, and (vi) a ransom note written on a coffee filter. These clues *must* be found by the students so monitoring the observation time is critical.

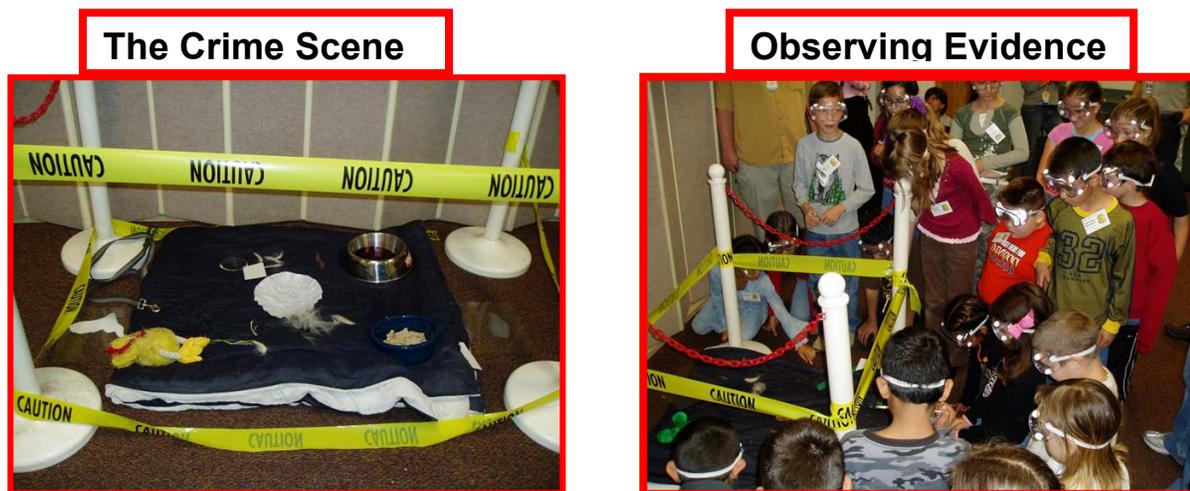


Figure 4. Students investigating the Crime Scene.

A list of what does and what does *not* belong is developed systematically by explaining logically why they do or do *not* belong. This again emphasizes the ability to observe, collect, and eliminate unnecessary data.

(3) Chromatography. One of the observed crime scene anomalies that will be found is a ransom note written on a coffee filter that states “I have your dog. If you want to see Beaux again, then you have to take him out of the chemistry magic show!” Using chromatography, a scientific technique that has been around for 100’s of years, the students will determine which pen was used to write this note. Chromatography is the collective term for a family of laboratory techniques that allow for the separation of complex mixtures. It involves passing a mixture dissolved in a "mobile phase" through a stationary phase, which separates the analyte to be measured from other molecules in the mixture and allows it to be isolated. For this station, the various types of inks used in the pen will be the analyte, alcohol the mobile phase using a coffee

filter as the stationary phase. The pens were ascribed to different suspects and the ink from the pen will implicate one of the suspects. The results, from the actual chromatography experiment on pieces of the ransom note, are shown in

Figure 5.

Equipment needed: coffee filter, 3 pens (black ballpoint, black sharpie, and black gel pen) water or isopropanol (rubbing alcohol), pencil

Procedure: A large dot from each pen is drawn on the bottom of a coffee filter (note it is important that the dots be far enough apart (at least $\frac{1}{4}$ of an inch) so that the inks won't run together as they

move along the paper), along with a sample of the ransom note which was written on a coffee filter, too. The filter is then placed vertically into a beaker that contains enough alcohol to cover the dots. After about 30 mins (typically, the other stations are undertaken while this one proceeds), the coffee filter is removed and the pen spectra were analyzed in comparison to the note on the filter. The pen matching the note leads to further identification of the suspect.

Knowing the types of pens the suspects prefer to use (from the brief biographies discussed), analyzing the different inks in the pens and comparing them to the ink used on the ransom note will allow the students to identify the guilty suspect. This process introduces the idea of complex mixtures and a method to separate them. Further, comparing samples to the unknown brings in a new idea of establishing baseline and comparisons. Additionally, this experiment is easily reproduced at home so that the students can do further investigations at home on other inks and complex mixtures. While this takes some time to complete, the other stations are undertaken while the inks are separated.



Figure 5. Chromatography results from a sample of ransom note written with a black gel pen

The students are then reassembled and instructed to look on the back of their badges where one of five colored dots has been placed. Based upon the color of the dot, the students are split up into 5 smaller groups and head off in separate directions to investigate the different clues they have listed previously. It is important that the students take their safety goggles, pencils and clues sheets since each will be needed throughout the stations.

(4) Stations. The various stations are broken down into these 5 categories: (a) Nanogold, (b) pH analysis – clear spill, (c) Milk Rainbow – white spill analysis, (d) Fiber analysis, and (e) Secret Messages based on the clues found at the crime scene.

(a) Nanogold. Upon arrival (see Figure 6), students are asked if they remember anything odd about Beau's water (help remind the students by having them looking at the crime scene on their clue sheet). The students are then asked, "What suspects could have made his water purple?" After hearing their assumptions, the students are told they are going to use science to determine what caused the water to be purple. Next, we ask them if they know what 'nano' means and are allowed to give their answers. Nanoparticles which can be powders, atomistic clusters, or crystals are very small particles with at least one dimension less than 100 nm in size. Using the posters (Appendix C), we first introduce the concepts of size and how small nano is. Props such as a dime, meter stick, and rope are used to convey size. First, the definition of a nanometer is 1 billionth of a meter is given. Then a meter stick is used and students are asked to imagine a billion tiny marbles lining up across the meter stick. As this analogy is given, we point to one end and move across to the other end to emphasize the entire length that a billion marbles would have to fill. Two extreme examples of ratio are then given. The first is that a dime to planet earth as nanometer is to a meter stick. The second, and most effective example is relating the size of nano to something the students perceive to be very small (i.e., hair). Students

are asked to look at a single strand of hair on themselves or on their neighbor. They are then told that nano is smaller than the diameter of a hair.

To demonstrate diameter and size, the students are asked to pick up a rope set in front of them. We then say “Nano is pretty small so we have to shrink down in size. So let’s SHRINK SHRINK SHIRNK, OK Stop!” During this time we taking the rope into our hands we begin to slowly “Nanosize” (Figure 6b) by going from a standing position to squatting position until our heads are right at table top height. We energetically say “Stop!” and we jump back up to the standing position. We then say, “Now let’s pretend that this rope is our hair. Do you feel the round part? The distance across it is called diameter. Do you feel the long part? (run the rope through your hands) This is called length. Now we are still too big to be a nanometer to so we need to shrink again.” We repeat the shrinking process and at the end of the stop command, we tell the students “Now drop the hair because we are too small too hold it.” The students are then shown an SEM image of a hair that has a 400 nm square on it. “Now that you know how small nano is,



Figure 6. (a) The NanoRoom, (b) Shrinking to nanosize, (c) TEM of nano gold.

we are going to make nano gold.

Small-scale reactions were performed in front of students using test tubes. Students were encouraged to shout out what they observed for each stock solutions and what they saw during the reaction.

Equipment needed: (2) 200 mL and (1) 25 mL Erlenmeyer flasks, stirplate, 2 stirbars, (2) 100 mL graduated cylinders, wooden spatula, metal spatula, plastic weigh boats, 20 mL vial, caps, hydrogen tetrachloroaurate hydrate ($\text{HAuCl}_4 \cdot \text{H}_2\text{O}$), sodium borohydride (NaBH_4), DI water, toluene, tetraoctylammonium bromide [(TOAB) or $[\text{CH}_3(\text{CH}_2)_7]_4[\text{NBr}]$], and dodecanethiol ($\text{CH}_3(\text{CH}_2)_{11}\text{SH}$). 5 test tubes, test tube rack, pipets, 8 foot rope, meter stick, dime.

Procedure: For the K-12 demonstration on how to make nanogold, we modified the synthesis procedure reported by Brust et al.[9] Three stock solutions of (i) aqueous gold (Au), (ii) organic surfactants, and (iii) reducing agent were prepared prior to the workshop. These stock solutions were prepared as follows. The aqueous Au stock solution was made by dissolving 0.354 g HAuCl_4 with 30 mL of DI H_2O in a 200 mL Erlenmeyer flask to form a clear yellow solution. In a second 200 mL Erlenmeyer flask, an organic surfactant stock solution was produced by dissolving 2.187 g TOAB with 80 mL toluene to form a clear and colorless solution. To the TOAB/toluene solution, 0.241g of $\text{CH}_3(\text{CH}_2)_{11}\text{SH}$ was added and stirred for 10 minutes. The reducing agent solution was made by dissolving 0.378 g of NaBH_4 in 25 mL of DI H_2O (Note, add water right before the first group comes and have excess NaBH_4 and H_2O on hand to add as needed).

First a pipette full of the Au stock solution is added to the test tube. Then two – three pipettes of the surfactant solution were added. The test tube is flicked to mix the reagents and then the organic layer was allowed to separate from the aqueous layer. Students could observe a color change and transfer between the layers. Next the bubbling reducing agent solution was

shown. It is explained that the bubbles (H_2 gas) are going to help make nano gold. At this point the students write down their observation for the color of nanogold (have the word purple written out for students weak in spelling). We show pictures of the transmission electron microscope (TEM, Figure 6c) used to see nanoparticles of Au. Finally, the students are asked “Who makes nanogold?” By referring the suspect’s characteristics, they mark down their choices.

(b) pH and (c) milk rainbow. For the ‘pH’ and ‘milk rainbow’ stations, the students need to determine what substances the two spills found at the crime scene are made of. These are two separate stations but are combined here to minimize repetitive discussion about the spills. By introducing the concept of analyzing the sample, the students learn to circumvent the way they normally interact with the world (i.e., the need to taste, touch). To help reinforce this concept, the students are reminded that forensics scientist can not taste or eat the evidence they find at the crime scene using the posters (Appendix C) and are told they can use “indicators or color” to help identify a substance.

For the pH station, the concept of ‘free protons’ coupled with the color change of litmus paper, as a means to analyze the spill are introduced. Figure 7 shows the students hard at work uncovering the identity of the clear spill. The students learn the concept of acids and bases through direct measurements using color changes indicating specific pH. The amount of protons (charged hydrogens H^+) present in water (H_2O) is represented by the pH scale ($pH = -\log [H^+]$). The pH scale ranges from 0 to 14 (there are no units for this scale). 7.0 is considered neutral and typically applies to H_2O . Anything, that when dissolved in water, which has a pH below 7.0 is considered acidic; anything above 7.0 is considered basic. For the milk rainbow station, the students learn the basics of a chemical reaction where the fat of the milk interacts with food dye

in a different manner than the components of glue (Figure 8). Again, observation and interpretation of the results are reinforced throughout these two stations.

For the pH station, the students are told that the clear spill was collected from the crime scene. In addition, three bottles were found in the trash can (ammonia, lemon juice, and water) near the crime scene. The students were asked “How can we tell what the mysterious spill is made of?”. It is important to remind the students that care must be taken when handling unknown compounds. We ask them which of their senses they can use to determine which of the bottles the spill is from. “Can you hear a difference? No. Can you see a difference? No, they are all clear. Can you taste it? No! It may be poison – what if it is ammonia? Can you feel a difference? No! What if it is an acid or base you’d get burned! So what do we do?”. This is the point where we enter the concept of potential hydrogen (or pH) and the color change of pH paper. Again, pH is a measure of the amount of protons available in an aqueous solution indicating acidity or alkalinity. Aqueous solutions at 25 °C with a pH less than seven are considered acidic, while those with a pH greater than seven are considered basic (alkaline). The pH of 7.0 is defined as 'neutral' at 25 °C. One way to measure this is to use pH paper or litmus paper. pH paper is usually small strips of paper (or a continuous tape that can be torn) that has been soaked in an indicator solution which changes color based upon the acidity



Figure 7. Students determine the pH of clear spill (lemonade) found at the crime scene.

of the solution and is used for approximations of pH. This allows us to visually see differences that we can not see normally. We explain how it could be used to determine the pH of a liquid and that from the pH you could ascertain whether the solution was acidic, basic, or neutral.

Equipment needed: water, ammonia, vinegar, lemonade, pH litmus paper, containers.

Procedure:

5 test-tubes are prepared prior to the students arriving at the station ranging from very acidic (vinegar) to acidic (dilute lemon juice) to neutral (water) to basic (diluted ammonia) to very basic (ammonia). After discussing pH, the students are given 5 piece of universal litmus paper. Each student dips one piece of paper in the first tube and places in a specified area. The acidity is determined by the color. This is repeated for each sample. Then the clear spill (dilute lemon juice) is brought forward and tested. If time permits, mixing of acids and bases can also be undertaken. *Note:* this will be a very vigorous reaction bubbling over in too small reaction vessels. Before testing any of the solutions, the students would be asked if they thought it was acidic, basic, or neutral, and they then were allowed to test it. After all three standard solutions were tested, they were allowed to test the unknown liquid from the crime scene and were asked to determine which of the known solutions it was. This could easily be relayed back to who drank what and eliminate some of the suspects. Then time permitting, the students would then be allowed to experiment what would happen to the pH if an acidic solution and a basic solution were mixed.

For the Milk Rainbow Station, the white spill is analyzed. The basic premise is what is the white spill milk (i.e., melted ice-cream) or glue. Again, the students are told that a sample of the “white spill” left at the crime scene was collected and brought to the station. The junior scientists were asked how to determine what the white spill was composed of. Again, the 5 sense were listed with reiteration that tasting or touching these materials is not a good idea.

Equipment needed: milk, glue, food coloring, dish soap, Petri dishes, sample of “white spill”, and plastic pipettes.

Procedure: A Two Petri dishes were given to the scientists identified to contain: (i) milk and (ii) glue. To each sample, several drops of food color were added. Then a pipette full of soap was added to both dishes to give a visual example of how fat (from the milk) reacts with soap to produce a rainbow effect while the soap and glue remained stagnant. Once the scientists performed the experiments on the known substance, as a group, the “white spill” was tested. The result was compared to their previous white sample results.

Since it was reported that several suspects liked ice cream they could deduce who might have left the spill at the scene.

White Spill Analysis – Chemical Indicators



Figure 8. Students add food coloring and soap to the white spill (melted ice cream) to form a milk rainbow (right).

