Solving the Mystery of Mock Mummies

Using Scientific Inquiry Skills in an Integrated Lesson

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Many middle school students assume that scientific studies must involve manipulative experiments in a laboratory. But scientific studies can be descriptive and may not involve "classic" experimentation, even though predictions are still tested. Both experimental and descriptive scientific inquiry involves documenting observations, making inferences, and engaging in scientific "arguments" with other scientists. Hence, there is no one scientific method (Gibbs and Lawson 1992). We suggest that when the nature of science (NOS) is reinforced, middle school students will be able to appreciate scientific inquiry processes and communication, as outlined in the National Science Education Standards (NRC 1996, p. 32–37).

To this end, we developed a mummy-making and dissection activity to help sixth- and seventh-grade students learn more about anthropological research and to reinforce NOS. Students become scientists who ask questions, collect data in a methodical and objective manner, make inferences, and form conclusions that are supported with evidence. Most recently we taught this lesson in a sixth-grade classroom in which we integrated the activity with a social studies unit on Central and South American cultures (specifically In-

can, Mayan, and Aztec), which is part of the standard social studies curriculum in this school district. This activity allowed us to incorporate writing activities, while demonstrating to students how professional anthropologists use skills and knowledge from three content areas: science, social studies, and English. The unit was a hit with students, who rose to the challenges of using their synthesis and evaluation skills.

Nature of science instruction

It is necessary to ensure that students understand the importance of documenting their observations in a systematic manner. By documenting data in an organized manner, scientists are better able to share their data with others and make data-supported inferences. With this objective in mind, we started this unit with an "Indiana Jones artifact" activity, during which students worked in cooperative groups of three. Students practiced documenting details about an artifact's *form* and inferred *function* in a field log. A field log is usually a notebook in which field scientists (those who do some of their data collection outside of a laboratory) write down their data. In this case, the data include illustrations of the artifacts, written descriptions of the artifacts' form, and explanations of possible functions of the artifacts. Students can either use small composition notebooks or a handful of papers stapled together, as we did. For the artifact activity, we did not introduce a format that required students to document their observations. Rather, we asked students to use a mixture of illustrations and text to describe the materials, the shape, and the details of the artifact (see Day 1, below, for more instructions). In a descriptive paragraph, students then had to make inferences about the function of the artifact using their observational notes in a field log.

The artifacts were household items that 11–13-year-old students may not recognize—we chose kitchen utensils (garlic press, corn kernel stripper, pastry decorator, pastry mixer, melon baller, etc.), office items (unusual-shaped letter opener, staple remover, pencil sharpener, etc.), hobby supplies (sewing items, tools, animal grooming brushes), and art supplies (decorative stampers, stencils, jewelry-making tools, and so on).

Day 1

Students began by randomly selecting an artifact from a paper bag; they were also supplied blank paper, a pencil, an eraser, a ruler, and access to a balance. Students' first task was to make a detailed drawing of their artifact. (Pen drawings are messy, so we required pencil sketches.) If the item was too big or too small, students created a scale legend indicating how many centimeters every 1 cm on the drawing represented. Students indicated with arrows if any parts were movable. In some cases, students decided to include more than one drawing.

Next students wrote along the side of the illustration what materials were used to make the artifact and the mass of the item (in grams). Students could select a descriptive name for their item and label their drawings; we encouraged creativity. Any decorative marks or words should be recorded next to the illustration.

Finally, students wrote a short, persuasive, paragraph about how the artifact may have been used. The proposed function had to be based on the artifact's form and be supported by the observations recorded in the field log. A discussion of "scientific argumentation" followed the writing activity.

Day 2

Students shared their inferences (i.e., their ideas about the artifact's function) with their group mates and determined who would be the *reporter*, *scribe*, and *artifact technician*. Together they decided what imaginary society could have used all three artifacts. We told students that they had to consider the diet and economy of this imaginary culture. They also could consider clothing, forms of communication, transportation, and governmental system. The scribe recorded the group explanations, and when groups were done (usually 30 minutes), each reporter shared with the class the conclusions of the group, while the artifact technician walked around the room displaying the artifacts.

Social studies and science

After the artifact activity, we introduced social studies content. We introduced students to Mayan, Incan, and Aztec cultures, because these are part of the sixth-grade curriculum in Colorado; however, we encourage teachers to use other cultures if they are more appropriate for their curricula. Students discussed geographical aspects and time periods of each culture after doing research (through reading, internet searches, and videos). At this point, we asked students to create columns on each page of their field

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guides with column headings of the three cultures and row headings of the cultural aspects (diet, clothing, communications [written language or not], mathematical notations, rituals, entertainment [games, dances, music], and religious ceremonies) that each culture used. By collecting data in a matrix form, students could compare and contrast the three cultures. Field guides were essential for students later as they constructed culturally appropriate artifacts to place in their mummy bundles.

