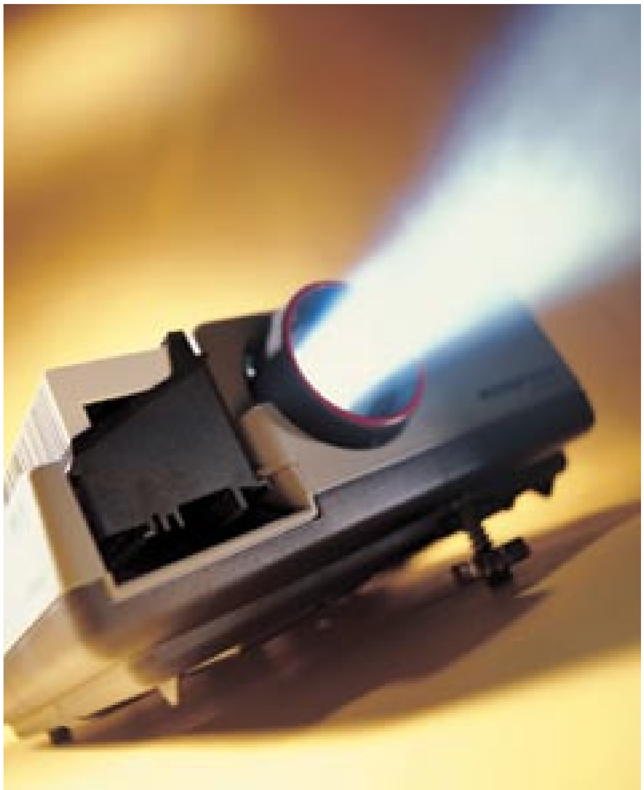
Light in the media spotlight



Movies, music, cartoons, comics, popular literature, and internet websites are all powerful resources for science teachers. Collectively, these media transform words from a textbook into reference points for understanding a complex world. This article will present science activities that use popular media as tools for interdisciplinary lesson planning and lesson differentiation. (See this issue's *Issues in Depth* for legal and copyright issues and general guidelines for using media in the classroom.)

There are many reasons why popular media should be used as tools in today's classroom. Among them are:

- The influence of the media on the creative processes of learners, as seen in the creative products of students; published media often serve as models for student work.
- The tendency of popular media to pose questions and present resolutions that are beyond ordinary limits. These media serve as "leaven" in the scientific process. Situations and characterizations presented are often based on real-life; these fictionalized versions safely catalyze solutions (or at least questions) about world-events and personal experiences that are difficult to discuss from a purely academic view.
- The ability of popular media to promote collaboration and demonstrate cultural diversity.
- The likelihood of popular media to influence thinking, introspection, and self-evaluation.

Differentiated instruction engages the multiple intelligences by allowing the learner to experience information in a variety of ways—abstract or tactile; using visual imagery, audio cues, text, technology and simulation, or experimentation. (See *www.ericdigests.org/2001-2/elementary.html* for more information.)

FIGURE 1 **Differentiated instruction: (CL)² Model of differentiation**

Lab area	Literature area
Colloquial space	Computer space

I developed a model for instruction in my classroom that will allow me to differentiate all of the key pedagogical elements: content, process, product, and environment. *The (CL)² model* divides the classroom into four learning zones similar to centers in the elementary classroom(see Figures 1 and 2):

- The Colloquial Space—the primary zone of discussion between teacher and student.
- The Lab Area—the place where students construct meaning by doing an activity to extend their learning.
- The Literature Area—the zone in the classroom where students will interface with various media.
- The Computer Space—enables access to technology by using hardware, software, or screenshot worksheets.

Students circulate around the room in 15–20 minute blocks of time. This allows me to divide my large class into smaller groups for more effective management. It also allows my

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FIGURE 2 **(CL)² Differentiated physical science lesson: Color as a mixture**

Colloquial Space: This lesson is useful for a discussion of light and color or characteristics of matter/homogeneous and heterogeneous mixtures. A poster of the electromagnetic spectrum is provided in the instructional space. The visible light portion of the spectrum shows wave properties (wavelength data) for specific colors. Students can review the components of mixtures and discuss their hypotheses about the composition of specific color mixtures.

Lab Area: Teach chromatography as a technique for the separation of components of mixtures. Most dyes found in water-soluble markers are mixtures. Ask students to separate the components of marker dye on filter paper and compare results for various brands and/or different colors. Hint: Black and brown markers consistently work well to generate a full spectrum of colors without regard to brand. (This technique can be found in several places online: www.exploratorium.edu/science_explorer/black_magic.html and http://pbskids.org/zoom/activities/sci/papertowelchromatogr.html.) The cost of hand-held spectroscopes and prisms may make additional lab experiences expensive, however, some teachers have found ways to create their own spectroscopes to teach students more about light (see Resources).

Literature Area: The Magic School Bus Makes a Rainbow: A Book About Color (1997) is a fun children's book that explores color. Based on the book's title, it might seem that this book is too simple for upper-level students. However, the book's title serves two purposes: to treat somewhat difficult concepts more concretely, helping students to know that they have some experience with the material; and to allow students to see how science text can be an integral part of their reading activities.

Computer Space: Visit the ChemConnections website at (http://mc2.cchem.berkeley.edu/Java/RGB/example1.html) to explore how red, green, and blue combine to create a full spectrum of colors useful for web design, stage lighting crews, and consumer use. This interactive site will reinforce information presented in the colloquial space and the lab area.