(d) Fiber Analysis. After identifying several different types of fibers at the crime scene (white cotton fiber, colored fiber and dog hair), the students are asked to differentiate them. Of course this is very difficult to do with normal eyesight, so the students are introduced to magnification glasses, Figure 9a. These allow the young investigators to get a closer look at the fibers; however, even higher magnification is needed to differentiate the various fibers that leads to the use of a simple 3X microscope, Figure 9b. The students are again asked to detail what they see and if they can tell natural fibers from man-made fibers. Even higher magnification is supplied through scanning electron microscopy (SEM) taken previously (and available upon request). These detail the subtle differences between natural and man-made fibers which are based on the surface morphologies observed.

Equipment needed: magnifying glass, microscope, samples: dog hair, nylon string, cotton string, Scanning Electron Micrograph (SEM) images of fibers.

Procedure: The students are presented with several fibers found at the crime scene. They are then asked to identify which ones belong there and which ones don't. The students are then given known samples of materials (natural and man-made). They first look at the different fibers with their eyes to see if they can tell any difference. Typically, there are some

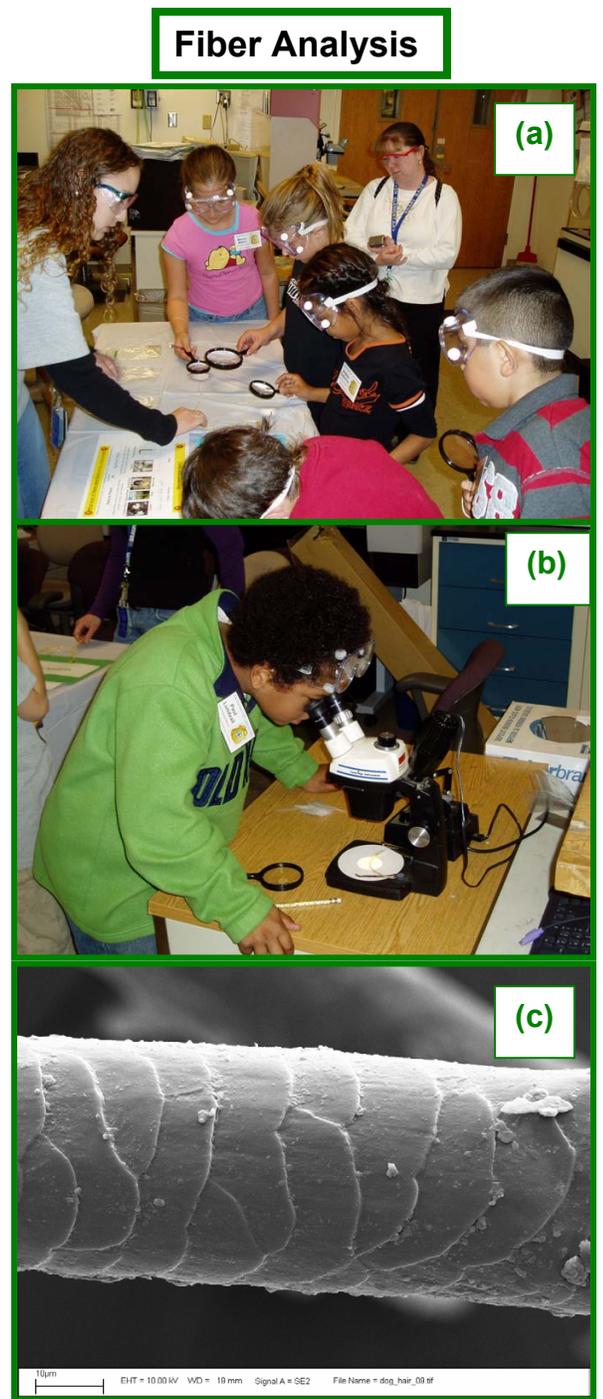


Figure 9. Students working to differentiate the various fibers using (a) magnifying glasses, (b) optical microscope, and (c) the actual SEM image of Beaux hair.

distinctions that can be made but not many. They are then given a magnifying glass (2 times the size) and the same scenario takes place. The students are then shown to a microscope that can magnify up to 10 times the size. The students begin to note the differences between the fibers. In addition, scanning electron microscopy (SEM) images are shown to the students of the different fibers. These results are compared to the fibers collected at the scene and those that didn't belong are identified. The suspects are then checked off on the sheet.

Once identified as dog hair, this fiber is removed from consideration as a clue since Beaux is the victim. The identified nylon fibers led to the scientist that wears a nylon lab coat. This removes the principal from consideration as a suspect. This also introduces the concept that many things exist that we can't normally see but a whole world of unusual phenomena can be observed through magnification.

(e) Secret Messages. The concept that things are there that we can't see is reinforced at this station. Two cards were found at the crime scene but appear blank. The students are then introduced to the idea that things can be present even if we can't see them in normal light. For the first secret message, it is explained that many different types of light exist and that one of these is ultra-violet or UV light. By shining a UV 'black' light onto the card, the students see that the first card reads "AML" – this is the first clue at this station. Students are asked, "Which scientist works at the Advanced Materials Laboratory (AML)?" Anyone working there receives a check mark by his or her name. The proctors explain that some compounds interact with UV-light and light up when exposed to it. Figure 10 shows some of the students discovering the secret messages.



Figure 10. Students discovering the secret clue “kitty” revealed by a chemical reaction.

Equipment needed: Hand-held UV-lamp, Fluorescent marker, Index cards, Cotton swabs (to write with), 5 % Phenolphthalein in ethanol, Larger cotton swabs (to wipe ammonia across), Household ammonia cleaner or Windex with ammonia.

Procedure: There are 2 index cards found at the crime scene. At this station, we show the participants a seemingly blank card and ask them what is on the card. “Nothing” is the expected and usual answer.

Secret Message #1: Using UV-light. We explain that some compounds interact with UV-light, and when they do so we can see them. In fact, under illumination one of the sample card reads AML – this is the first clue at this station. Which scientists work at the Advanced Materials Laboratory (AML)? Anyone working there receives a check mark by his or her name.

Secret Message #2: Using Acid-base Indicators Chemistry. A second card is then held up and the participants are asked if there is anything on it. We demonstrate that there is nothing obvious under UV-light that can really be read. We emphasize that again some chemicals interact with light, and that some do not. What about chemicals reacting with other chemicals? We then stroke a cotton swab dipped in ammonia across the card to discover the word “Kitty” written on the card. This is another clue, and those suspects that like cats get a check mark by their name. We had

previously written this word using phenolphthalein indicator as ink. Upon reaction with ammonia, the ink becomes visible due to de-protonation. After evaporation, the words disappear.

They are then given a second secret message card and try the UV light experiment again which fails. It is again emphasized that not all chemicals interact with light but “there are other ways of finding secret clues” such as reacting chemicals with the secret message on the card, Figure 10. In this case, using a special chemical called ‘phenolphthalein’ as the ink, the proctor writes a secret message. Upon drying the card appears blank. However, it is demonstrated that wiping with ammonia reveals the secret message. It is then explained that the ink reacts with ammonia and becomes visible due to de-protonation. After evaporation, the words disappear.

The students are then allowed to write their own secret message. The proctor collects the cards and mixes in the second secret clue. As the student’s secret messages are revealed and handed back to the student it is found that one extra card remains. As the cotton swab dipped in ammonia is rubbed across the card the word “Kitty” appears. The actual card used is shown in Figure 10. Everyone denies writing it and therefore it determined to be another clue. Those suspects that like cats get a check mark by their name. We then re-emphasize that we used science, to “see” 2 secret messages. The first was written with a chemical or ink that is visible under UV-light, while the second was written with an ink that reacts with ammonia. The participants then write their own messages on index cards using phenolphthalein and expose it with ammonia.

(5) Data Interpretation. This completes the checklists and the students are all then the 5 sub-groups are assembled back into the original large group. The chromatography (*vide infra*) results are gone over with the pen that was used to write the note identified which finishes the check list.

The clues are discussed one by one for each station to ensure everyone has the ‘right’ results, the tally taken, and the perpetrator revealed. The host goes to get Beaux and the suspect. Upon returning with Beaux and the ‘criminal’ the class asks “Why’d ya do it?”. The dognapper indicates they wanted their cat to be the star of the show and that they are sorry. Upon return of Beaux, due to the limited time, the students are asked if they would like to help make liquid nitrogen ice cream (*vide supra*) and the celebration begins. The entire experience was captured by N. Singer in the Sandia Daily News article published on February 16, 2007 (Vo 59, No 4). The article can be found in Appendix D. In the end, science was used to solve the crime. So, upon completing the lab exercises and solving the mystery, the students are rewarded with recognition as “Official Junior Scientist” who is authorized to explore whatever science topic they desire. In addition, they are given several souvenirs (i.e., tee-shirts, toys, etc) which they can take with them to remind them of their memorable experience and, they eat lunch at the building with a few more surprises-Liquid Nitrogen Ice Cream, RoboTreats, and Firefighters!

(6) Other Scientists: RoboTreats & FireFighters! Besides showing chemical and materials analysis, the Junior Scientists were given an opportunity to explore the world of engineering through a technique called Robocasting. Robocasting, as its name implies uses a programmable robot that can control the placement of any kind of fluid material to cast it into special shapes and is used in materials manufacturing. The students use the Robocaster to make RoboTreats – cake icing covered graham crackers. The students prepared RoboTreats by first programming their handwritten initials, after which the Robocaster squeezes or ‘pipes’ out cake icing onto the graham cracker. This fun activity allowed students to speak to engineers and be engaged with hands on experience. The Junior Scientists were also able to observe that familiar professions,

such as firefighters, use science everyday in their careers. The New Mexico Fire Training Academy, form Socorro NM, was on hand to share their experiences with the students. They emphasized fire safety and showed how science is used to help fight fires. Some of the interactions noted for the post-workshop activities are shown in Figure 11.

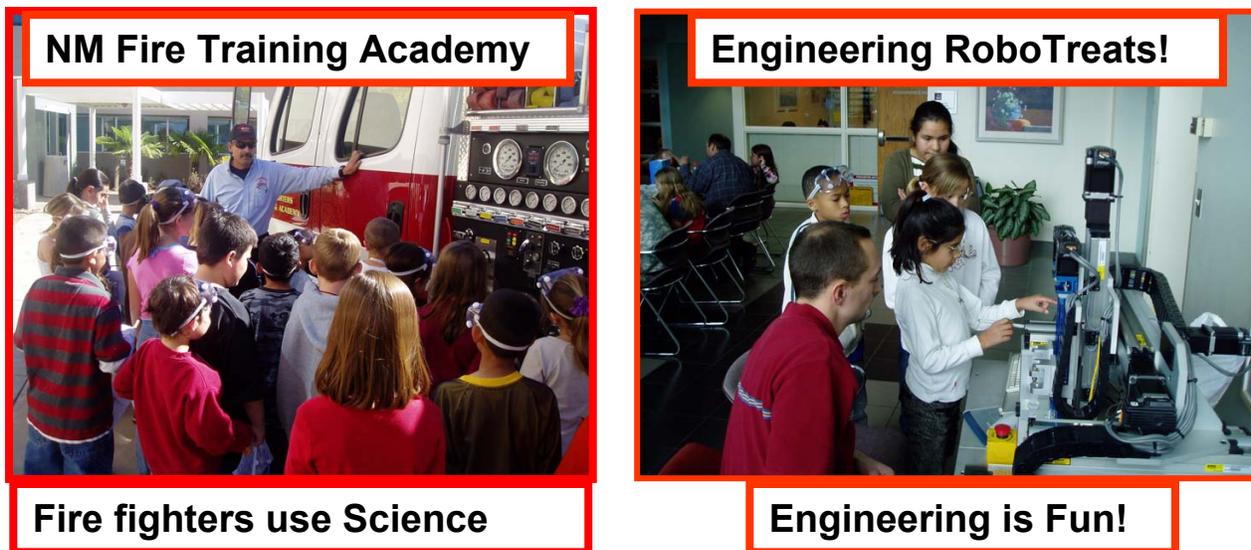


Figure 11. Interacting with other scientist (firefighters) and engineers.

(7) Liquid Nitrogen Ice Cream. By combining the various elements used in the stations, the students are asked if they'd like to make liquid nitrogen ice cream. This is an opportunity to discuss the wide use of science in everything, including cooking. They get to watch the various mixing of ingredients and then its conversion (in this instance cooling with liquid nitrogen) to the desired ice cream. This makes a large nitrogen cloud (Figure 12) that harmlessly billows out of the bowl and around the students causing shrieks and gasps of awe. Finally, when done, the students get to sample this final sweet treat as their desert. This wraps up the workshop and while eating lunch with the staff, they get to talk about what they liked and didn't like about the

workshop and meet with Beaux the Magic Chemistry dog who is more than willing to share any of their food. Finally the bus arrives and they take off with their collection of ‘goodies’, new learned knowledge about science, their certificates that says they can do science, and an overall positive feeling towards science and scientists.

Liquid Nitrogen Ice Cream



Chemistry is Fun!

Figure 12. Synthesis of liquid nitrogen ice cream, photo by Randy Montoya from the Sandia Daily News.

Equipment needed: Half & Half, vanilla extract, sugar, bowl (metal or wood), spoon (wood), liquid nitrogen, bowls and spoons for serving.

Procedure: Two quarts of Half & Half are poured into a bowl. Two cups of sugar and two tablespoons of vanilla are added to the cream and stirred. At this point the demonstrators would reiterate that science was all around the junior scientists as cooking was a type of chemistry. Once the sugar dissolves completely, the children were asked to put on their safety goggles.

Small portions of liquid nitrogen were slowly poured into the cream mixture then the mixture was stirred vigorously. This creates a foaming effect in the ice cream mixture as well as a fog show for the children. As the ice cream was mixed the junior scientists were also asked to look at the ice cream as it was being frozen—it should resemble a pot of oatmeal until all the ice crystals begin to melt. Continue to add nitrogen to the mixture and stir until it is frozen to the consistency of ice cream, this may require that the mixture thaw slightly to remove some of the ice crystals depending on how quickly the nitrogen was added to the mixture. The ‘ice-cream’ is served up to the students.

A Field Trip That Meets Scientific Standards

The CSI: Dognapping Workshop described above is not just an ordinary science magic show, but a fun way to explore science and engineering with hands on opportunities to solve a mystery. More important, it meets the New Mexico’s Science Benchmark and Performance Standards, (see Table 1 below). In this workshop, students are presented the crime (a dognapping) and the suspects through theatrical play (*vide infra*). Each aspect of the workshop is designed to bring the students into the world of science and to interact with scientists. While not all of the tasks and equipment used during the workshop are readily available at home, most were selected based on what was common place around their house and what experiments could be repeated safely. The CSI:Dognapping workshop was successful in producing 100 HONSS, some of which are shown in Figure 13 by the volunteer efforts of more than 65 Sandia staff and students (see Table 2 for a list of assistants for which we are extremely grateful).