Students also went to an interactive National Geographic website (*http://channel.nationalgeographic.com/channel/content/inca*) to examine an Inca mummy, which they could unwrap layer by layer. This site is free and intended for educators and students to use. On the same site students could link to a documentary on how Inca mummies were found and studied by anthropologists using scientific methods. The video clip explains what artifacts were buried inside of mummy bundles and the religious importance of connecting earthly objects with the dead in the afterlife.

FIGURE 1 Directions for preparing turkey bones for use in mock mummies

Bone preparation "recipe"
(One 6.8 kg [15 lb.] turkey yields enough bones for 7 mummies)

1. Save turkey bones from a meal.
2. Pull off as much meat as possible.
3. Boil bones in water. The first round of boiling removes most of the meat.
4. Boil bones once more in borax laundry soap for 20–30 minutes (this helps remove the fatty tissue).
5. Remove bones and place on cookie sheet. Bake on the lowest setting for 20 minutes. It is important to be diligent in removing as much meat as possible after the boiling processes and before baking.
6. Discard any brittle or small, sharp bones.

It is critical to have a discussion of why certain cultures make mummies so that students can

- understand the difference between natural mummification (in bogs, ice, or deserts) and purposeful mummification (for burial purposes), and
- appreciate that cultures often mummified their dead as part of a religious ritual that students must respect.

If teachers want to incorporate science inquiry activities that allow students to explore how the process of mummification occurs, we suggest they have students "mummify" apples. Apples can be preserved by freeze-drying, pickling, and evaporating, all methods that mimic how natural mummification occurs. To explore more about apple mummification, we suggest this free lesson plan from Education World (*www.educationworld.com/a_lesson/dailylp/dailylp/dailylp102.shtml*; both National Science and Social Studies Education Standards are included on this site) or this activity, also free, at Newton's Apple (*www.newtonsapple.tv/TeacherGuide.php?id=1422*), which lists wonderful references written at different scientific levels and allows teachers to use reading-to-learn strategies. In addition, the Smithsonian Institute's Museum of Natural History currently has a forensic anthropology exhibit on display until 2011. The accompanying

FIGURE 2 Mummy-creation rubric

Points earned: /16

	Unsatisfactory (1)	Partially proficient (2)	Proficient (3)	Advanced (4)
Design	The design was messy (e.g., bones were exposed) and showed no effort to follow the method described in class.	The design had some minor mistakes. Did not follow the correct methods for designing the mummy.	Followed directions. The mummy was designed well and included external decorations.	The design was excellent and showed a deeper understanding of the culture (external decorations reflected one of the cultures studied in class).
Culture and artifacts	No original artifacts were created and included with the mummy.	Less than four original artifacts were created and included with the mummy.	Four original artifacts were created and included with the mummy.	More than four original artifacts were created and included with the mummy.
Cultural consistency	There was no consistency with one culture, or, other cultures not discussed in class were used.	Displayed evidence of mixed cultures that were discussed in class; does not clearly identify one distinct culture.	All pieces of the mummy point to only one culture (one of the three cultures studied in class: Maya, Inca, or Aztec).	There was evidence of one distinct culture and an obvious effort by the group to present details.
Participation and collaboration	The group did not finish the mummy due to lack of participation; the group did not work well together.	There was little collaboration between group members, although the mummy was completed. Noticed unfair workloads within the group.	Everyone in the group worked together and participated in the design, creation, and assembly of the mummy.	The entire group worked well and performed to their highest potential. It is clear that the group took pride in including all group members' ideas.

website (*http://anthropology.si.edu/writteninbone*) lists lesson plans for grades 5 and 6, 7 and 8, and 9–12 that may either focus on social studies or science and technology.

Making mummies

As we began our mummy-making project, we showed students photographs of mummies in books from our school library. If your public or school library has access to *Dig* magazine (an archaeology periodical targeting middle school students), we recommend borrowing copies to show students. We asked students what they knew about how cultural mummies were made before we provided instructions on how our mummies were to be constructed. We made our mummies using turkey bones, paper plates, cotton muslin, white glue, and "artifacts" (beads, feathers, clay, paper cut into shapes, string, cotton batting, aluminum foil that could be shaped). The teacher must prepare the turkey bones before the lesson (Figure 1). One turkey usually provides enough bones for six or seven mummies. If students work in groups of three, then seven mummies are

usually sufficient for one class. Please note that chicken bones are too brittle and are not recommended for use. We reused the bones from one turkey for three successive classes that were taught this unit in different months. Please note that each class will need its own set of bones from a single turkey if teachers plan on teaching this unit concurrently in their classes. We strongly encourage teachers to request that students and colleagues donate their turkey bones after Thanksgiving, as we did. Ask turkey donators to pull off as much meat as possible, rinse and dry bones with paper towels, and place them in a plastic zip bag. If teachers cannot prepare bones immediately after receiving them, bones should be kept in the freezer until they can be prepared for use.