FIGURE 3 **Examples of science segments in popular media**

Terminator 2
Scene description—"Prologue/L.A. 2029 A.D.": Reality of nuclear war
Scene description—"The T-1000": Properties of metal conductivity/malleability/ductility
Scene description—"Corridor Shoot-out": Characteristics of metal mixtures (steel vs. amalgam)
Scene description—"Tanker Chase" through "Terminator vs. Terminator" (five consecutive chapters): Properties of matter:

- Elements (Nitrogen, Mercury)
- States: Liquids (surface tension, molecular forces) and solids (boiling/freezing points)

Gattaca
Scene description—Opening credits: Nucleotide abbreviations
Scene description—Opening narration: Description of biomedical engineering and societal/social implications of biomedical technology

Civil Action
Scene description—"Scene of the Crime": the protagonist lawyer contemplates whether this case is worth pursuing. The scene shows the lawyer using inquiry skills to analyze the setting
Scene description—"Lake of Fire": evidence to suggest that a water source is contaminated by pollutants

FIGURE 4 **Criteria for "good" science media for children**

- Authentic representation of scientific phenomena
- Creative presentation of science information
- Integration of vocabulary either through text or through illustrations
- "Reality check" sections for lab safety principles
- Authentic characterizations of professional scientists
- Diversity among characters

students to collaborate in a productive way. This is a very effective model for block schedules. For a 90-minute block, the first 10 minutes are dedicated to explaining the objectives of the lesson and providing specific directions for each station. Students spend 15 minutes at each station where directions are mounted to the table as a reference. The last 15 to 20 minutes are spent sharing results and clarifying misconceptions

Using popular media and instructional videos for interdisciplinary lesson development must be done carefully. Teachers should always preview and select segments that are specific to teaching a particular concept and that support course content.

The old adage "a picture is worth a thousand words" has profoundly different meaning in modern culture. The use of images as stimuli for writing assignments and test questions represent the beginning of the impact popular media could have in today's science classroom. As the technology continues to expand, teachers must acknowledge, embrace, and appreciate its impact on the way students learn; the best acknowledgment is incorporation**.**

See Figure 2 for an example of how I used $(CL)^2$ to teach science. Students were learning about color for this middle school lesson.

Resources

Lights and optics—*http://sci-toys.com/scitoys/scitoys/light/cd_spectroscope/spectroscope.html*

Mini spectroscopy—*http://mo-www.harvard.edu/Java/MiniSpectroscopy.html*

Simple spectroscope—*http://asd-www.larc.nasa.gov/edu_act/simple_spec.html*

Reference

Cole, J., B. Degan, and C. Braken. 1997. *The magic school bus makes a rainbow: a book about color*. New York: Scholastic Paperbacks.

Fossil detectives

Middle school students can examine the fossil record and use evidence about paleo-environments to develop an understanding of "structure and function in living systems" and changes over time in Earth history. Earth history is based on the study of rocks and the fossils associated with sedimentary rocks . To answer questions about past life on Earth paleontologists use many branches of science including anatomy, comparative morphology, biometrics, pathology, botany, ecology, phylogeny, paleo-environment reconstruction, and art.

In this enrichment activity, students work in teams to research an assigned geologic time period. They determine available habitats, food sources and types (animal, plant; woody, herbaceous, etc.), cover sources, methods of getting food, defense, and reproduction that would allow an animal to live in the assigned paleo-environment. Then they create a diorama to display their findings.

Turtle treads

To begin, it is helpful to facilitate a discussion to determine what students understand about fossils and the stories they have to tell us. I start this by passing some sample fossils among the students. Ask if they have been fossil hunting, if they know how fossils are formed, and how old they think the sample fossils may be. Geologists use the principle of uniformitarianism to help unscramble geologic puzzles. This is the premise that the physical and chemical laws of nature have remained constant over geologic time. While discussing, help students to see that, if natural laws have not changed, natural process governed by those laws have not changed either. How can your students use this to understand how physiology and phylogeny may have responded to paleo-environments?

An example to consider with your students to illustrate the uniformitarianism is the turtles. The first fossil turtles date from the Triassic Period, more than 200 million years ago. Over time, two types of turtles appeared in the fossil record and are found on Earth today: they are sea turtles and land turtles. The sea turtle's front legs resemble flippers, and their carapaces are streamlined. Both these physical features help sea turtles to move through their ocean habitat. The land turtles and tortoises have stumpy legs suited for life on land. Their carapaces are often a high-dome, allowing them to withdraw their head and legs inside the shell as protection

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against land based predators. These adaptations are as successful for turtles today as they were when they first appear in the fossil record. To involve the students in this information, I use puppets and model skulls (available from several life science education suppliers), which can illustrate motion, to help them understand characteristics of sea and land turtles. Videos may also be used to illustrate turtle locomotion.

Ask students how sea turtles and land turtles protect themselves from predators. What might a predator who can catch and eat each type of turtle look like? How might the turtle's structure or behavior change in response to attacks by a specific type of predator? Have them brainstorm as a class the answers to these questions.

Continue this line of discussion until students understand how known information about turtles and turtle fossils may be used to draw conclusions about how organisms adapt to changing environments. Have students name other organisms which have characteristics that allow them to succeed in specific habitats? How and why do squirrels climb trees? Why does a humming bird have a long, narrow bill?

Fossils in our own backyards

Connecting the study of Earth history to the area in which you are teaching can enrich this activity. The state of Oregon, where I teach, has fossil locations that provide evidence the state was ocean millions of years ago. Then, plate tectonics carried the North American continent westward, mountain ranges were created and weathered, and the climate changed dramatically over geologic time. This story is told by an amazingly continuous fossil record.