Table 1. New Mexico SCIENCE Content Standards, Benchmarks, and Performance Standards (2003)

Strand I: Scientific Thinking and Practice	Benchmarks	Grade Level 3	Aligned Curriculum Resource(s)
<p>Standard I: Understand the processes of scientific investigations and use inquiry and scientific ways of observing, experimenting, predicting, and validating to think critically.</p>	<p>K-4 Benchmark I:</p> <p>Use scientific methods to observe, collect, record, analyze, predict, interpret, and determine reasonableness of data.</p>	<ol style="list-style-type: none"> 1. Make new observations when discrepancies exist between two descriptions of the same object or phenomenon to improve accuracy. 2. Recognize the difference between data and opinion. 3. Use numerical data in describing and comparing objects, events, and measurements. 4. Collect data in an investigation and analyze those data. 5. Know that the same scientific laws govern investigations in different times and places (e.g., gravity, growing plants). 	<p>CSI Lab: Who Dognapped Beaux?</p> <p>“EXAMPLES for workshop”</p> <ol style="list-style-type: none"> 1. Students can identify the differences between types of string, etc... 2. What is their first best guess? Then verify with tests and data. 3. Find ways to obtain numerical data for some of the comparisons. 4. Create tables and graphs that can be used. 5. Introduce simple laws of chemistry.
	<p>K-4 Benchmark II:</p> <p>Use scientific thinking and knowledge and communicate findings.</p>	<ol style="list-style-type: none"> 1. Use a variety of methods to display data and present findings. 2. Understand that predictions are based on observations, measurements, and cause-and-effect relationships. 	<ol style="list-style-type: none"> 1. Create tables, graphs, charts, affinity diagrams, etc... 2. Ideas for how to make new predictions?
	<p>K-4 Benchmark III:</p> <p>Use mathematical skills and vocabulary to analyze data, understand patterns and relationships, and communicate findings.</p>	<ol style="list-style-type: none"> 1. Use numerical data in describing and comparing objects, events, and measurements. 2. Pose a question of interest and present observations and measurements with accuracy. 3. Use various methods to display data and present findings and communicate results in accurate mathematical language. 	<ol style="list-style-type: none"> 1. This is similar to above, use tables and charts to display data. 2. The BEAUX case is great here! Discuss accuracy of measurements, instruments, and human error for example. 3. Can there be some math integrated into the investigation here?

Table 2. List of volunteers who made the CSI:Dognapping Workshop a success.

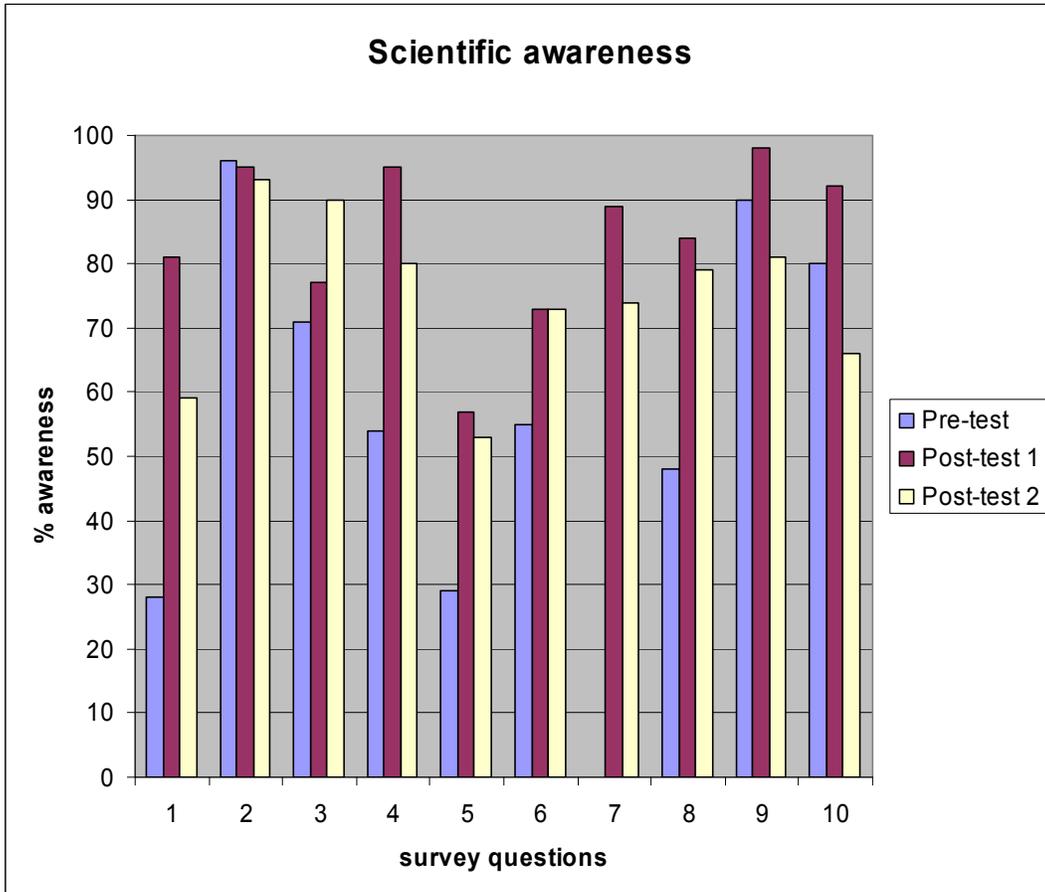
Names of Volunteers (Affiliation)	Names of Volunteers (Affiliation)
Amy Tapia (SNL)	Joe Cesarano (SNL):
Andres Sanchez, (APS)	John Stuecker (SNL)
Anna Gorman (SNL)	Kathleene Schnider (Bellehaven/APS)
Aruro R. Sais (NM FTA)	Kevin Ewsuk (SNL) and Jill Glass (SNL) – James and Gabe
Beaux-Bo Boyle (retired)	Leigh Anna Ottley (SNL)
Bernadette Hernandez-Sanchez (SNL)	Lorene Valdez-Boyle (CRSC)
Bill Hammetter (SNL): AML BLDG.	Malynda Aragon (SNL/Manos)
Bonnie McKenzie (SNL)	Manuel Garcia (SNL):
Bruce Burckel (SNL)	Marlene E. Chavez (SNL)
Bruce McClure (SNL)	Mike DeWitte (SNL)
Cathy Casper (SNL):	Nedda Hamilton (APS):
Christina Baros (SNL)	NM Firetraining Academy (State):
David A. Romero (NM FTA)	Norbert Tencza (SNL)
Denise Benco (SNL)	Patrick Sims (UNM)
Diane Dickey (SNL/UNM)	Rebecca Raymond
Dominique Foley-Wilson (SNL):	Reyes Romero (NMFTA)
Duane Dimos (SNL): AML/SNL	Rick Kemp (SNL): group members
Ed Wood (NM FTA)	Robin Sewell (SNL): Cody and Kaliee
Eric Branson (SNL/UNM)	Roby Meyers (Bellehaven/APS)
Erica Coral (SNL)	Ron Loehman (SNL): his group members
Federica Solano (Bellehaven/PTA)	Saskia King (SNL/Manos)
Geoffrey L. Brennecka (SNL)	Scarlet Widgeon, (SNL)
Hanna McCabe (Bellehaven/APS)	Sean Winters (SNL)
Harry D. Pratt III (SNL)	Seema Singh (SNL)
Jamen Medina (Bellehaven/APS)	Shari Baze (Bellehaven/APS)
Janitor (Translation)	Sherrika Daniel Taylor (SNL) and Daniel Taylor: Diamond Taylor
Jeffery Brinker (SNL): group members	Susan Leach (SNL)
Jeniffer Jewell (Bellehaven/APS)	The Zintaks - Spence Zintak
Jill Glass (SNL)	Tim Boyle (SNL)
Jill Glass (SNL/Rio Grande Symposium)	Timothy N. Lambert, (SNL)
Jim Duncan (Bellehaven/APS)	Troy D. Russell (SNL)
Jim Maroone (SNL)	Donna Stumpf (YMCA)
Jim Miller (SNL): group members	Lynette Rocheleau (SNL)

Results of Survey Analysis

The effectiveness of the workshop was evaluated by an 11 question survey given to the students before and after the workshop, and at the end of the school year (see Appendix A). Our aim was to determine if the workshop improved the scientific interaction with the community, access what information was learned (e.g., nanotechnology), and determine what the retention time for the Junior Scientists new found enthusiasm and self confidence. Both multiple choice and fill in the blank questions were analyzed wherein, the data collected was recorded and averaged using Microsoft Office ExcelTM. Due to differences in class size, an average percent (%) of correct answer for each question was determined for each class. These percentages were then averaged again over the entire population sampled, to normalize the results. The normalized data were used for the input on the chart for each question/answer and are presented in Table 3.

Table 3. Analysis of survey questions on scientific community interactions and knowledge of fundamental concepts presented during the workshop.

Average of 130 3rd-5th Grade Students



Questions:

1. SCIENCE/ENGINEERING COMMUNITY INTERACTION
2. SAFETY
3. SCIENTIFIC METHOD
4. SCIENCE: ACID BASE
5. SCIENCE: CHARACTERIZATION
6. SCIENCE: NANO bigger
7. SCIENCE: NANO color
8. SCIENCE: NANO smaller
9. SCIENCE: INTEREST like
10. SCIENCE: INTEREST good

Over a 100 Official Junior Scientist from Bellehaven Elementary School were produced in five 2h CSI:Dognapping Workshops (Figure 13). Bellehaven is part of the Sandia High School District for Albuquerque Public Schools (APS) and gratuitously supplied their teacher's time and arranged transportation of students to make this workshop a success. Survey results for the pre-and post-workshop analyses indicate that a significant improvement in all the targeted areas was realized. After receiving Official Junior Scientist status:

- scientific interest rose from 90 to 98%,
- students who thought they were good at science increased from 80 to 98%,
- awareness of students knowing a scientist or engineer increased 50% (students who knew a scientist or engineer prior to the workshop, listed their parents or teacher's name
- understanding the concepts of nanotechnology such as the color of nano-particulate gold increased by a whopping 89% (do you know its color?),
- being able to describe something at the nano-scale regime also improved by over 30%.

Figure 13. 130 (3rd-5th grade) Official Junior Scientist!



These improvements demonstrate a significant achievement in the development new pedagogical methods aimed at enhancing the public's awareness and education of nanotechnology. In addition, increases in standard science curriculum such as the scientific method and characterization of pH and fibers were also confirmed. These results demonstrated the effectiveness of the CSI:Dognapping workshop and in five 2h spans we developed 100 new HONSS. Some of these newly minted scientists are shown in Figure 13.

The retention of the material learned during the CSI workshop was also examined at the end of the school year – referred to as the timed-workshop survey. For questions 3 – 8, zero to very small differences were noted from this timed- and the post-workshop analysis. In contrast, it was surprising to note that the percentage of students who liked science and who thought they were good at science *decreased* from post-workshop results. This result is not well understood and further investigations are needed to pin point this loss. Our current hypotheses include: (i) lack of interest and self confidence based on *not* winning the recently held school science fair, (ii) perceiving/concluding that science is hard, and (iii) end of the year exhaustion due to standardized testing. We have initiated more interactions with the various school teachers to examine this problem closer. Due to the school's curriculum and science fair activities, students understanding the scientific method rose ~12% since attending workshop. The percentage of students understanding the different characteristics of pH (80% of the students correctly identified an acid) and fibers decreased from post-workshop; however, in comparison to pre-workshop levels these areas in the timed-workshop survey had overall improvement. Additionally, for concepts relating to nanotechnology, the scores were outstanding with over 70% students retaining an understanding of this new material.

Critique on Workshop

The hands on activities used during the workshop to teach standard scientific curriculum and nanotechnology not only improved the volunteers ability to speak to the general public and K–5 community, but also made an impact in the student’s retention of material. We also learned that even though this 2h workshop improved the interaction between students and the professional scientific community (with over 50% of the students listing someone from the workshop or parent), a one time interaction may not be enough for a student to say they know a scientist or engineer. This may be the reason why we see a decrease from 80% of the students knowing someone. Thus indicating that our professional community may need to interact with the same students multiple times before a student is confident to say they know a scientist.

In reviewing the workshop several key ideas of “What went right?” were listed, including:

- Improved interaction of students with scientists,
- Increased awareness of nanotechnology by the students,
- Improved intern and staff scientist ability to speak to the public about science,
- Increased excitement and self confidence from the students about science immediately following the workshop (several statements of “I want to work here” were overheard) ,
- Increased excitement in staff and intern volunteering: ERA nomination 60 volunteers and offers of external support (i.e., ACS, MRS, ASM),
- Methodology presented by Thomas Bowles (Science Advisor to NM Governor Bill Richardson) at the 2007 National Symposium for Scientists and Engineers Panelist: Effective Role of Scientists and Engineers in Statewide Initiatives. Santa Fe, NM April 10–13, 2007.
- Spin off of workshop led to ASM international collaboration to develop an online CSI laboratory and Austen’s detective agency for the “City of Materials”
<http://dev.sancsoft.com/educationasm/asmeducation.html>.

In addition, “What went wrong?” questions were raised. The listings below details some of what was reported.

- Working with one school caused all the students to “talk” to each other about who the criminal was and changes in story line were needed for every class,
- Timing of the stations were off and volunteers were not used to “improvising” or bringing in the story line to analytical stations,
- Nanostation and Fibers station took the longest to complete,
- Answer to safety question: sunglasses or safety glasses decreased, possibly due to “shaded” safety glasses worn by several researchers during workshop.

From these critiques, we discovered that the story line of the presentation is of utmost importance. The students often found holes in logic and shared results. Therefore, it is vital to continually improve, alter, and update the storyline. In addition, the plot did not work as well for the older students who seemed to be too mature for a “dognapping scenario”. As noted above, the Fiber and Nanogold stations were too long and needed to be shortened. In addition, the Fiber station yielded the poorest understanding of the concepts presented as indicated by the questionnaire. This station needs to be simplified and streamlined to make it more appealing to the students.

Teaching by Example: Giving back.