Students cut each layer of muslin using scissors. Because layers contained writing and illustrations, it was important to document the observations before removing layers. Some mummies had artifacts tucked in between layers, as well.

1. Preparing the base and muslin: Large, flimsy paper plates were used to make the base of the mummy (to which bones and materials are attached and around which muslin is wrapped). Students folded the plate so it was roughly in the shape of a rectangle and then cut the excess paper to use to make artifacts. While one student in each group was preparing the base, another prepared the muslin strips. Inexpensive muslin should be cut into 10 cm strips along the width of the fabric (often 95 cm). Students cut the fabric about 2 cm and then ripped it. Each mummy required no more than a meter's worth of muslin. Teachers should discuss scissor safety with students before any cutting begins.

2. Gathering and preparing artifacts: The third student in the group gathered materials from the front of the room to make or prepare artifacts. First, however, the group decided what culture their mummy would represent. They decided what artifacts were culturally appropriate (using their field-guide data). We reminded students to only use language symbols that are culturally and historically relevant.
3. Preparing the mummy: The teacher should divide and distribute the turkey bones. Using white glue, students glued the bones to the paper plate in any fashion they chose. If teachers plan to use the bones again, tell students to not be too "glue happy," so it is possible to pull the bones off and boil them to remove the glue. One strip of muslin was glued to the bottom of the plate and then loosely wrapped around the mummy base. Either on the plate or in between each layer of muslin, students placed their artifacts. When a strip of muslin was wound around firmly, students used a small amount of white glue to attach it to an existing piece of muslin. Students either wrapped entirely horizontally, or both horizontally and vertically, as long as their mummy was completely covered.
4. Decorating the mummy: Students researched the language (hieroglyphics, written language, and common art symbols) and the numbering system of each of the three cultures in the unit (see Resources). Students used markers and string to write a brief message on the outside of the mummies in culture-specific symbols.

5. Labeling the mummies: Students placed their prepared mummies on an index card with their names so we could set these aside. Ask students to not write their names on the mummy itself. From our observations of the working groups and from the mummies themselves we were able to assess the mummy-making activity (Figure 2).
6. Mummy narrative: During the following class period, each group typed out a narrative description of the life of their mummy. In one case a group made a "child and mother" set; they wrote the description of both of their mummies. Each group must carefully describe the artifacts used to define the mummy's previous life. Having students create a story for their mummy gave a purpose for the artifacts that they wanted to include (Sebranek, Meyer, and Kemper 1990).

Dissecting mummies

The final part of this unit is an inquiry activity that students absolutely loved. We used this activity as one part of the summative assessment, along with a traditional assessment (paper-and-pencil test).

1. The teacher handed each original group of three students a mummy that they did not create. Only the teacher should know (using index cards) which group created each mummy.
2. Students must use the same documentation skills they practiced during the "Indiana Jones" activity by documenting any artifacts, along with the mummy itself, in their field log. They must illustrate and label, describe, measure, and weigh the mummy and any artifacts that were found within each layer.
3. Using school-owned digital cameras, students created images of their mummies. If a teacher does not have access to a digital camera, then disposable cameras can be used if the school has resources to develop the film. Although it is not essential that photographs be used, we included this step as a replacement for the scanning step that archaeologists use. We explained that mummy archaeologists typically first conduct CT (computer topography) scans of their subjects in order to create an image of what is under the wrappings. This process is nondestructive and helps the mummy archaeologists determine the state of the mummy and any accompanying artifacts. X-rays release radiation,

FIGURE 3 Examples of mummies made by students

a.

b.

FIGURE 4 Possible extensions of the mock mummy unit

Science

Conditions for natural mummification (conditions where water has been removed and bacteria are unable to obtain any oxygen)—Both of the following sites describe and test how bodies can be dried out using apples:

www.education-world.com/a_lesson/dailylp/dailylp/dailylp102.shtml
www.newtonsapple.tv/TeacherGuide.php?id=1422

Studying the dead: Forensic anthropology—Modern anthropologists use technology in order to make observations and inferences about bone age, structure, and wound history:

www.writteninbone.si.edu

Social studies

Instead of studying ancient aspects of cultures, ask students to study how extant cultures approach death, afterlife, and mourning ceremonies. How do Zoroastrians living in India depend on vultures for body disposal? What are Native American burial mounds? Why do some cultures bury and others cremate their dead? These are some questions that teachers can use as prompts in this extension activity. This can be a sensitive topic for some students, so tailor the discussion to the comfort level of your class.

Time capsule—If students created a time capsule for people of the future, what artifacts would define their lives, interests, and culture? What artifacts can we discover in our own homes that tell about the past lives of our immediate family members?