Teachers and students can use the website of the University of California at Berkeley's Museum of Paleontology to locate information about particular states (see Resources). This website has a wealth of paleontology information and photographs of plant and animal fossils. You may wish to use this information to select a particular time period, from the Precambrian to the Quaternary, for your students to investigate. While websites are known to change, this one has been consistently getting better over the last four years I have used it.

Creating the dioramas

The combination of science and art creates an excellent cooperative learning activity. The activity should take place over several days, up to a few weeks. The goals are for (student) teams of two or three students to use the library and the internet to research an assigned paleo-environment's components; identify and describe the relationships between their proposed organism's structure and function; identify and describe the factors that influenced or changed the balance of populations; and communicate their conclusions in 10-minute oral reports, illustrated by a diorama .

Each team is assigned to research a specific time period and design an organism that will be uniquely suited to live and thrive in a habitat of that time. Students may be assigned to research the same or different periods of geologic time. Before they begin the research, the teams will answer questions to help them design an organism (see Activity Sheet on page XX). They will report on their questions and answers when they share their completed dioramas with the full class. It is helpful to have the teams report their progress to the teacher prior to beginning their dioramas to allow coaching through any misconceptions which may arise. This is also an opportunity for formative assessment.

If students are to create their dioramas in class you will need to supply each team with a shoe box or something similar and art supply items such as craft sticks, modeling clay, construction paper, cardboard, and colored pens. If you use shoeboxes, keep the lids so the dioramas can be stacked neatly between class work periods.

Set aside a time period for the teams to give their reports. Plan 15 minutes per report to allow for questions and discussion from other students. Make it special by inviting the principal or other teachers to attend. Each member of the team should give a segment of the oral report. Be sure students know how much time they have for their reports and what they are expected to report on. When the report is concluded, other students should be given the opportunity to ask questions or challenge assumptions of the presenting team. The dioramas and oral reports provide opportunity for assessment of the performance tasks by both the teacher and from peer teams.

Where's the inquiry?

It is true that this activity does not involve students in a classic laboratory activity. However, students do design an investigation, gather, analyze and interpret information, and develop a model to communicate their explanation of life in a paleo-environment. The creative thinking and artistic components of this activity are popular with most students. This lesson can be adapted to early Earth history units by asking students to pose the question, "Why did dinosaurs become (what they did)?" instead of the often posed question, "Why did they become extinct." Student use the same investigation and analytical skills to review the fossil record and interpret how dinosaurs evolved in the paleo-environments of the Mesozoic Era.

In *Assessing Student Understanding in Science*, Enger and Yager state, "Although there is no consensus regarding what kinds of science content are necessary for scientific literacy, a scientifically literate person is believed to be one who appreciates the strengths and limitations of science and who knows how to use scientific knowledge and scientific ways of thinking for living a better life and for making rational social decisions" (2001). Students have the opportunity to build their scientific knowledge and think scientifically as they answer questions about past life on Earth.

Resources

University of California at Berkeley's Museum of Paleontology —*www.ucmp.berkeley.edu*

References

Enger, S. K. and R. E. Yager. 2001. *Assessing Student Understanding in Science: A Standards-Based K–12 Handbook*. Corwin Press, Inc.: Thousand Oaks, Calif.

Thompson (Bourdeau), V. and A. C. Bourdeau. 2000. *Oregon 4-H Earth Science Projects Leader Guide: Be a Fossil Detective*.Oregon State University Extension and Experiment Station Communications: Corvallis, Ore.

Become a Fossil Detective

You and your team are fossil detectives. You will identify information you need to compare and contrast life-forms of the Clarno Period. You will research information about the fossil record in books and on the internet. Create a bibliography of all the books and resources your team uses in the project. Each team will create a diorama depicting an organism they design to live in the Clarno Period. You will use your science investigation skills, imaginations and art talent in this project. Your team will also present a 10-minute presentation about your research and the design of the organism in your diorama. Be sure all members of the team have a chance to contribute.

Procedures

1 Give your team a name

2. Work with your team to answer the questions below on a separate sheet of paper.
   - What do you need to know about habitats in the Clarno Period to begin to design an organism?
   - What do you need to know about food sources available to organisms?
   - What do you need to know about defenses that an organism might use?
   - What do you need to know about possible methods of reproduction and rearing of young?
3. When your team has answers to the questions, ask your teacher to review them and your written bibliography before you begin to construct your diorama.
4. Your diorama should illustrate the information your team will present in your 10 minute oral report.
5. In your oral report, be sure to clearly explain, not only how the organism looks and behaves, but why you chose these characteristics and behaviors. Each member of the team should give a segment of the report. At the conclusion of your report, the other teams will have the opportunity to ask you about the conclusions you have made to create the diorama.

The diorama should illustrate the critical elements of the life of your proposed organism. Each of the characteristics and behaviors listed below is worth from 1–5 points. The maximum number of point possible for each team for this project is 30 points.

- Food supply
- Water supply
- Type of shelter
- Method of defense
- Method of reproduction and rearing of young
- Bibliography documenting references and resources used

Making movies in the science classroom

When you overhear students talking excitedly about video games, the internet, television, or movies, do you ever wish that they could get that excited about what was happening in the classroom? What if you could put them on the other side of technology—the productive and rewarding side? Using simple software, students can plan, shoot, and edit movies of their own design. Not only is this high-tech skill applicable in the real world, it is a powerful and engaging way to teach science content.