We realize that involvement in science requires an early and constant renewal of interest through structured hands-on research projects as well as learning to ‘give back’ to be initiated as early as possible. One way to represent how we are trying to accomplish this goal is with the timeline (Figure 14) that illustrates how HONSS at various levels of education can be attracted to science and be taught how to give back through outreach programs and peer mentoring. This type of early introduction to science will excite this generation of students wherein both Sandia and the nation benefit by developing strong ties with elementary school kids who will become

Involvement in science requires **early** and **constant** renewal of interest through structured, hands-on research projects

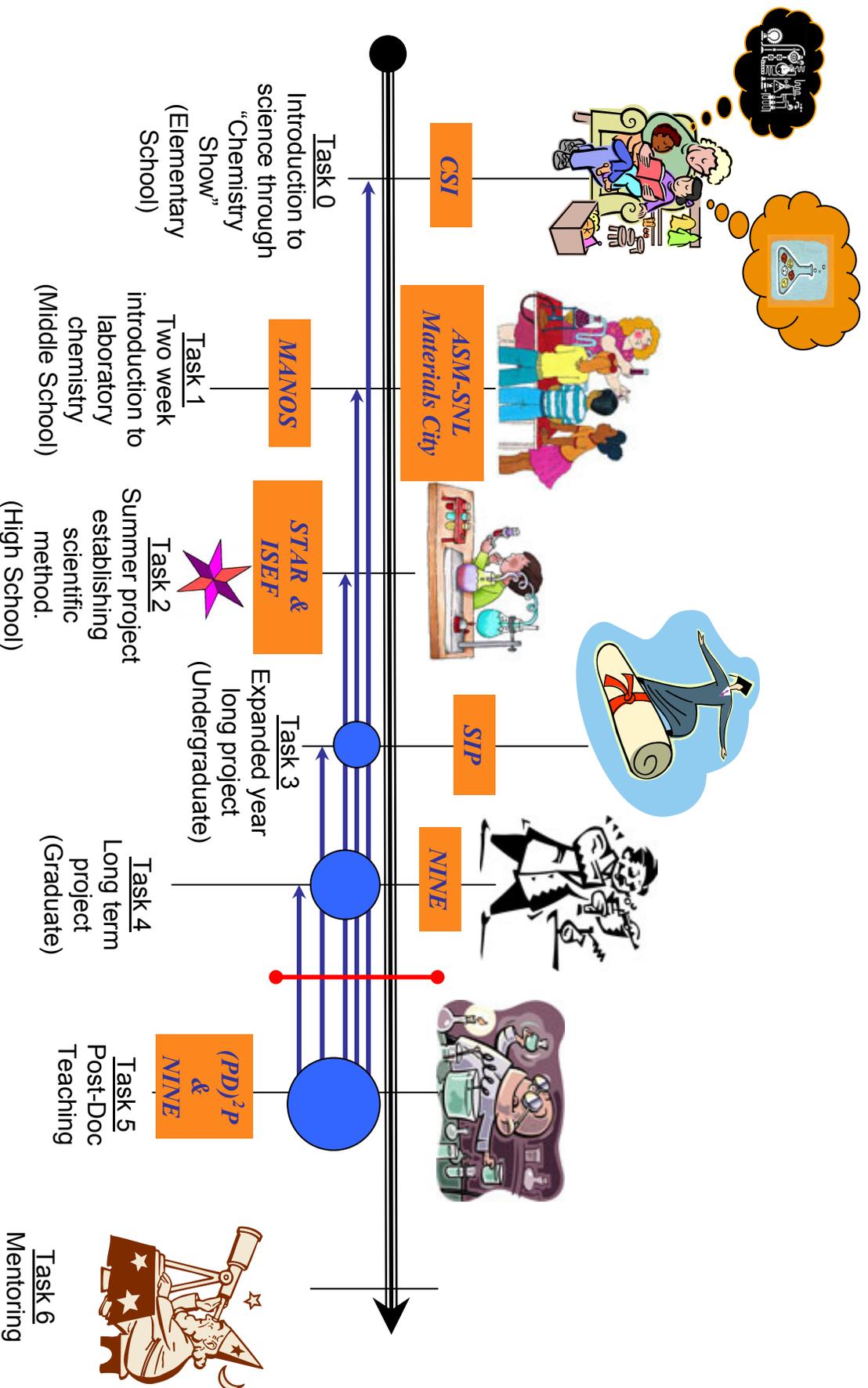


Figure 14. Timeline of Student Interaction with the Professional Scientific Community.

the future industrial, academic, and government technical leaders. We believe that through these future established relationships, a workforce who is less anti-science bias and more pro-national labs will be developed. Scientific innovations will occur faster since these future collaborative parties will also understand what is needed by Sandia and how it operates. Already, today's interns from STAR, International Science and Engineering Fair (ISEF), Student Internship Program (SIP), Undergraduate Research Program (URP), and Post-doctoral programs enhance Sandia by contributing to research that impacts our national mission, Figure 15. With this type of program, we can teach students early on, that an easy and valuable way to give back is by volunteering in our community outreach programs.

STARS



Natalie Freinmuth
Rio Rancho High School

Christopher Quintana
Bernalillo High School

SIP Students and Post-Doc



Rebecca Raymond
UNM

Leigh Anna M. Ottley
UNM

James King
UNC

Dr. Scott Bunge,
Prof. Kent State

Figure 15. HONSS enhance and contribute to Sandia's research to solve our national missions.

Through this workshop we are teaching an age appropriate set of mentors (our SIP students, young grads, and young post-docs) to begin interacting with the K–5 community to in order to make a difference for their future. We are also leading other professionals in the fight to reverse a growing education problem. For example, in addition to the HONSS that we produced locally, we have begun to assist in the development of potential HONSS across our nation and internationally. Recently, results from the CSI:Dognapping Workshop were presented at the 2006 American Chemistry Society meeting, the 2007 Inorganic Gordon Research Conference and at 2007 ASM International Leadership Days Conference, where they were met with enthusiastic interest and several requests for “how to kits” from these professional society members.

Another positive result of our K–5 outreach experiment was observed from a group of 20 International Science and Engineering Fair (ISEF) student interns who attended our Materials Science and Engineering workshop at Sandia. For two weeks they were shown the various aspects of Sandia research. For one of those weeks, they focused on nanotechnology. Part of their work in nanotechnology was to help develop a new CSI:Dognapping- like workshop. Their efforts led to “Lost Memories: the Quest for Nano Gold” workshop where they enlisted help from elementary school students to solve a problem. Several volunteer elementary school students of all ages attended the “Lost Memories Workshop” which was designed and run by these ISEF students (with a little help and direction from the Sandia staff). The ISEF student interns are listed in Table 4. This outreach exercise allowed the ISEF students see that they could make a very rapid and strong impact on younger students. Initially we thought this lesson might pay off much further down the line (i.e., years), it was found that several of these ISEF students are now attempting to develop their own similar workshop for elementary students at

their local institutions. Three of these students have already requested “how to kits’ for the workshop to establish at their local high school and undergraduate institution. This interest is the *optimum* result for the workshop because future elementary students will be exposed to the excitement from peers closer to their age and will continue to build the much needed source of potential scientists.

Table 4. List of ISEF Student Interns and Their Winning Projects.

Student Name	Project Title
Alison Stace-Naughton	RFID Applications to Transfusion Medicine
Billy Dorminy	Improper Fractional Base Encryption
Cameron Kruse	The Dirt on Baseball: Standardizing the Baseball Mudding Process
Chris King	Wireless Power Transmission Through Electromagnetic Resonance
Derek Smith	Ascorbic Acid and Naphthoquinone Inoculated Keratinocyte and Fibroblast Cultures Resistance to HSV-1, Continued
Ganga Moorthy	Maltose Utilization of Escherichia coli K12
Jane Fomina	Computational Exploration of Protein Functions
Jenna Kromann	The Effect of Drought on the Salinity Zone in the Edwards Aquifer
Jordan Krell	Smart Swim: A Drowning Alert System
Karthik Prasad	Cancer: What Can Garlic Do for You?
Laurie Agosto	The Pathological Effect of Bacteria on Muscle Tissue
Markrete Krikorian	Synthesizing DMPC-capped Gold and Water-soluble Cadmium Sulfide Nanoparticles
Mustafa Iqbal	The Effects of Electricity on Paralyzed Worms
Nancy Dong	Determining the Cause for the Evolutionary Phenomenon of ADP-glucose Pyrophosphorylase's Subunits
Natalie Alberman	A Comparative Study of Chlorophyll Fluorescence and Chlorophyll Density of <i>dkg-1</i> and Wild Type
Norman Pai	Simulation of Light Scattering of Mitochondria After Cell Apoptosis
Rajasree Roy	Efficacy of the Modified Conditioned Defeat Model in Odor Recognition
Rebecca Grout	Surface Properties of Sugar Cookies
Stephen Bergin	Selective Elemental Determination Within Multiple Molecular Compounds Through Gas Chromatography
Thiago Olson	Neutron Activation Analysis Using an Inertial Electrostatic Confinement Fusion Reactor

Sandia's Leadership Impacts Our Nation

Since many national reports have shown that more interest must be generated in MS&E to improve our nation's prosperity, Sandia is acting on these reports by enhancing collaborations with educators for all levels of a scientific career path: Kindergarten–Postdoctoral. The CSI:Dognapping is one part of our efforts to lead the nation in hands-on science education. The question as to “How does this benefit Sandia?” is often stated in discussions concerning the CSI:Dognapping Workshop.

One way to think of how the CSI:Dognapping program works is to use the analogy of how the heavy ‘snowpack’ on the mountains keeps the rivers flowing in New Mexico. The majority of water in the Rio Grande River comes from the thaw of the snowpack on the mountains. If there is no ‘snow’, then the free flowing ‘river’ (applicants for science jobs) is reduced to a trickle. We believe this workshop initiates the snow storm (initial interest in science) that nourishes the snowpack (potential science students). Granted not all of the snow will reach the river, but more snowpack at the top means more opportunity for water. Catalyzing a snow storm is one of the first critical steps that ensures a continuous flow of water into the river or students into science. While we realize that not all of the Official Junior Scientist will become Sandians or even scientists, numerous alternative positives are realized, such as: developing a much larger ‘snowpack’ of students interested in science that will increase the pipeline of students, paving the road from Sandia to a variety of scientific careers (Figure 16), initiating a healthy relationship with these future scientific researchers and hopefully maintaining it through the programs shown in Figure 14 as they progress in science and give back. Further, the positive feedback from the local community will be invaluable as the HONSS continue to interact with the national laboratories in a positive manner that helps everyone.

Figure 16. CSI:Dognapping Workshop initiates the snow storm of students who will begin their journey from Sandia to careers in MS&E fields as future teachers, professors, and industrial and government scientists.



For example, following select students several weeks later, it was found they still displayed their certificates in prominent places and thought science was cool. Teachers and parents also had stories of the HONSS wearing their safety goggles to bed and excitedly speaking about their scientific work to save Beaux, the Chemistry Magic Dog. This led many of the parents to express an interest on how their children can get involved in other Sandia educational programs at the middle school (MANOS, Dreamcatcher, HM-Tech) and High School level (SIP, STAR). These positive experiences, generated by the enthusiastic volunteers and hands on activities, have parents, students, and teachers eager to continue their ties with Sandia to gain assistance in scientific areas they may not be as strong in. This may garner a glimmer of public support by the parents for scientific endeavors they once shunned.

Additionally, the ability of the staff to ‘show-off’ their skill sets to a group of interested HONSS will only continue to improve the moral of the staff involved. Laboratory staff will also become invested into the HONSS they are introduced to, since staff will be able to attract a ‘set of hands’ to assist them in research. In our group, we have used this effectively to such a point that current student interns now train the new HONSS entering our lab. This method of peer training and learning allows an amazing amount of research that benefits Sandia’s mission with a minimal amount of training required by an established staff member. A number of these valuable group members are shown in Figure 16.

Figure 17. Picture of the peer training and learning method used in the Boyle research group.



Summary and Conclusion

The CSI:Doggnapping Workshop is a culmination of the more than 65 Sandia's staff and interns volunteers' (Table 4) dedication to exciting and encouraging the next generation of scientific leaders. This 2 h workshop used a 'theatrical play' and 'hands on' activities that was fun, exciting and challenging for 3rd – 5th graders while meeting science curriculum standards. In addition, new pedagogical methods were developed in order to introduce nanotechnology to the public. Survey analysis indicate that the workshop had an overall improvement and positive impact on helping the students to understand concepts from materials science and chemistry as well as increased our interaction with the K–5 community. Anecdotal analyses indicate that this simple exercise will have far reaching impact with the results necessary to maintain the United States as the scientific leader in the world. This experience led to the initiation of over 100

Official Junior Scientist (HONSS) that will solve some of science's and the world's most vexing problems.

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Appendix D.

- I. Sandia Daily News Article: Vol. 59, No. 4. February 16, 2007**

A. I. Pre-Workshop Lesson Plan for Observation and Safety

- I. Introduction of myself to the students
 - a. I am a scientist who works at Sandia National Laboratories
 - b. I am a chemist; a chemist is person who works with chemicals to make different materials.
- II. Students will be asked if they can help me answer a survey (**See Appendix A. II**)
 - a. Let the students know there is no right or wrong answer
- III. Begin lesson on observation
 - a. Tell the students that we are going to learn about the five senses and observation.
 - b. Ask if anyone can tell me what the five senses are:
 - i. sight, hearing, touch, smell, taste
 - ii. We use the senses to help us describe people, places, things and actions.
 1. give examples on observation with people and things
 - a. what is the color of my shirt?
 - b. is it hot or cold outside?
 - iii. Today we are going to use our senses to make observations about chemistry experiments.
 - iv. You will be coming to Sandia National Laboratories to watch a chemistry magic show and we want you to be prepared.
 - v. Scientist use observation to tell us what happens in our experiment
 - vi. Not all things in science are safe to observe without protecting our senses
 - vii. Give students safety information about protecting our senses:
 1. we protect our sight with safety glasses
 2. we protect our touch with gloves or we use tools
 - a. e.g., thermometer can test the temperature of something really hot like boiling water. Relate to cooking.
 3. we protect our smell and taste
 4. Chemicals can be poison and should never be tasted
 - c. Students will be lead into what is a hypothesis and observation exercises
 - d. Student will be give safety glasses and will be asked to watch a chemistry experiment: $\text{CuSO}_4 + \text{NaOH} \rightarrow \text{Cu(OH)}_2 + \text{NaSO}_4$
 - e. Students will be asked questions about observation
 - i. What is the color of Copper Sulfate
 - ii. What is the color of water
 - iii. What do you think will happen when I add copper sulfate to the water
 - iv. What is the color of aqueous NaOH
 - v. What do you think will happen when I add the ammonium hydroxide to the copper sulfate dissolved in water

- f. To explain the metathesis reaction, four volunteers are asked to come to the front. Each student is given a piece of paper with the starting cations (no charge) and the name underneath and asked to hold it in front
 - i. Cu copper
 - ii. SO_4 sulfate
 - iii. Na sodium
 - iv. OH hydroxide
- g. Students are paired: CuSO_4 and NaOH
- h. Then students are asked to read, lead students explain that the atomic symbols are abbreviations for the words underneath. Point and have students say aloud “COPPER” then “SULFATE” then “SODIUM HYDROXIDE”
- i. Students are told to begin dancing as I pretend to add water to them
- j. Then have the students begin to separate from their partners.
- k. Now tell the student that they are going to meet each other and switch dancing partners. (Help guide the anions to switch).
- l. Now have explain that the $\text{Cu}(\text{OH})_2$ is the blue solid that was just made. Have them now read the new combinations to let them know they just made $\text{Cu}(\text{OH})_2$ ppt and NaSO_4
- m. Lesson will end by reminding students that they just made several observations and hypothesizes, and to keep practicing so they can use these skills when they come to SNL for the chemistry magic show.
- n. Collect safety glasses and let them know they will use them again.
- o. Students are told that Sandia is excited to have them come visit

A II. Workshop Survey for Scientific Awareness: Survey administered to the elementary Students prior to, after the workshop, and at the end of the school year.