English/language arts

Mock mummy memoirs—Using the creative writing genre, ask students to recreate the life of their mummy in story form. Alternatively, ask students to create an imaginary society and describe it thoroughly enough that the archaeological artifacts can be "discovered" in the text.

which can affect the state of preservation, so these are typically not used. In fact, these days mummies are only unwrapped if they are vulnerable to environmental degradation. It is not possible to CT scan mummies in the classroom; instead, students made inferences about what was inside of the wrappings using other available information. Students gently shook their mummies, determined whether one end was heavier than another, guessed how many layers of cloth might have been used based on the feel of the mummy, etc. These observations were recorded in the field log.

4. Next students deciphered any symbols found on the mummy's exterior. Using resource materials, students determined which culture the symbols represented and what they conveyed. These findings were documented in the field log.
5. Each layer was methodically and carefully removed. Students used scissors but were extremely careful to not inadvertently cut artifacts wrapped between layers. Note that safety scissors can be difficult for students to use to make small incisions in the muslin; we used Fiskars-style, all-purpose scissors instead. Each group should have their own pair of scissors. Students labeled which layer they unraveled, as they documented (drew, measured, explained) each artifact. This essential process can take up to two class periods.
6. Using their field logs, students inferred which culture the mummy represented. Students typed out their justification, using evidence and scientific argumentation to support their claim. In one class, a group was perplexed by their findings because the artifacts and symbols represented two different cultures. The mummy-making group had made an error. Although we anticipated a problem after reading the mummy-making justification paper, we allowed the dissection team to record their findings. When this group did, indeed, discover the discrepancy, we guided them as they explained this in their final paper. This group explained why they could not make a final judgment, although they inferred that the mummy was likely from one culture because the majority of the evidence supported that conclusion.
7. Each group assembled their field logs, artifacts, and photographs (which we had printed for them). Using their findings, students presented their scientific interpretation of their mummy to the class and prepared posters, which were displayed in the hallway (see Figure 3 for examples of mummies).

Students worked in cooperative groups to make and study mummies.

Conclusion

Students were enthusiastic to share their interpretations of their scientific investigations and used the terms *observations* and *inference* and multiple sources of data to support their claims, important steps in understanding NOS (NRC 1996). The class discussed any alternative interpretations of data presented and the importance of documenting observations. We did not want to promote a misconception and were pleased that all of the students in this sixth-grade class remembered that only the Inca constructed mummies.

We recommend this interactive activity because it not only engages students in learning, it integrates social studies (geography) standards with science standards and promotes the use of writing genres that are important for scientific studies. This activity also reinforces that scientific inquiry depends on the methodical collection of data, making data-supported inferences, and constructing and defending scientific arguments with colleagues. Although this hands-on and minds-on activity requires little direct instruction, through guided questions and discussion, the teacher can help students consider how to use evidence to support their scientific claims about mummy origin. In addition, teachers can extend this activity in other ways as they see fit to address science, social studies, or English standards (see Figure 4 for extension ideas). ■

References

Gibbs, A., and A.E. Lawson. 1992. The nature of scientific thinking as reflected by the work of biologists and biology textbooks. *American Biology Teacher* 54 (3): 137–52.

National Resource Council (NRC). 1996. *National science education standards*. Washington, DC: National Academies Press.

Sebranek, P., V. Meyer, and D. Kemper. 1990. *Write source 2000*. Burlington, WI: Write Source Educational.

Resources

Books

Adams, E. 1999. *Color & learn: Inca, Aztec, Maya*. Dana Point, CA: EduPress.

Coulter, L. 2001. *Secrets in stone: All about Maya hieroglyphs*. Boston, MA: Little, Brown.

Kramme, M. 2002. *Mayan, Incan, and Aztec civilizations, grade 5–8+*. North Mankato, MN: Mark Twain Media.

Marty, L. 2006. *Ancient Incas*. St. Louis, MO: Milliken.

Matthews, S.S. 1997. *The sad night: The story of an Aztec victory and a Spanish loss*. Boston, MA: Houghton Mifflin.

Websites

The Aztec calendar—*http://media-2.web.britannica.com/eb-media/43/7043-004-C8081944.jpg*

The Aztec calendar symbols—*www.ancientscripts.com/images/aztec_days.gif*

Aztec numbers—*www.ancientscripts.com/images/aztec_numbers.gif*

The cryptic knotted strings known as khipu—*www.ee.ryerson.ca/~elf/abacus/images/inca-khipu.jpg*

Maya hieroglyphs— *www.mnsu.edu/emuseum/prehistory/latinamerica/images/maya_hieroglyphs.gif*

Mayan numbers—*http://fsweb.bainbridge.edu/bdubay/mexico/math2.gif*

William Burns' ideas of Incan textiles as a form of writing—*www.rso.cornell.edu/scitech/archive/97spr/img/incascan2.jpg*

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