It all starts with a great idea

This activity arose out of my efforts to integrate science and social studies. Specifically, I wanted students to be able to understand the scientific underpinnings of plate tectonics as well as the human impact of disasters caused by the plates. The theory of plate tectonics is a unifying concept in my curriculum and I wanted students to be able to put a unique spin on it. I decided to have students create a documentary on a famous earthquake, volcanic eruption, tsunami, hurricane, or other natural disaster.

To begin, I gave each team of four to five students a rubric listing criteria on which their documentaries would be judged, including science content knowledge, human impact, technology application, and group cooperation (Figure 1). From there, students were able to take the movie in any direction that they could imagine. Some students did news reports, some used models to show tectonic plates in motion, and others included video clips of interviews with scientists and actual footage of the disaster sites. Students eagerly came to class with extra props and technology equipment, such as fake microphones for reporters, costumes, laptops, and digital cameras. They ran around like crazy, multi-tasking and working together from the beginning of class to the very end (sometimes longer) in order to make their movie the very best.

Students are required to turn in a script and layout, shoot and edit the video, and address future concerns or technological solutions for the community at risk for these disasters. Students are given two weeks to work and they must have the script and layout finished before they may begin to shoot the video (which is what they are most excited to do).

At the end of our two-week project, I set up a projector in our media room and play full-screen versions of the movies for the entire class. Students eat popcorn as they watch (not allowed in a science classroom!), while I fill out their final assessments. At the end, each student is given a CD of his or her movie to take home.

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This is too much hassle, isn't it?

Not at all! The minimum you need is access to about six computers, one digital video camera, and one digital camera. If you have Macs at your school, your computers need to be equipped with iMovie software (ask your tech specialist if this is available; most recent Macs are already equipped). If your school has PCs, you can easily download Windows Movie Maker for free (see Resources). A dedicated laptop cart or a computer lab is ideal, but not necessary. The first time I tried this, I only had five computers (one was mine), a digital camera, and a digital video camera (also mine).

Students need to be placed in groups such that each group has a computer (the less students per group, the better). You might think that students would have trouble sharing the one digital video camera or digital camera, but this isn't the case. When lines do form for equipment, students can

- work on their scripts,
- rehearse a skit that they want to shoot (which helps them to get it right the first time and minimizes the number of takes needed),
- transfer video to the computer,
- create a soundtrack for the film,
- search for appropriate photos or video clips, and
- edit their projects on the computer.

While students work, the teacher is constantly on the move, helping students

- search for information on the internet,
- brainstorm ideas for their script and layout,
- incorporate science content creatively,
- fine-tune scripts and layout,
- develop their on camera skills (voice level, awareness of camera position, etc.),
- troubleshoot technology issues, and
- setup lights, cameras, and other equipment.

Lights, camera, action?

There are some things to keep in mind as you begin your movie-making adventure. For instance, students

FIGURE 1 **Project rubric**

Points	Excellent (10)	Good (7)	Needs Work (3)
Script/ layout	Your script is neat, grammatically correct, and complete. It includes a layout of clips/pictures and titles.	Your script is mostly neat, has few grammatical errors, and is mostly complete. There may be clips/ pictures missing from your layout.	Your script/layout is incomplete and sloppy.
Background	The movie contains complete background information on where the event took place, how it took place. The Science of how the land forms is complete and explained very well.	The movie contains some background information on the event. The Science of how the land formed is mostly complete.	The movie lacks important background information.
The day of the disaster	The movie tells the story of what happened when the event took place. The presentation addresses both above ground and below ground in a thorough and complete way.	The movie explains the day of the disaster. The presentation may be vague about both above ground and below ground events.	The movie is vague on the day of the actual disaster.
Present/ future	The movie does a fantastic job of explaining how the community is doing today and what they can do to save them from disaster in the future.	The movie explains the current situation and offers a piece of advice on the future.	The movie says very little about the present and the future.
Originality/ creativity	The movie is creative, original and demonstrates a large amount of work and critical thinking.	The movie is original and creative.	The movie should have had more time dedicated to it.
Teamwork	Your team worked out difficulties and completed the assignment against any distractions.	Your team had some difficulties that were a constant problem.	Your team's effort was slowed by problems that could not be solved.

in the middle grades should know about Multimedia Fair Use Guidelines because many will want to include images and video clips they find on the web in their films. These are copyright guidelines to make sure that owners of original work are recognized. These guidelines can be found at www.utsystem.edu/ogc/intellectualproperty/ccmcguid.htm#3.

Also, you will want to try your own movie first before you begin with your students so you can anticipate problems and act as a troubleshooter. Equipment problems cost valuable class time. Keep manuals on hand for any hardware used. If you are not sure how to use the software, work through the online tutorials for iMovie and Microsoft Movie Maker (see Resources).

And now for the most important piece of information: Have fun! Students are very fast learners when it comes to technology. Most of them have been using a computer since before they can remember. They will catch on quickly and will probably be able to help you out. Give them the chance to use what they know by interacting with technology in a positive way!