1. Do you know a scientist or engineer?
 - a. Yes
 - b. No
2. Do you know his/her name? Please write it down. _____
3. Are sunglasses or safety glasses worn during science experiments?
 - a. I don't know
 - b. Sunglasses
 - c. Safety glasses
4. What senses do you use to make observations?
 - a. Sight and Touch
 - b. I don't know
5. Is lemon juice an acid or a base?
 - a. I don't know
 - b. Acid
 - c. Base
6. Do you know if nylon is?
 - a. synthetic
 - b. natural
 - c. I don't know
7. Which is bigger?
 - a. nanometer
 - b. meter
 - c. I don't know
8. What color is nanogold? _____
9. Which is smaller?
 - a. Hair
 - b. Nanogold
10. Do you like science?
 - a. Yes
 - b. No
11. Are you good at science?
 - a. Yes
 - b. No
12. What kinds of science activities have you done? _____

B I. Slide Show Script

Students enter crime scene room and sit on the floor. As the students get settled in safety glasses are handed out. **Slide 1** is animated to welcome the students to the magic show. As we wait for our “Chemistry Magic Dog and Magician”, students are reminded of safety practices discussed during pre-visit.

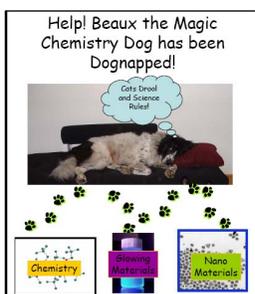
Note: All workshop participants do not wear any special costumes, just casual clothes. During the presentation, one volunteer is needed to scroll through the presentation slides while the presenter is speaking (or this can be achieved remotely). Presenters are all volunteers who are also in charge of the various analytical stations.

Main Presenter - enters room in a huff and frantic. He sits on the floor with the students to be at their level and begins his conversation with a concerned look on their face.



Main Presenter (TJB), slide 1: “Hi my name is Tim and I’m a Chemist here at Sandia National Laboratories. Have any of you ever been to Sandia before? No, well welcome but first things first./// I’m sorry//// but the magic show has to be CANCELLED! (the cancelled slide pops up over the magician.

❖ Volunteers make outcries of dismay: (Oh No!)



Main Presenter (TJB), slide 2: It turns out that my assistant Beaux (pronounced “bo”) has disappeared. He was left right behind you (point to the crime scene with the crime tape). But he is gone NOW! Beaux is very important to our work here. He helps us do chemistry – where we make molecules, luminescent materials – those things that glow when you shine a light on them, and he helps us make very small materials called nanoparticles. Does anyone know what a nanoparticle is? (usually a few grumbles of ‘No’). I am sorry. I am really old and don’t hear so well, so I need ya’ll to speak up! (“No”) Louder? (“NO!”), Louder! (“NOOOOO!”). Good I can hear that. So, don’t worry we’ll get to nano stuff in a bit. First, let’s find Beaux. I looked around the building and talked to all my friends here (helpers along the wall) and they say they didn’t do it, right guys? (all assistants say “Right!” I’ve known them all for a long time now so I trust them. Which leads me to believe (switch slides)....

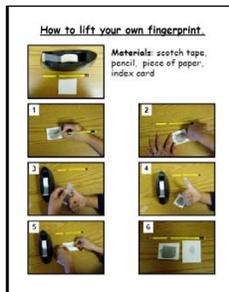


Main Presenter (TJB), slide 3: that...YOU did it!

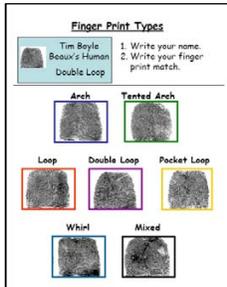
(wait several seconds or longer depending on their protests – I answer any catcalls with – ‘I don’t know. I think you did it’).

Now, we have found some fingerprints at the crime scene so we’d like to compare to yours! OK? (grumbled responses). OK? (“OOOOOKKKK!!!” back)

- ❖ Presenter Two comes forward and invites the students to gather around a table for the first group activity. Pencil, paper, tape, and index cards should be distributed around the table.

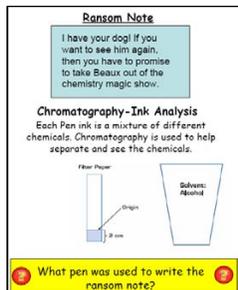


Presenter Two (BAHS), slide 4: I need your finger prints to prove you did not take Beaux. I am going to show you how to lift your own fingerprint. So come up and gather around. Does everyone have a pencil, paper, and index cards? Alright, the first step is to take your small piece of paper (hold up items so students see and perform procedure as you say it) I want you to draw a big box on it. Now color in your box quickly. Go fast like me. Ok Stop. Now everybody give me a thumbs up! (Hold up your thumb high). Now take your thumb and rub it over your box. Make sure your thumb is covered. Next, take a piece of tape and cover your thumb. Pull off the tape and stick your print onto the index card.



Presenter Two (BAHS), slide 5: Now we have to get our finger prints ready for analysis. Did you know that there are seven fingerprint types? Lets go over them. What does this name of this print? (Volunteers and Students SHOUT ARCH!)...ect. Now that you know they types, I want you to write your name on the card and compare your thumbprint to the prints on the screen. Here is an example of what I want you to do (point to blue box). Tim has already made his. He has a double loop.

- ❖ Volunteers and Teachers gather around the students to help. Cards are collected and handed to Presenter 4, who goes away to “analyze” the fingerprints. Students are then asked to sit back down to help read aloud the message found on the ransom note.



Presenter Three (RR), slide 6: (several of the volunteers should sit inter-dispersed throughout the audience to get the students involved). We also found a ransom note at the crime scene. Can you HELP me read it. “I have your dog! If you want to see him again, then you have to promise to take Beaux out of the chemistry magic show.” Now we have the note and we have three pens that might be the pens that the dognapper may have used to write the note. We are going to do an experiment to compare the inks of our three pens to the ink on the ransom note. We are going to take our three pens and put a dot of each on a piece of filter paper (volunteer picks three students to put small dots of ink on a long rectangular piece of filter paper). We are going to compare these samples with the filter paper our note was found on. (Each piece of filter paper is put into a beaker with isopropanol) We are going to leave this here and when you are all done with the other experiments then we will see which pen wrote the note.

❖ Presenter 4 re-enters room to “clear” the students of the crime



Presenter Four (HP3) slide 7: I’ve just received the results from your fingerprinting, and the good news is that none of your fingerprints were found at the crime scene. Now I have an important question to ask you, will you help use find Beaux? (Students shout YES)



Presenter Four (HP3), slide 8: Now that you’ve agreed to help us, we need to see if we can determine who took Beaux based on looks alone. We found four sets of fingerprints at the crime scene, and they belonged to your principal, Bernie, Timmy, and Bill. So raise your hand, if you think that your principal is guilty? (Take a hand count). Bernie? (Take a hand count) Timmy? (Take a hand count). Bill looks pretty mean. How many of you think Bill took Beaux? (Take a hand count, and tally up votes) Most of you thought insert name took Beaux.

❖ Volunteers raise their hands and vote on every suspect. They also egg on the students by shouting “ He did it or She did it. I know she did it because she looks mean, ect.”

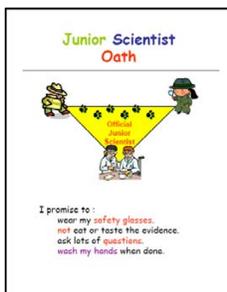


Presenter Five (LAMO), slide 9: “So by looking at the pictures of the four suspects can we fully say who committed the crime? NO! but we can prove who stole Beaux by using science.”



Presenter Three (RR), slide 10: (This slide is read aloud with special emphasis on the specific pieces of evidence such as the type of chemistry that each suspect conducts, the type of lab coats they all wear, favorite drinks or foods and the types of pens they use. Based on this information alone the students are then asked to pick which suspect they think is guilty)

- ❖ During the reading, volunteers in audience “Ooo” and “Ahhh” at the emphasis of evidence.



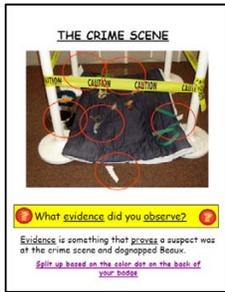
Presenter Seven (TNL), slide 11: Before we can solve this crime, we need you to take an oath. Does everyone know what an Oath is? It is like a promise. We need you guys to promise to be good scientist and practice safe procedures. And always remember, “Safety has no quitting time!” Please hold up your right hand and repeat after me. The presenter then leads the participants having them repeat after him, line by line. When done, the presenter tells them they are all Junior Scientists.

- ❖ After the students are sworn in, they are “Deputized” and receive their name badges. Teachers and field trip chaperons hand out the badges to the students while they are sitting. (See Appendix B III).



Presenter Two (BAHS), slide 12: Are you ready to help find Beaux! (YES!) Now that you have been cleared of suspicion, you can help us look for evidence at the crime scene! Evidence is something that proves a suspect was at the crime scene and dognapped Beaux.

- ❖ Students are asked to get up and observe the crime scene. Volunteers encourage students to find objects that appear out of place. Students are encouraged to say their observations aloud. Activity time of ~5 min. is given before the students return to their seats



Presenter Two (BAHS), slide 13: So what evidence did you observe?! (Let students shout answers then advance slide to reveal evidence they will analyze. Point out quickly)

- ❖ After viewing evidence as a class, the students are handed clue sheets and pencils. They are then divided up based on the color of dot they have on the back of their badge. Each group goes to their assigned analytical station and the groups rotate through the remaining stations. To determine the last piece of evidence, students return to their seats in the crime scene/presentation room as a class.



Presenter Three (RR), slide 14: So looking at the three pens that we found and comparing that to the ransom note, based on the chromatography which pen do you think wrote the note? (Students then shout out various answers) Look at the ransom note, there are three different colors of inks, shout out and tell me what colors you see... (students then shout “yellow, black and blue”). So based on that which pen has the same three ink colors? (Students shout out that it must be the gel pen) Which suspect likes to use gel pens? (Students then shout out the answer—in this case the suspect that likes gel pens is Timmy) Mark that on your evidence sheets.

- ❖ Students are asked to write down their answer

Evidence Sheet

Match the Evidence to the Suspects

Write down your observations from the evidence stations. Check the box with a Y, if there is a match to the suspect.

Evidence Station	Observations	Crime Questions about the Suspects	Timmy	Beaux	Timmy
Yellow Evidence	The color of the ink is yellow.	Who likes to write notes?			
Blue Evidence	On some joints or parts of the pen.	Who likes to write notes?			
Red Evidence	What is the pH of lemon juice?	Who likes to write notes?			
Green Evidence	What happens to milk?	Who likes to write notes?			
Black Evidence	Which block will a magnet attract? A, B, or C?	Who used the pen?			
Orange Evidence	Is carbon tetrachloride or carbon tetrachloride?	Who wrote the note?			
Purple Evidence	What kind of polymer is gelatin?	Who wrote the note?			
White Evidence	Who wrote the note?	Who wrote the note?			
Blue Evidence	Who wrote the note?	Who wrote the note?			

Presenter Two (BAHS), slide 15: Now that you have used science to analyze the evidence, let’s go over what you have found.

- ❖ Slide is animated to see the results of each analytical station individually. The whole class is led through the clue sheet.

OK, great. Unfortunately, there is not enough time to do the magic show (grumbles, switch slide) but since we are chemists, Becca will show you how to take what we used today to make ice-cream. Does anyone like ice cream? (YEA!!!!). OK but what was the last thing you swore to do as an OFFICIAL JUNIOR SCIENTIST? (grumbles) WASH Your hands right? (RIGHT!!!). SO let's line up and wash our hands, get lunch and learn how to make liquid nitrogen ice cream.

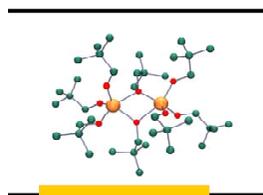
- ❖ Students are dismissed to WASH THEIR HANDS then go to make liquid Nitrogen ice cream, visit with engineers to make Robocasted cookie treats, learn about how firefighters use science, and eat lunch with all their new science and engineering friends they met.

Note: Students provide their own sack lunches. No food items with peanuts or chocolate are served. We suggest you contact your local Canine Therapy Societies (e.g., Delta Society) or other animal service centers to find your “Animal Star”.

B II. Animated Slide Show: Suspects, Evidence, Safety (PowerPoint file available upon request)



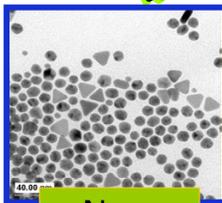
Help! Beaux the Magic Chemistry Dog has been Dognapped!



Chemistry



Glowing



Nano

I SUSPECT...

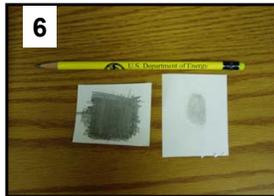
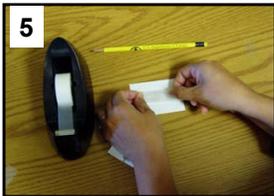
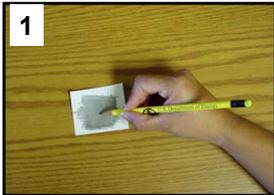


YOU!

How to lift your own fingerprint.



Materials: scotch tape, pencil, piece of paper, index card



Finger Print Types



Tim
Beaux's Human
Double Loop

1. Write your name.
2. Write your finger print match.

Arch



Tented Arch



Loop



Double Loop



Pocket Loop



Whirl



Mixed

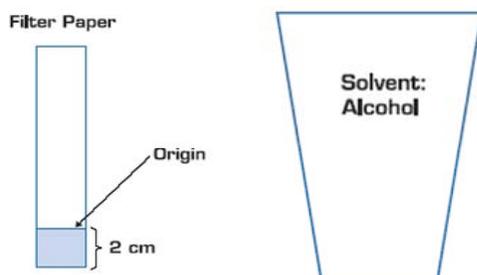


Ransom Note

I have your dog! If you want to see him again, then you have to promise to take Beaux out of the chemistry magic show.

Chromatography-Ink Analysis

Each Pen ink is a mixture of different chemicals. Chromatography is used to help separate and see the chemicals.



What pen was used to write the ransom note?





You passed your fingerprint test!

It is now up to you to help find

BEAUX.

Will YOU help
BEAUX?



Who do you think looks guilty?



TAKE A VOTE!



Ms. Hamilton



Chris



Timmy



Bill

Can you prove it.....

NO!

WE

can with
SCIENCE!!!

Suspects



Ms. Hamilton: Is your principal. She came to the AML to make sure we had your permission slips for the magic show. Her favorite pen is a black sharpie. Ms. Hamilton's favorite drink is lemonade. She heard that Tim Boyle and Beaux make excellent nano gold. She also likes to wear clothes made from cotton. She likes cats (gatos) and dogs (perros), but does not know Beaux the magic chemistry dog.



Timmy: Is a scientist. Timmy synthesizes polymers. He wears a white nylon lab coat. His favorite pen is a black ball point pen. Timmy has a cat (gato) named Little One who doesn't like Beaux. Timmy wants Little One to be in the magic show instead of Beaux. In fact, Little One thinks she can make better chemical explosions! For breakfast, both Timmy and Little One drink milk shakes.

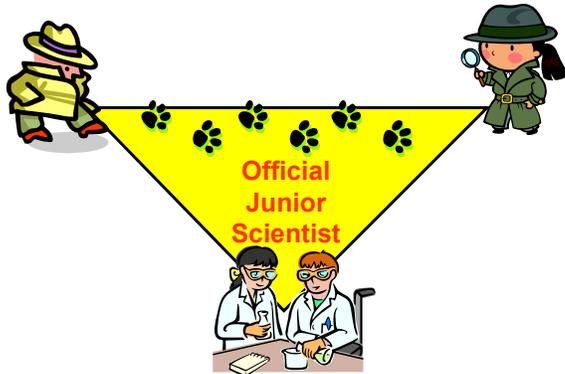


Bill: Is our manager. He has keys to all the rooms and knows the AML building well. Bill is also a scientist and makes nano gold and works with glow in the dark chemistry. Bill likes to eat ice cream and wears a multi-colored nylon lab coat. His favorite pen is gel pen. Bill is mad at Tim Boyle for not cleaning his lab. Bill likes dogs, but he is mad at Beaux for exploding a reaction during the chemistry show.



Chris: Is a scientist. Chris makes nano gold for Tim Boyle and wears a white nylon lab coat. Her favorite pen is a black ball point. Tim Boyle and Chris disagree with each other about her latest science experiment results and hypothesis. Chris loves Beaux and really wants Beaux to be her chemistry dog. Last week, she asked Tim Boyle what Beaux's favorite treat was. Tim said it was ice cream. Chris loves ice cream too!

Junior Scientist Oath



I promise to :
wear my **safety glasses**.
not eat or taste the evidence.
ask lots of **questions**.
wash my hands when done.

Badge handed out after being sworn in

Sandia National
Laboratories

NAME
Junior Science Detective

Advanced Materials Laboratory



THE CRIME SCENE



? What evidence did you observe? ?

Evidence is something that proves a suspect was at the crime scene and dognapped Beaux.

THE CRIME SCENE



? What evidence did you observe? ?

Evidence is something that proves a suspect was at the crime scene and dognapped Beaux.

Split up based on the color dot on the back of your badge

Ransom Note

I have your dog! If you want to see him again, then you have to promise to take Beaux out of the chemistry magic show.

Each Pen ink is a mixture of different chemicals. Chromatography is used to help separate and see the chemicals.



What pen was used to write the ransom note?



Evidence Sheet

Match the Evidence to the Suspects

Write down or circle your observations from the evidence stations.
Check the box with an X if there is a match to the suspect.

Evidence Station	Observations	Crime Questions about the Suspects	Suspects			
			Ms. H	Bill	Timmy	Chris
<u>NanoRoom</u>	The color of Nano Gold is:	Who makes Nano Gold?				
<u>Spill Analysis</u> pH of spill	Is lemon juice an Acid or a Base? What is the pH of lemon juice? _____	Who likes acidic drinks?				
<u>Spill Analysis</u> indicators	What happens to milk?	Who made a white spill?				
<u>Ink Analysis</u>	Which black ink is made from three colors? A, B, or C?	Who used this pen ink?				
<u>Fiber Analysis</u>	Is cotton Natural or Synthetic? What kind of polymer is cotton?	Who wears nylon?				
<u>Secret Messages</u>	Message under black light reads:	Who works there?				
	Message with a chemical indicator reads:	Who likes them?				
<u>Guilty Person</u>		Who did it? Add up the evidence				

Evidence Sheet

2. Match the Evidence to the Suspects

Write down or circle your observations from the evidence stations.
Check the box with an X if there is a match to the suspect.

Evidence Station	Observations	Crime Questions about the Suspects	Suspects			
			Ms. H	Bill	Timmy	Chris
NanoRoom	The color of Nano Gold is: Purple, Morada	Who makes Nano Gold?		X		X
Spill Analysis pH of spill	Is lemon juice an Acid or a Base? What is the pH of lemon juice? <u>2</u>	Who likes acidic drinks?	X			
Spill Analysis indicators	What happens to milk? Moving rainbow	Who made a white spill?		X	X	X
Ink Analysis	Which black ink is made from three colors? A, B, or C?	Who used this pen ink?		X		
Fiber Analysis	Is cotton Natural or Synthetic? What kind of polymer is cotton? Cellulose	Who wears nylon?		X	X	X
Secret Messages	Message under black light reads: AML	Who works there?		X	X	X
	Message with a chemical indicator reads: GATO	Who likes them?	X		X	
Guilty Person		Who did it? Add up the evidence	2	5	4	4



NOW Who do you think did it?



TAKE A VOTE!



Ms. Hamilton



Chris

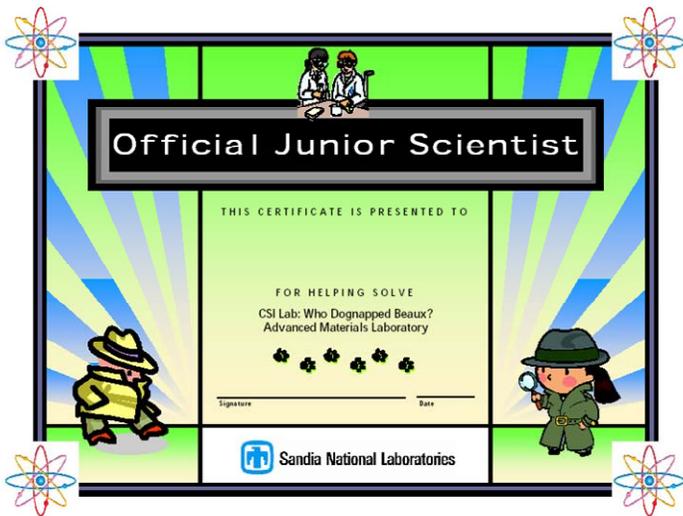


Timmy



Bill

CONGRATULATIONS!



Scientist Careers?



Chemists
Engineers
Firemen



Policemen



Biologists

Physicists



Doctors



B III. Junior Scientist Badge and Official Junior Scientist Certificates

Sandia National
Laboratories

NAME
Junior Science Detective

Advanced Materials Laboratory



C I. Clue Sheets in English and Spanish.

Evidence Sheet

Match the Evidence to the Suspects

Write down or circle your observations from the evidence stations.
Check the box with an X if there is a match to the suspect.

Evidence Station	Observations	Crime Questions about the Suspects					
			Ms. H	Bill	Timmy	Chris	
<u>NanoRoom</u>	The color of Nano Gold is:	Who makes Nano Gold?					
<u>Spill Analysis</u> pH of spill	Is lemon juice an Acid or a Base? What is the pH of lemon juice? _____	Who likes acidic drinks?					
<u>Spill Analysis</u> indicators	What happens to milk?	Who made a white spill?					
<u>Ink Analysis</u>	Which black ink is made from three colors? A, B, or C?	Who used this pen ink?					
<u>Fiber Analysis</u>	Is cotton Natural or Synthetic? What kind of polymer is cotton?	Who wears nylon?					
<u>Secret Messages</u>	Message under black light reads:	Who works there?					
	Message with a chemical indicator reads:	Who likes them?					
<u>Guilty Person</u>		Who did it? Add up the evidence					

Evidence Sheet

Nombre _____

1. Crime Scene

Circle the evidence.



Evidencia Hoja

Nombre _____

Vincular al Evidencia para Sospechoso

Escribe su propia contesta para su observaciones de los estaciones de puerba. Marca la caja con un X si puedes ligar un sospechoso con puebra.

Estacion de Evidencia	Observaciones	Preguntas sobre las Sospechosos	Ms. H Bill Timmy Chris			
<u>NanoSala</u>	Que color es Nano Gold?	Quien hace Nano Gold?				
<u>Analisis de Derrame</u> pH of spill	Es el jugo de limon un Acido o Base? Que es el pH del jugo de limon: _____	Quien gusta bebidas acidas?				
<u>Analisis de Derrame</u> indicios	Como ocurrir para leche?	Quien deajo un mancha de color blanco?				
<u>Analisis de Tinta</u>	Cual tres colores hace la tinta negra? A, B, o C?	Quien usa este boligrafo?				
<u>Analisis de Fibra</u>	Es fibra algodones natural o sintetico? Que polimero es algodou?	Quein vestia en nylon?				
<u>Mensajes Secretos</u>	Mensajes con luz negro:	Quien trabaja alli?				
	Mensajes con quimica indico:	Quien le gusta esos?				
<u>Criminal</u>		Quien lo hizo? Sumar el evidencia				

C II. Analytical Station Experiments

(1) **Fingerprints.** The students must pass a fingerprint test. A photo of this activity is shown in Figure 3. The students are taught how lift their own fingerprints with a pencil, paper, and tape, analyze them by deciding which type of fingerprint they have, and then compare them to the ones found at the crime scene. The students must “pass” a fingerprint test before they are allowed to investigate the crime scene and move on to the analytical stations.

Equipment needed: regular pencil, scotch tape, and 3x5 card.

Procedure: The students are called up to the table which has a pencil for everyone and a 3 x 5 card. The students are asked to write their name on the card. They are then told

to draw a box on the right hand side of the card and color it in as dark as possible. After the students roll their thumb in the box until it has been covered in graphite. The students also get a piece of tape. The tape is placed over their thumb and they lift off their fingerprint and tape it to the left hand side of the card. A series of fingerprint types (i.e., whorls, swirls, etc.) are then shown and the students are asked to identify what type their fingerprint is and to write it down. The cards are then collected to be analyzed.

An incentive for passing their test is that these students will be sworn in and honorably badged as “Junior Scientists”. Of course, the students are all cleared and the four suspects turn out to be: (i) the school’s principal, (ii) a beloved manager at SNL, (iii) and (iv) are two scientists at SNL. In addition to learning about fingerprints, this aspect of the workshop is designed to introduce the idea of collecting, analyzing, and interpreting data.

A slide detailing the basic information concerning the characteristics of these suspects is presented. Their “biographies” must contain the various clues described below. One aspect of performing this workshop is that all of the logic does not have to be perfect, but the story line *must* be maintained. The students are asked – with no data – to decide who did it. They base their opinions on what the guilty the suspects look in their mug shots. Once a consensus is reached, by the group, they are asked to prove it. Since they cannot, they are asked if they’d like to use science to solve the crime and get on with the chemistry magic show. Once the students agree, they are *all* given ‘Official Junior Scientists’ badges.

(2) Observation. Once badged, the students then use their power of observation to study the crime scene. This was performed as a group activity emphasizing that some things belong and some things are out of place. Figure 4 shows the students investigating the crime scene.

Crime Scene: Must consist of things that a dog would have (i.e., water bowl, bed, chew toys, dog treats, leash, etc.). In addition, it is critical that the clues for the crime be

present. For this case, several critical clues must be present (i) clear liquid spill, (ii) white liquid spill, (iii) several fibers or strings, (iv) two white 3x5 cards, (v) purple water in the dog bowl, and (vi) a ransom note written on a coffee filter. These clues *must* be found by the students so monitoring the observation time is critical.

A list of what does and what does *not* belong is developed systematically by explaining logically why they do or do *not* belong. This again emphasizes the ability to observe, collect, and eliminate unnecessary data.

(3) Chromatography. One of the observed crime scene anomalies that will be found is a ransom note written on a coffee filter that states “I have your dog. If you want to see Beaux again, then you have to take him out of the chemistry magic show!” Using chromatography, a scientific technique that has been around for 100’s of years, the students will determine which pen was used to write this note. Chromatography is the collective term for a family of laboratory techniques that allow for the separation of complex mixtures. It involves passing a mixture dissolved in a "mobile phase" through a stationary phase, which separates the analyte to be measured from other molecules in the mixture and allows it to be isolated. For this station, the various types of inks used in the pen will be the analyte, alcohol the mobile phase using a coffee filter as the stationary phase. The pens were ascribed to different suspects and the ink from the pen will implicate one of the suspects. The actual chromatography experiment is shown in Figure 5.

Equipment needed: coffee filter, 3 pens (black ballpoint, black sharpie, and black gel pen) water or isopropanol (rubbing alcohol), pencil

Procedure: A large dot from each pen is drawn on the bottom of a coffee filter (note it is important that the dots be far enough apart (at least $\frac{1}{4}$ of an inch) so that the inks won't run together as they move along the paper), along with a sample of the ransom note which was written on a coffee filter, too. The filter is then placed vertically into a beaker

that contains enough alcohol to cover the dots. After about 30 mins (typically, the other stations are undertaken while this one proceeds), the coffee filter is removed and the pen spectra were analyzed in comparison to the note on the filter. The pen matching the note leads to further identification of the suspect.