Resources

Microsoft Movie Maker—www.microsoft.com/windowsxp/downloads/updates/moviemaker2.mspx
Fair use guidelines for education multimedia—www.utsystem.edu/ogc/intellectualproperty/ccmcguid.htm#3
iMovie tutorial—www.apple.com/support/imovie/tutorial
Microsoft Movie Maker for beginners—www.microsoft.com/windowsxp/using/moviemaker/getstarted/default.mspx

Teaching science using the movie *Apollo 13*


NASA JOHNSON SPACE CENTER (NASA-JSC)

For over 40 years the space program has inspired students of science and engineering. The movie Apollo 13, about the third lunar mission, provides opportunities to teach students about several science concepts and the nature of scientific investigation (Goll 1999). Before you launch into an exploration of the science presented in the film, have students discuss if further missions to the Moon are warranted. Guiding questions could include:

- Why should humans be sent to the Moon—a dangerous and costly endeavor—rather than unmanned probes?
- What benefits, in terms of knowledge and technology, have resulted from our exploration of space?
- Could unmanned probes and rovers collect enough information to find out everything we want to know about the Moon?
- Should we even consider sending humans to Mars?

NASA asked these questions when deciding if it was worth the risk of sending humans into space and continues to wrestle with these issues while planning future missions. This demonstrates to students the types of questions real scientists must address.

Forces at work

During the launch of Apollo 13, the rocket reached a speed of 25,000 mph, subjecting the astronauts to a force four times that of Earth's normal gravity. When the spacecraft underwent staging, the process of releasing a used rocket followed by ignition of the next rocket, it slowed down and the crew members were flung forward against their seat restraints because of inertia. This is referred to as the "little jolt" in the movie.

Inertia is Newton's first law of motion. It states that a body in motion will stay in motion and a body at rest will stay at rest unless acted on by an outside force. This same phenomenon happens when a car suddenly stops. The humans in the car continue forward and are then restrained and forced back into their seats by their seat belts.

The hypothesis-observation cycle

Another subject for class discussion can be the hypothesis-observation cycle that occurs in the movie. The hypothesis-observation cycle is the process of forming a hypothesis and making observations that support or refute it. If a hypothesis is refuted, a new one may be created. During the mission, a routine procedure to stir the oxygen and hydrogen tanks resulted in an explosion that placed the astronauts' lives in danger. The astronauts and the people in mission control did not know that there had been an explosion. From observations, several hypotheses were created at the same time. The first observation was the loss of electrical power. This observation was followed by changes in the movement of the spacecraft caused by the navigation system attempting to remain on course to the moon. The astronauts then observed changes in the structure of the craft, specifically a bending that was in the tunnel between the command module and the lunar lander.

Scientists and engineers on the ground at mission control and the astronauts in space both started to make hypotheses. The first hypothesis generated from the people at mission control was that the readings from the spacecraft could not be possible and therefore the instruments used to make measurements of electrical power and amounts of oxygen were not operating correctly. The astronauts developed a hypothesis that a meteor hit the lunar module.

Each hypothesis had to be tested, which required more observations to refute or retain each hypothesis. The uncontrolled movement of the spacecraft ruled out the incorrect instrument readings. The hypothesis that a meteor struck the lunar module was eliminated because such an event would have pierced the spacecraft and allowed all of the life-sustaining atmosphere to escape.

Astronaut Jim Lovell then observed gas venting from the spacecraft. This also confirmed that the data sent to Earth from the spacecraft's instruments were accurate. At that time, the working hypothesis was that a meteor hit the service module

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causing the oxygen tank to leak. At the end of the flight, the service module that contained the oxygen tanks could be seen. This indicated more extensive damage than was first thought.

The cycle of observation making and hypothesis generation and testing by observation is useful not only in science but also in students' everyday lives. As an exercise, students are assigned to consider an observation that they made recently that required some problem solving on their part. A sample observation that students might make is that the boom box in the other room stopped playing music. This observation may have led them to make several working hypotheses such as a family member turned it off, the batteries ran low, or the CD ended. Further observations are needed to support and/or refute any one of the hypotheses. Students complete this exercise prior to watching the Apollo 13 movie and then compare their methodology to that of the astronauts.

Health in space

Infectious bacteria are all around us, even on a spacecraft. Under normal conditions, these bacteria are controlled by our immune system. However, when the body is under stress, it is not as able to attack the invading bacteria. On Apollo 13, astronaut Fred Haise was under stress. First there was the mental strain from the uncertainty surrounding the fate of the spacecraft. He was also dealing with extreme cold, dehydration, and sleep deprivation. These factors made the crew much more susceptible to illness, and astronaut Haise contracted a bladder infection.

Most middle school curricula include units on personal health whether as a part of the formal science curriculum or in a separate health class. We often talk to students about staying healthy by exercising, eating right, and handling stress in their lives. This example from the movie shows how even astronauts, pictures of health and fitness, are subject to and even succumb to, maladies associated with these factors.

As many students may already know, we exhale carbon dioxide into the air. Because of this they will also know that carbon dioxide is not generally harmful. However, if the amount of carbon dioxide becomes too great, it can be very harmful. With high amounts of carbon dioxide in the blood, a person goes into a state of narcosis. This is a condition of confusion accompanied by possible tremors, convulsions, or a coma. Eventually, it can lead to asphyxiation. On the Apollo 13, this was a major concern. The crew had enough oxygen on board, but as time went on and the crew continued breathing, the concentration of carbon dioxide increased. To solve this problem they needed to filter out much of the carbon dioxide. Apollo 13's crew used lithium hydroxide as a filter to remove carbon dioxide from the air in the spacecraft. The products of the filtration were water and lithium carbonate.

This section of the film provides one of the strongest lessons for science and engineering. We sometimes erroneously think that we stifle creativity by placing parameters around it. This section of the film deals with the profound creativity required of the engineers because there was an important problem to be solved with very well defined criteria for success and materials available. This is a good time to introduce a fairly common activity which gives students a finite set of materials and asks them to construct the tallest tower that they can using the materials given. The simplest of these activities consist of three sheets of newspaper and a foot of masking tape.

Mission debriefing

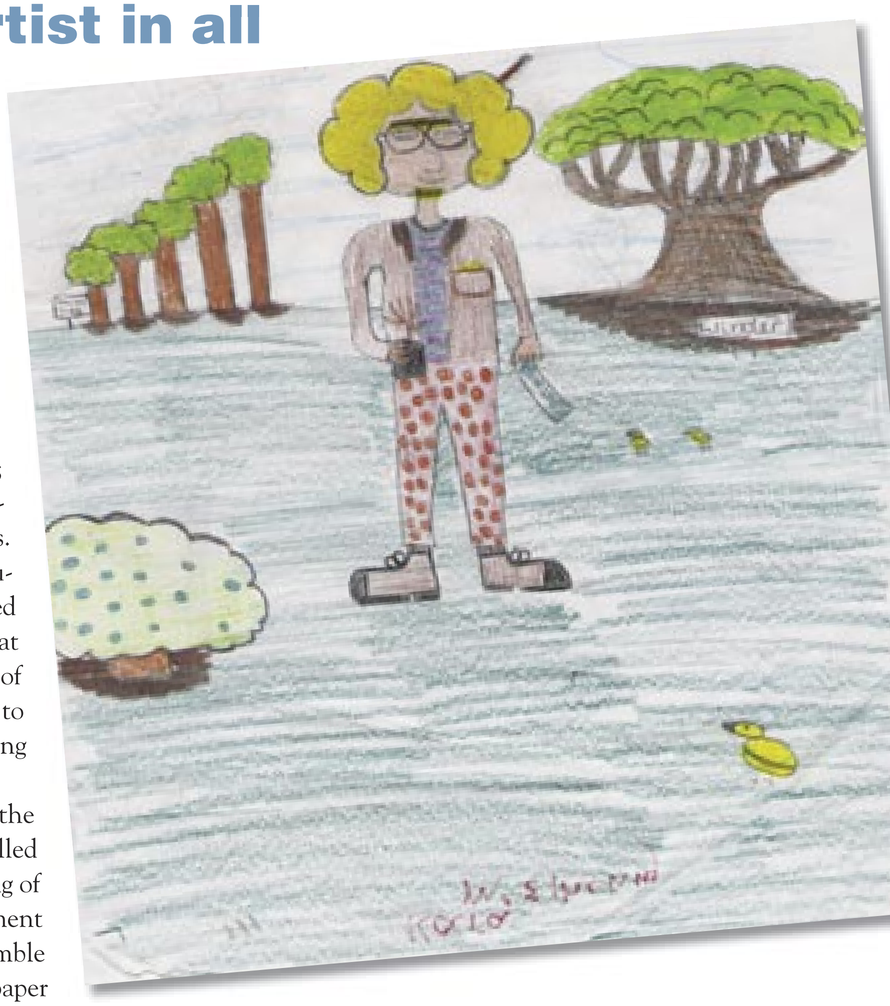
At the end of the movie, the cause of the explosion is revealed when actor Tom Hanks, in a voice-over, explains that an investigation of the history of the oxygen tank revealed that the tank had been dropped about 2 inches. This caused damage to a metal tube used to drain the tank. The tank was filled during a test to determine if the liquid oxygen would not leak. When the tank was drained after the test, it did not drain quickly. Heaters inside the tank were turned on to aid in draining the tank. It was discovered that the heater had incorrect wiring so the temperature in the tank eventually raised to several hundred degrees. These conditions allowed some of the insulation to crack and burn, exposing the wiring. The bare wires then created a spark that set the remaining insulation on fire and resulted in the sudden conversion of the oxygen in the tank to a gas. The pressure caused by the oxygen gas caused the tank to rupture and blow the side off of the spacecraft. This scenario was recreated and the result was the rupture of an oxygen tank. From this students can learn that initial hypotheses are not always correct. Often careful study and recreation of conditions are required to determine the most likely explanation.

There are a variety of ways that a teacher might use this film. One of the most powerful, we have found, is near the beginning of a school year when teachers are setting the tone for the year of learning to come. It gives relevance to the study of science, lends an air of excitement, and is replete with activities that students can engage in that reinforce the role of observation and hypothesis generation. It also emphasizes the role of creativity, clearly shows that the real problems that scientists tackle are often not confined to pure biology or chemistry but are complex problems requiring a knowledge of science and the systems that scientists study, and ties the curriculum to issues of interest to students.

Reference

Goll, James. G. and B.J. Woods. Teaching chemistry using the movie *Apollo 13*. *Journal of Chemical Education* 76 (4): 506–508.

The scientist and artist in all



The scientist illustrated, in cartoon style, is a male chemist, the nerdy type with thick glasses, white lab coat, and pocket protector. Behind him brew concoctions of colorful liquids, and lab rats are revealed in various states of experimentation. It is a teacher-drawn rendition of a stereotypical scientist formed from student suggested features, stature, and setting. The class discussion and drawing activity that follow bring students to understand that their perception of who scientists are and the nature of science can be enhanced by learning about the diversity of scientists; the environments in which they work; and the materials, equipment, and knowledge necessary in their fields. When Barman, Oslund, Gatto, and Halferty studied student perceptions of scientists, they found that when asked to draw a scientist, most did so under the perception that they are "white males who do their work in some type of laboratory" (1997). The objective of the assignment is to address that perception and widen student understanding to include the array of scientists and their work.