Knowing the types of pens the suspects prefer to use (from the brief biographies discussed), analyzing the different inks in the pens and comparing them to the ink used on the ransom note will allow the students to identify the guilty suspect. This process introduces the idea of complex mixtures and a method to separate them. Further, comparing samples to the unknown brings in a new idea of establishing baseline and comparisons. Additionally, this experiment is easily reproduced at home so that the students can do further investigations at home on other inks and complex mixtures. While this takes some time to complete, the other stations are undertaken while the inks are separated.

The students are then reassembled and instructed to look on the back of their badges where one of five colored dots has been placed. Based upon the color of the dot, the students are split up into 5 smaller groups and head off in separate directions to investigate the different clues they have listed previously. It is important that the students take their safety goggles, pencils and clues sheets since each will be needed throughout the stations.

(4) Stations. The various stations are broken down into these 5 categories: (a) Nanogold, (b) pH, (c) Milk Rainbow, (d) Fiber analysis, and (e) Secret Messages based on the clues found at the crime scene.

(a) Nanogold. Upon arrival (see Figure 6), students are asked if they remember anything odd about Beaux's water (help remind the students by having them looking at the crime scene on their clue sheet). The students are then asked, "What suspects could have made his water purple?" After hearing their assumptions, the students are told they are going to use science to

determine what caused the water to be purple. Next, we ask them if they know what ‘nano’ means and are allowed to give their answers. Nanoparticles which can be powders, atomistic clusters, or crystals are very small particles with at least on dimension less than 100 nm in size. Using the posters (Appendix C), we first introduce the concepts of size and how small nano is. Props such as a dime, meter stick, and rope are used to convey size. First, the definition of a nanometer is 1 billionth of a meter is given. Then a meter stick is used and students are asked to imagine a billion tiny marbles lining up across the meter stick. As this is analogy is given, we point to one end and move across to the other end to emphasize the enter length that a billon marbles would have to fill. Two extreme examples of ratio are then given. The first is that a dime to planet earth as nanometer is to a meter stick. The second, and most effective example is relating the size of nano to something the students perceive to be very small (i.e., hair). Students are asked to look at a single strand of hair on themselves or on their neighbor. They are then told that nano is smaller than the diameter of a hair.

To demonstrate diameter and size, the students are asked to pick up a rope set in front of them. We then say “Nano is pretty small so we have to shrink down in size. So let’s SHRINK SHRINK SHIRNK, OK Stop!” During this time we taking the rope into our hands we begin to slowly “Nanosize” by going from a standing position to squatting position until our heads are right at table top height. We energetically say “Stop!” and we jump back up to the standing position. We then say, “Now let’s pretend that this rope is our hair. Do you feel the round part? This is called diameter. Do you feel the long part? (run the rope through your hands) This is called length. Now we are still too big to be a nanometer to so we need to shrink again.” We repeat the shrinking process and at the end of the stop command, we tell the students “Now drop the hair because we are too small too hold it.” The students are then shown an SEM image of a

hair that has a 400 nm square on it. “Now that you know how small nano is, we are going to make nano gold.

Small-scale reactions were performed in front of students using test tubes. Students were encouraged to shout out what they observed for each stock solutions and what they saw during the reaction.

Equipment needed: (2) 200 mL and (1) 25 mL Erlenmeyer flasks, stirplate, 2 stirbars, (2) 100 mL graduated cylinders, wooden spatula, metal spatula, plastic weigh boats, 20 mL vial, caps, hydrogen tetrachloroaurate hydrate ($\text{HAuCl}_4 \cdot \text{H}_2\text{O}$), sodium borohydride (NaBH_4), DI water, toluene, tetraoctylammonium bromide [(TOAB) or $[\text{CH}_3(\text{CH}_2)_7]_4[\text{NBr}]$], and dodecanethiol ($\text{CH}_3(\text{CH}_2)_{11}\text{SH}$). 5 test tubes, test tube rack, pipets, 8 foot rope, meter stick, dime.

Procedure: For the K-12 demonstration on how to make nanogold, we modified the synthesis procedure reported by Brust et al.[8] Three stock solutions of (i) aqueous gold (Au), (ii) organic surfactants, and (iii) reducing agent were prepared prior to the workshop. These stock solutions were prepared as follows. The aqueous Au stock solution was made by dissolving 0.354 g HAuCl_4 with 30 mL of DI H_2O in a 200 mL Erlenmeyer flask to form a clear yellow solution. In a second 200 mL Erlenmeyer flask, an organic surfactant stock solution was produced by dissolving 2.187 g TOAB with 80 mL toluene to form a clear and colorless solution. To the TOAB/toluene solution, 0.241g of $\text{CH}_3(\text{CH}_2)_{11}\text{SH}$ was added and stirred for 10 minutes. The reducing agent solution was made by dissolving 0.378 g of NaBH_4 in 25 mL of DI H_2O (Note, add water right before the first group comes and have excess NaBH_4 and H_2O on hand to add as needed).

First a pipette full of the Au stock solution is added to the test tube. Then two – three pipettes of the surfactant solution were added. The test tube is flicked to mix the reagents and then the organic layer was allowed to separate from the aqueous layer. Students could observe a

color change and transfer between the layers. Next the bubbling reducing agent solution was shown. It is explained that the bubbles (H_2 gas) are going to help make nano gold. At this point the students write down their observation for the color of nanogold (have the word purple written out for students weak in spelling). We show pictures of the transmission electron microscope (TEM) used to see nanoparticles of Au. Finally, the students are asked “Who makes nanogold?” By referring the suspect’s characteristics, they mark down their choices.

(b) pH and (c) milk rainbow. For the ‘pH’ and ‘milk rainbow’ stations, the students need to determine what substances the two spills found at the crime scene are made of. These are two separate stations but are combined here to minimize repetitive discussion about the spills. By introducing the concept of analyzing the sample, the students learn to circumvent the way they normally interact with the world (i.e., the need to taste, touch). To help reinforce this concept, the students are reminded that forensics scientist can not taste or eat the evidence they find at the crime scene using the posters (Appendix C) and are told they can use “indicators or color” to help identify a substance.

For the pH station, the concept of ‘free protons’ coupled with the color change of litmus paper, as a means to analyze the spill are introduced. Figure 7 shows the students hard at work uncovering the identity of the clear spill. The students learn the concept of acids and bases through direct measurements using color changes indicating specific pH. The amount of protons (charged hydrogens H^+) present in water (H_2O) is represented by the pH scale ($pH = -\log [H^+]$). The pH scale ranges from 0 to 14 (there are no units for this scale). 7.0 is considered neutral and typically applies to H_2O . Anything, that when dissolved in water, which has a pH below 7.0 is considered acidic; anything above 7.0 is considered basic. For the milk rainbow station, the

students learn the basics of a chemical reaction where the fat of the milk interacts with food dye in a different manner than the components of glue (Figure 8). Again, observation and interpretation of the results are reinforced throughout these two stations.

For the pH station, the students are told that the clear spill was collected from the crime scene. In addition, three bottles were found in the trash can (ammonia, lemon juice, and water) near the crime scene. The students were asked “How can we tell what the mysterious spill is made of?”. It is important to remind the students that care must be taken when handling unknown compounds. We ask them which of their senses they can use to determine which of the bottles the spill is from. “Can you hear a difference? No. Can you see a difference? No, they are all clear. Can you taste it? No! It may be poison – what if it is ammonia? Can you feel a difference? No! What if it is an acid or base you’d get burned! So what do we do?”. This is the point where we enter the concept of potential hydrogen (or pH) and the color change of pH paper. Again, pH is a measure of the amount of protons available in an aqueous solution indicating acidity or alkalinity. Aqueous solutions at 25 °C with a pH less than seven are considered acidic, while those with a pH greater than seven are considered basic (alkaline). The pH of 7.0 is defined as 'neutral' at 25 °C. One way to measure this is to use pH paper or litmus paper. pH paper is usually small strips of paper (or a continuous tape that can be torn) that has been soaked in an indicator solution which changes color based upon the acidity of the solution and is used for approximations of pH. This allows us to visually see differences that we can not see normally. We explain how it could be used to determine the pH of a liquid and that from the pH you could ascertain whether the solution was acidic, basic, or neutral.

Equipment needed: water, ammonia, vinegar, lemonade, pH litmus paper, containers.

Procedure:

5 test-tubes are prepared prior to the students arriving at the station ranging from very acidic (vinegar) to acidic (dilute lemon juice) to neutral (water) to basic (diluted ammonia) to very basic (ammonia). After discussing pH, the students are given 5 pieces of universal litmus paper. Each student dips one piece of paper in the first tube and places it in a specified area. The acidity is determined by the color. This is repeated for each sample. Then the clear spill (dilute lemon juice) is brought forward and tested. If time permits, mixing of acids and bases can also be undertaken. *Note:* this will be a very vigorous reaction bubbling over in too small reaction vessels.

Before testing any of the solutions, the students would be asked if they thought it was acidic, basic, or neutral, and they then were allowed to test it. After all three standard solutions were tested, they were allowed to test the unknown liquid from the crime scene and were asked to determine which of the known solutions it was. This could easily be relayed back to who drank what and eliminate some of the suspects. Then time permitting, the students would then be allowed to experiment what would happen to the pH if an acidic solution and a basic solution were mixed.

For the Milk Rainbow Station, the white spill is analyzed. The basic premise is what is the white spill milk (i.e., melted ice-cream) or glue. Again, the students are told that a sample of the “white spill” left at the crime scene was collected and brought to the station. The junior scientists were asked how to determine what the white spill was composed of. Again, the 5 senses were listed with reiteration that tasting or touching these materials is not a good idea.

Equipment needed: milk, glue, food coloring, dish soap, Petri dishes, sample of “white spill”, and plastic pipettes.

Procedure: A Two Petri dishes were given to the scientists identified to contain: (i) milk and (ii) glue. To each sample, several drops of food color were added. Then a pipette full of soap was added to both dishes to give a visual example of how fat (from the milk)

reacts with soap to produce a rainbow effect while the soap and glue remained stagnant.

Once the scientists performed the experiments on the known substance, as a group, the

“white spill” was tested. The result was compared to their previous white sample results.

Since it was reported that several suspects liked ice cream they could deduce who might have left the spill at the scene.

(d) Fiber Analysis. After identifying several different types of fibers at the crime scene (white cotton fiber, colored fiber and dog hair), the students are asked to differentiate them. Of course this is very difficult to do with normal eyesight, so the students are introduced to magnification glasses. These allow the young investigators to get a closer look at the fibers; however, even higher magnification is needed to differentiate the various fibers that leads to the use of a simple 3X microscope. The students are again asked to detail what they see and if they can tell natural fibers from man-made fibers. Even higher magnification is supplied through scanning electron microscopy (SEM) figures taken previously (and available upon request). These detail the subtle differences between natural and man-made fibers which are based on the surface morphologies observed. Figure 9 shows the students working to differentiate the various fibers and some of the actual pictures that are used at this station.

Equipment needed: magnifying glass, microscope, samples: dog hair, nylon string, cotton string, Scanning Electron Micrograph (SEM) images of fibers.

Procedure: The students are presented with several fibers found at the crime scene. They are then asked to identify which ones belong there and which ones don't. The students are then given known samples of materials (natural and man-made). They first look at the different fibers with their eyes to see if they can tell any difference. Typically, there are some distinctions that can be made but not many. They are then given a magnifying glass (2 times the size) and the same scenario takes place. The students are

then shown to a microscope that can magnify up to 10 times the size. The students begin to note the differences between the fibers. In addition, scanning electron microscopy (SEM) images are shown to the students of the different fibers. These results are compared to the fibers collected at the scene and those that didn't belong are identified. The suspects are then checked off on the sheet.

Once identified as dog hair, this fiber is removed from consideration as a clue since Beaux is the victim. The identified nylon fibers led to the scientist that wears nylon lab coats. This removes the principal from consideration as a suspect. This also introduces the concept that many things exist that we can't normally see but a whole world of unusual phenomena can be observed through magnification.

(e) Secret Messages. The concept that things are there that we can't see is reinforced at this station. Two cards were found at the crime scene but appear blank. The students are then introduced to the idea that things can be present even if we can't see them in normal light. For the first secret message, it is explained that many different types of light exist and that one of these is ultra-violet or UV light. By shining a UV 'black' light onto the card, the students see that the first card reads "AML" – this is the first clue at this station. Students are asked, "Which scientists work at the Advanced Materials Laboratory (AML)?" Anyone working there receives a check mark by his or her name. The proctors explain that some compounds interact with UV-light and light up when exposed to it. Figure 10 shows some of the students discovering the secret messages.

Equipment needed: Hand-held UV-lamp, Fluorescent marker, Index cards, Cotton swabs (to write with), 5 % Phenolphthalein in ethanol, Larger cotton swabs (to wipe ammonia across), Household ammonia cleaner or Windex with ammonia.

Procedure: There are 2 index cards found at the crime scene. At this station, we show the participants a seemingly blank card and ask them what is on the card. “Nothing” is the expected and usual answer.

Secret Message #1: Using UV-light. We explain that some compounds interact with UV-light, and when they do so we can see them. In fact, under illumination one of the sample card reads AML – this is the first clue at this station. Which scientists work at the Advanced Materials Laboratory (AML)? Anyone working there receives a check mark by his or her name.

Secret Message #2: Using Acid-base Indicators Chemistry: A second card is then held up and the participants are asked if there is anything on it. We demonstrate that there is nothing obvious under UV-light that can really be read. We emphasize that again some chemicals interact with light, and that some do not. What about chemicals reacting with other chemicals? We then stroke a cotton swab dipped in ammonia across the card to discover the word “Kitty” written on the card. This is another clue, and those suspects that like cats get a check mark by their name. We had previously written this word using phenolphthalein indicator as ink. Upon reaction with ammonia, the ink becomes visible due to de-protonation. After evaporation, the words disappear.

They are then given a second secret message card and try the UV light experiment again which fails. It is again emphasized that not all chemicals interact with light but “there are other ways of finding secret clues” such as reacting chemicals with the secret message on the card. In this case, using a special chemical called ‘phenolphthalein’ as the ink, the proctor writes a secret message. Upon drying the card appears blank. However, it is demonstrated that wiping with ammonia reveals the secret message. It is then explained that the ink reacts with ammonia and becomes visible due to de-protonation. After evaporation, the words disappear.

The students are then allowed to write their own secret message. The proctor collects the cards and mixes in the second secret clue. As the student's secret messages are revealed and handed back to the student it is found that one extra card remains. As the cotton swab dipped in ammonia is rubbed across the card the word "Kitty" appears. The actual card used is shown in Figure 10. Everyone denies writing it and therefore it determined to be another clue. Those suspects that like cats get a check mark by their name. We then re-emphasize that we used science, to "see" 2 secret messages. The first was written with a chemical or ink that is visible under UV-light, while the second was written with an ink that reacts with ammonia. The participants then write their own messages on index cards using phenolphthalein and expose it with ammonia.