This project is often one of my first lessons for the school year. It brings about an initial drawing session filled with giggles and silly suggestions, an interesting sharing of ideas and information, and a wrap-up artwork assignment of interest to most students. Before the class, I assemble markers and one large piece of white bulletin board paper per class. I place one of the pieces of paper for all to see and then give the class the task of telling me what to draw. What we attempt to portray is a detailed drawing of a "scientist" and the environment in which the scientist works. We sketch the scientist together bit by bit, feature by feature, and test tube by beaker, so to say. The portion of the lesson that follows should work to eliminate the faulty, stereotypical concept of the scientist and expose science as a diverse realm.

We then move to a consideration of the branches of science: life science, chemistry, physics, and Earth science. Highlighted are works of career scientists in various fields. A well-known historical scientist or a scientist connected to recent discovery or current events may become the subject of close investigation. By exploring an assortment of famous scientists, from researcher Marie Curie to today's astrophysicist Stephen Hawking, or evolutionist Charles Darwin to primatologist Jane Goodall, students will gain insight into the diversity of the scientific community. Teachers and students brainstorm the kinds and names of scientists and briefly discuss their areas of study. I guide students to create a list through the brainstorm, but some online research or reading could help (see Resources for websites). Geologists, marine biologists, astronauts, botanists, volcanologists, biochemists, oceanographers, and meteorologists are just a few. The list becomes long as it is placed on the board, and the sharing of ideas is enthusiastic.

The next phase of the activity is the assigned illustration. Students are to choose a particular kind of scientist to draw in a setting appropriate for the kind of work the individual might do. Ask students to include in their artwork the scientist's clothing, equipment, and environment. Stress that it is important that detail, color, and creativity be used, and the kind of scientist be identified in a written heading.

Criteria for assessment can include careful, colorful illustration of the chosen scientist, identifying the scientist by specifying the kind of scientist portrayed, and inclusion in the drawing of the setting or environment in which

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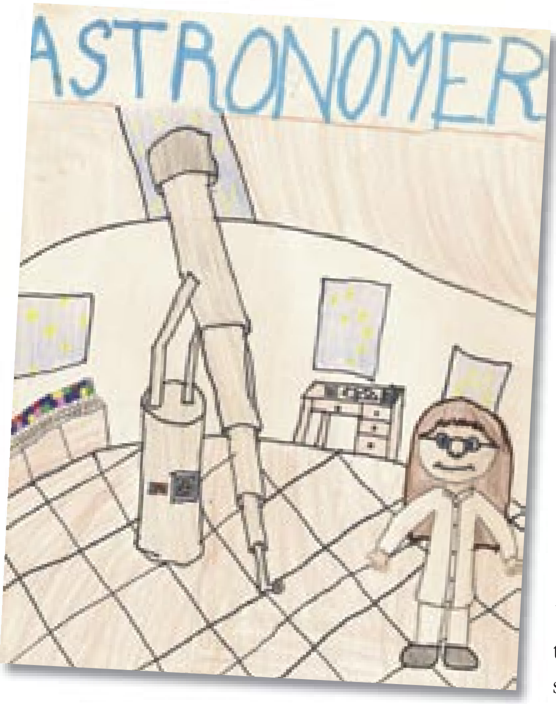
the scientist works, the clothing, and equipment pertinent to the job they perform. If portfolios are used as a method of assessment in the classroom, the illustration will often be an ideal addition.

What about those students who complain that they cannot draw? Surely there will be a few of those. I usually encourage them to try anyway and explain that I am not assessing their drawing ability, but the ideas and concepts presented and their ability to follow directions. I help them recall the number of times they have completed drawing assignments in school. They often acquiesce; however, a few will simply refuse to accomplish the task. In this case, an alternative to the drawing can be a research report on the scientist of their choice that has criteria similar to those for the drawing. The report can include information about what the scientist does, what kind of setting or environment in which they work, and their necessary equipment and clothing.



The project can also be designed as a cooperative learning activity, having students not only work together on their drawing but also on a report. As this is normally an activity at the beginning of the school year, I allow students to select their partners. This allows for a good working relationship and understanding of how to easily divide the labor. It is also possible to divide the class into preferred artists and writers, then match up pairs. If a list of scientists is given to chose from, the teacher could ask students to record their chosen scientist to illustrate, then match up individuals who want to work on the same scientist. The student who is the better artist may wish to draw the scientist while incorporating the other student's suggestions. Perhaps one is the better writer and pens the report while the peer does the editing. A heightened sense of self-esteem may be the result of working in pairs, and the end product much better from two heads than one. Similar choices in scientists to illustrate exist, but individuality is usually seen in each scientist portrayal. If repetition occurs, it is usually fun to compare and contrast.

The assignment is usually accomplished in class which generates an excellent discourse between students about their ideas and understandings of the scientist and their work. It can also be started in class and completed at home if time is a factor. In class, it will take one 45-minute class period for the brainstorming process, teacher drawing, and student time to begin their drawing, and two class periods to complete the actual drawing. If homework is assigned, the actual drawing portion of the assignment could consume only one day.

The scientist drawings are excellent examples of student work to display. My school has an open house soon after the year begins, and when the artwork is lined up in the hallway or adorns a bulletin board, it offers attractive conversation pieces and the opportunity for students to feel good about their work early in the year.