C III. Teaching Board Posters Used at Analytical Stations



What does Nano Mean?



*A nanometer is to a meter what a dime is to the planet earth

Nano = 1 billionth of a meter (10^{-9})

- Nanoparticles are materials below 50 nanometers in size.

*Available since the 5th millenium B.C. !
- soluble gold, Ruby glass*

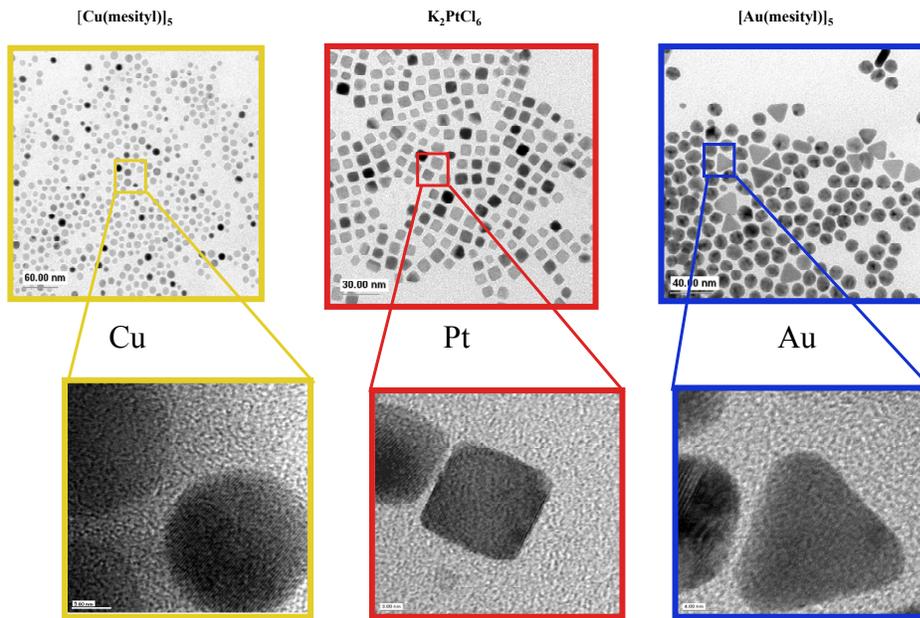


How do you see and measure Nano?



Transmission Electron Microscope (TEM)

Sizes and shapes of metal nanoparticles.



What is the color of Nano Gold?



Bulk Gold

Nano Gold



Who makes Nano Gold?



? What kind of fibers were found at the crime scene? ?

Fibers are made from many “poly” repeating units “mers”. Polymers can be natural or synthetic.

Natural Fibers

OR

Synthetic Fibers

Natural fibers come from plants, animals, insects humans, and minerals.

Cotton-Plant Agave-Plant Animal-Dog



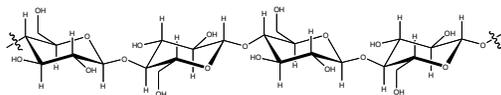
Cotton



Sisal



Beaux Hair



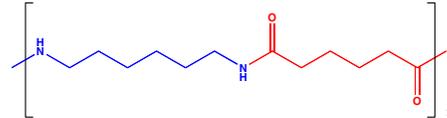
“Cotton” cellulose

Synthetic fibers are man-made. They are formed by reacting chemicals together.

Nylon



Polypropylene



Nylon

? Who wears nylon fibers? ?

*Scanning Electron Microscope Images (available upon request).

? Are the index cards found at the crime scene blank? ?

Forensic scientist use special light called **ultraviolet light (UV)** or “black light” to examine paper for evidence.

“White Light”

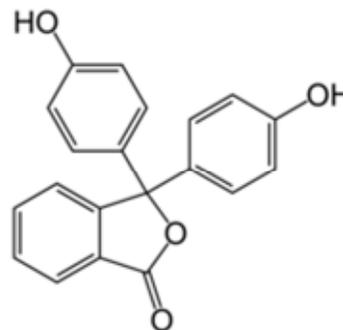


Ultraviolet light (UV)
“Black Light”



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Forensic scientist also use special chemicals to examine paper for evidence.



Phenolphthalein

? (1) Message with chemicals (Ammonia) reads: ?

? (2) Message under “black light” (UV-light) reads: ?



What is the clear spill found at the crime scene?



Forensic scientists **CANNOT** taste or eat evidence they find at a crime scene. Instead, they can use **COLOR** to determine what a substance is. Below is the **pH scale** which uses color to determine if a liquid is an **Acid** or a **Base**.

Lemon Juice
"Citric Acid"



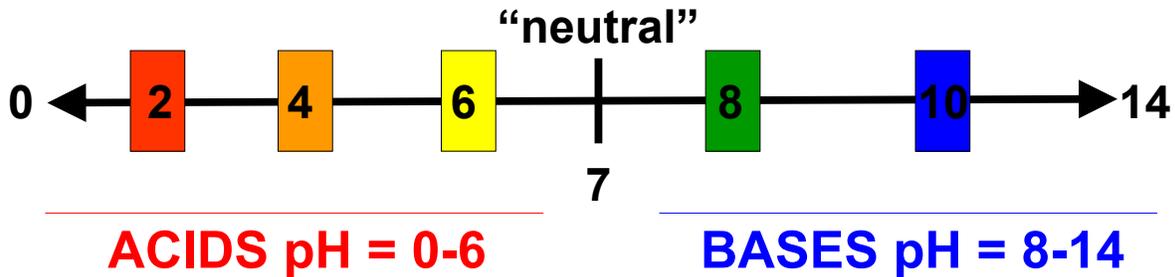
Vinegar
"Acetic Acid"



Water



Household Cleaner
Ammonia



Who likes acidic drinks?





What is the white spill found at the crime scene?



Forensic scientists **CANNOT** taste or eat evidence they find at a crime scene. Instead, they can use **COLOR** to determine what a substance is. Add drops of food coloring to **Milk**. See what happens to milk when **Soap** is added.

The white spill could be....

Milk



Ice Cream



School Glue



or

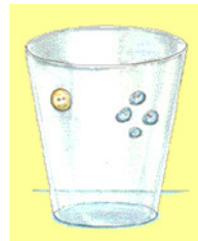
Ice cream is made from milk.

Milk is made of vitamins, proteins, **fat** and **water**.

School glue is made from **water** and polyvinylacetate (**PVA**)

What is happening with Milk and Soap?

Fat and **Water** don't mix!



Soap attached to **Fat** and **water**



A **moving rainbow** forms because the soap surrounds the fat and the food coloring is attracted to the water.



What happens to Milk? Who made a white spill?



DI. Sandia Daily News Article: Vol. 59, No. 4. February 16, 2007

Hey, kid, you stole my dog: Workshop on stolen dog interests students in science

By Neal Singer

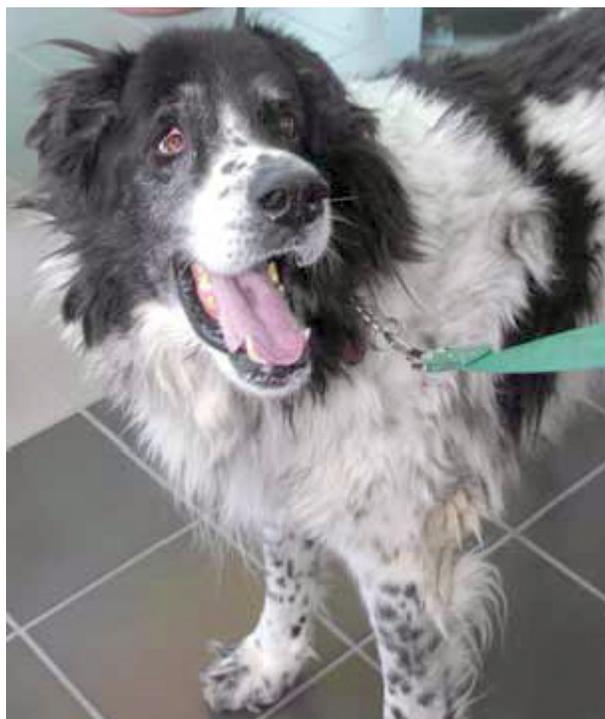
Adults wonder how to get kids interested in science. One way, Tim Boyle (1815) and his volunteers have found, is to collect them in a room and accuse them of stealing your dog. You have their immediate, undivided attention. Then teach the students to use science to find who really did the deed.



While the approach is not systematic teaching but merely the arousal of interest in scientific techniques, it is still somewhat stunning to experience the effect achieved by Boyle's group, one classroom at a time. There's nothing grandiose about it. They won't save the world and certainly won't get rich. But Thursday morning two weeks ago, 25 fifth graders from Bellehaven Elementary School came into an impromptu classroom — the meeting room in the Advanced Materials Laboratory on University Blvd. — sat down on the wall-to-wall rug, and learned that Tim's dog Beaux — yes, Beaux the Magic Chemistry Dog — had been dognapped. And that Tim thinks one of the kids sitting in front of him took his pet. And Tim isn't going to do the purported chemistry magic show until his dog is found.

Who'd do such a thing?

Of course it's all in fun. The kids laugh and protest. They have their teacher Ms. Jewell and a few parents in the room for backup; they're not scared.



Tim says he can't believe any of the adults who work in the building would do such a thing. But wait, he says: He has a fingerprint he believes was left by the perpetrator. He challenges the kids to take a fingerprint test. Interested, they agree. Led by Tim's assistant and event manager, post-Doc Bernadette Hernandez-Sanchez (1815), the volunteer staff provide each kid a pencil to blacken a square on a piece of paper. The kids press their finger on the blackness, place a piece of Scotch tape over their fingertips, and press

that tape onto another piece of paper. Presto, each child has created a fingerprint.

The game is afoot.

Tim and his assistants — drawn from a pool of more than 60 willing volunteers internal and external to Sandia — project images on a screen to show how to match one set to another — the whorls, the dips, and other patterns. Do any of the students' prints resemble that of the perpetrator? No? Then who stole the dog?

And now the kids are off, involved in a game in which there is no competition to be best of show, as in science fairs, or the best at solving problems in a particular field for a competition. What they are going to experience — fully — and only — is using science to find the answer to a problem that interests them.

Why? "Fourth grade, fifth grade is where kids make their career choices," Tim tells the Lab News. "They say, 'Oh, I can't do math or chemistry,' and they're gone forever. Here, at a crucial moment in their lives, they get a chance to see that science is useful and fun. And that they're good at it."

For Galileo, it was inclined planes. For James Clerk Maxwell, it was wires, electricity, and magnetism. For Tim, it was fireworks and how they produced the varied colors of their displays. For these kids, still very young, Tim and his staff create an artificial interest, a la the TV program "CSI," which uses intensive scientific investigation to solve crimes. Tim credits Bernadette, along with Sandia student intern Christina Baros (1815) and Saskia King (2701), for first creating a "CSI"-type program used by Sandia's outreach MANOS program for middle school students, and then helping modify the program for elementary grades.

Tim shows pictures of four adults on a wall screen. These are the only people who were in the building at the time of the 'nap. One was the elementary school principal, Ms. Hamilton.

"That's her!" the kids say excitedly. "She's guilty!" It didn't help Hamilton's credibility to be the only suspect portrayed with a skeleton standing behind her.

"So, you think you can tell from a picture who's guilty?" says Tim.

Energetic but indecisive

Now he shows a description of the habits of the four suspects. Some like dogs, some don't. Some like ice cream, some lemonade. Some wear lab coats, some do not. The kids vote for guilt by a show of hands. They are energetic but, as a group, now indecisive.

Tim, sitting in the back of the room, raises his hand for each suspect, and Bernadette calls him on it.

"To me, everyone's guilty," he says, "until we prove otherwise." Dressed in jeans and running shoes, a Spy-vs.-Spy T-shirt visible under his black corduroy jacket, with dark shades and thick dark hair

combed forward over his forehead, he could be a walk-on scientist on the mathematically oriented "Numb3rs" TV crime show.

"So, from habits and appearances, you can't tell?" says Tim. "Okay, let's do some science."

The kids, aided by Bernadette and other volunteers, inspect the "crime scene" — a collection of objects that seem to have nothing visually to do with each other, side by side: purple-colored water, the ransom note — "I have your dog! If you want to see him again, then you have to take Beaux out of the chemistry magic show" — a white spilled liquid, other oddities. "What do you see that's strange, that's a little unusual?" Tim asks.

"Purple water, right? What is that and why is it there? Is there anything that could lead us to the dognapper?" He points out other tiny bits of material that look as though they weren't part of the original décor of the office.

Now the kids are broken up into groups. Each goes to a table where they watch or perform a particular kind of analysis. A pH test determines that one liquid found in a cup was acid-based, suggesting a drink enjoyed by two of the suspects. A chromatological ink analysis finds the ransom note was written by a gel pen. "Who uses a gel pen?" A nanotechnology lab (which takes some explaining) finds that nanoparticles of gold, treated with certain solvents, becomes purple in the water. "Who among the suspects do we know was working with gold nanoparticles?"

At the end of the analysis, the kids file back into the conference room, sit back on the floor, and line up suspects and attributes with analysis of the clues.

"We match the evidence to the suspects," says Tim.

The guilty party, as portrayed unassailably or at least most probably by science was big, ostensibly friendly and even fatherly-appearing manager Bill Hammetter (1815).

"Give it up, Bill," says one kid's voice.

"Why'd you do it, Bill?" the others shout.

"I wanted Beaux to be my dog and I wanted my cat to be used in the show," Bill confesses as he returns Beaux to the room.

The kids go off to celebrate the successful solution of the case by creating liquid-nitrogen-cooled ice cream.

Having fun, learning about science

The show has hidden costs. Someone needs to pay for a school bus to transport the kids and substitute teachers to stay with the kids who, for one reason or another, can't come. There are supplies.

Tim and Co. figure they can handle the fourth and fifth graders from two schools in a week during winter break, and the same in spring. That means the team can excite kids in four schools a year. Tim tells the kids they can use science in jobs like engineering and chemistry and even firefighting. He keeps statistics on many positive results arising from the three-hour event — more students turned on to science; teachers, administrators, parents all happy with the project and more aware of Sandia; the possibility of a larger student base for Sandia among local students over the years.

But Tim needs a grant to continue this effective program.

Can he get it? He doesn't have the buzzwords; he doesn't mention "strengthening the syllabus" or "fortifying the science experience."

The kids are just having fun learning about science. And, oh, yes, finding Beaux, the Magic Chemistry Dog. -- [Neal Singer](#)

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