Students' knowledge of the nature of science is increased with all parts of this project. They are informed of the branches of science and the diversity of study in each by brainstorming and research sessions. Students further explore specific sciences and scientists, and in doing so develop insight into their own interests. The drawing and assignment requirements allow students to express themselves extensively and creatively.

Extension ideas

- Begin the whole process the first week of class by asking students to write a paragraph about what science is.
- Students make their drawings and also write papers about their scientist.
- Students present their work to the class.

Resources

Barman, C.R., K.L. Ostlund, C.C. Gatto, and M. Halferty. 1997. Fifth grade students' perceptions about scientists and how they study and use science. Available online at www.ed.psu.edu/ci/Journals/97pap33.htm

Phenomenal women: space and science—http://school.discovery.com/schooladventures/womenofthecentury/phenomenalwomen/space.html

Researcher profiles—www.idrc.ca/en/ev-30164-201-1-DO_TOPIC.html

What do scientists do?—www.sciencenetlinks.com/Esheet.cfm?DocID=41, www.sciencenetlinks.com/lessons.cfm?DocID=289

Six rules for integrating the arts

Creating science lessons using the arts is an enjoyable and meaningful opportunity for both students and teachers. Students get to showcase their scientific ideas in artistic and personal ways in front of an audience of their peers, teachers, and parents. Students learn, marvel, and critique their peers' creations; opening up conversations between themselves, and their teacher. For the teacher, it's an opportunity to see the artistic products that result from their students' learning experiences and also to use their students' artistic processes for formative and summative assessments. Although students construct ideas from their combined scientific and artistic experiences, the "imagined worlds" that result might contradict those of science (Amos and Boohan 2002). So how can teachers help their students to imagine and construct knowledge in the way that science sees it? Using six simple rules for integrating the arts into science learning, students' imagined worlds come closer to the way science sees it.

1 Make sure the artistic processes are aligned with the conceptual understanding for the topic being taught. I use a "Big Ideas" handout that summarizes the required conceptual understandings (scientific concepts and how are they relate to one another) to guide students' during the artistic process (see Figure 1) (Cronin-Jones 2003). The "Big Ideas" handout can also include key words and explanations that are required to support students' conceptual understanding of the topic and explanations (such as blend, protective coloring, shape, behavior, environment in the example provided). These key words can be in bold.

2 Ask your students to list and relate the skills that go into their artistic processes. The observations, inferences, data, predictions, and comparisons serve as the framework or "blueprint" on which students plan, and eventually create, their artistic renditions.

3 The artistic process should integrate the essential features of classroom inquiry. Students have to engage in both scientifically oriented questions and questions relating to the artistic processes, instead of just looking at questions that deal with the aesthetic issues. Students need to give priority to conceptual understanding that connects their explanations to scientific knowledge and the artistic process. These inquiry steps keep the artistic process closer to the science focus and also help your students to frame and formulate their presentations—the "Expression" phase of the modified 5E learning cycle.

4 Make sure the artistic processes are spread out within the differentiated teaching strategies used in your classroom. Because most science and arts integrated activities occur within non-laboratory settings, inquiry within these settings has to be promoted through cognitive inquiry abilities like contemplation and evaluation (Ingram, Lehman, and Polacek 2004).

5 Examine your students' imagined worlds—what is the basis of the imagination and does it have links to the "Big Ideas," process and inquiry skills. Listening to students' ideas, as well as looking and approving preliminary students' sketches and drawings, are short cuts into students imagined worlds and provide a mirror into their conceptual understanding. This leads teachers to determine the next steps in the learning process: First, it helps them to decide on the nature, quality, and quantity of the teacher feedback to students. Second, it opens up communication channels that enable the teacher to discuss with their students their progress in completing the combined scientific and artistic experiences.

6 Have rubrics for both formative and summative assessments in the combined science and arts integrated learning activities. The rubrics allow students to know the outcomes of their combined scientific and artistic experiences and to set goals towards the completion of the related tasks with equal emphasis on conceptual understandings and artistic expression. The rubrics also function as the standards that guide, communicate, and document student learning to teachers, enabling them to monitor and provide feedback on both students' conceptual understanding and artistic endeavors.

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FIGURE 1 **Big Ideas example**

- Camouflage is the means by which an animal blends with its surroundings.
- Camouflage includes an animal's protective coloring, shape, pattern, and behavior
- Most prey animals use camouflage in three main ways: to fool predators, to hide from predators, or to avoid being found.
- Most predator animals use camouflage in two ways to catch prey—"hide and wait" or "sneak up."
- Camouflage is dependent on the environment in which the animal lives.

Conclusion

By adapting these six simple rules into combined science and arts activities, teachers can effectively integrate current trends such as formative assessments, differentiated teaching strategies, process skills, and inquiry skills with their students' imagination and artistic expressions. Moreover, the rules guide teachers in helping their students construct "imagined worlds" that cohere rather than contradict science and, in the process, help their students construct knowledge in the way science sees it.

References

Amos, S. and R. Boohan, Eds. 2002. *Aspects of teaching secondary science: Perspectives on practice*. RoutledgeFalmer: London, England.

Cronin-Jones, L. 2003. Are lectures a thing of the past? Tips and techniques for success. *Journal of College Science Teaching*, 32 (7): 453–457.

Ingram, E., A.C. Lehman, and K.M. Polacek. 2004. Fostering inquiry in nonlaboratory settings: Creating student-centered activities. *Journal of College Science Teaching*, 34 (1): 39–43.