The Great Fossil Fiasco: Teaching about Peer Review

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Abstract for JABT Website

We used a discussion of a pair of articles published in the National Geographic and a hands-on activity with fossils to teach middle school students about peer review. The first article described the discovery of a new fossil that was thought to be a missing link between reptiles and birds. The second article detailed how the scientists reacted when their article about the fossil was rejected by several peer-reviewed journals; this rejection eventually led to the discovery that the fossil had been pieced together and thus was a fake. Comments made by students on a homework assignment after the activity indicated that they felt the most important role for peer review was helping scientists and journals to make sure their articles were true before publishing.

Peer Review in High School Science

Peer review is a fundamental aspect of conducting scientific research. The scientific community relies on peer review in making important decisions, including whether or not a research project should be funded and whether the results should be published in a particular journal. Peer review also is used to provide input to help scientists improve the design of their experiments and the presentation of their results. In schools, peer review can provide analogous opportunities for students to help focus their research questions and improve their methods, and can challenge them to think critically about their results (Carlsen et al. 2001, Trautmann et al. 2000). Because peer review is

such a fundamental part of conducting scientific research, it should be an important component of inquiry-based science teaching (NRC 1996, 2001).

The Cornell University Environmental Inquiry program has developed an Internet-mediated system for high school students to peer review each other's research reports (http://ei.cornell.edu/), as well as a rubric-based system for face-to-face peer review at student congresses or within individual classrooms (Trautmann et al. 2001). These efforts to teach peer review in the context of students conducting independent research have proven promising; lower level as well as high performing students were motivated to do well in science when they knew their work would be critiqued by peers. In addition, when students all had conducted similar research, they were able to ask insightful questions and provide meaningful reviews of each other's work (Carlsen et al. 2001; Trautmann et al. 2000). However, not all classroom teachers find the time to engage students in hands-on research combined with peer review.

The purpose of this paper is to describe a lesson that engaged middle school students in learning about peer review, using a pair of articles describing a real life story of how peer review forced scientists to critically reexamine a fossil discovery. Because we incorporated this lesson into a paleontology unit, it demonstrates how one might combine teaching about the "nature of scientific research" with a subject matter that is normally taught as part of middle school science. Furthermore, we found that including the hands-on activity with fossils motivated students, whereas an earlier pilot activity in which students only read the articles but did not handle fossils failed to engender enthusiasm. We also present some preliminary results of the impact of this lesson on student understanding of peer review.

The Fake Fossil

In November 1999, the National Geographic published an article about the discovery of a new fossil, *Archeoraptor liaoningensis,* that appeared to have the tail of a land-based dinosaur and the body and head of a more bird-like creature (Sloan 1999). The fossil generated a great deal of excitement because it purportedly provided the missing link in the search for a bird-like creature that evolved from a dinosaur. It was National Geographic policy not to publish an article prior to it being published in a scientific journal; in this way, the National Geographic could be assured that it only published work accepted by the scientific community. In the case of *Archeoraptor liaoningensis*, the finders of the fossil assured National Geographic that the article would be published in a scientific journal; when this did not happen as scheduled, National Geographic made the decision to publish their article anyway.

In October 2000, National Geographic revealed that the fossil had, in fact, been a composite of the two types of creatures, and thus was a fake. With encouragement from the editor, the author of the second article offered a very detailed explanation of how the fossil had gotten published as a new species in the first place. In what may sound like a bizarre statement to make about scientists, who most students and many adults assume are unbiased, the author of the second article claimed, "It's a tale of misguided secrecy and misplaced confidence, of rampant egos clashing, self-aggrandizement, wishful thinking, naïve assumptions, backbiting, lying, corruption, and, most of all, abysmal communication" (Simons 2000). More importantly, the second article provides insight into the peer review process, and how the fact that the article was not accepted for

publication by a scientific journal led the scientists to eventually discover the disturbing truth about the fossil.

Implementing the Fossil Fiasco Lesson

The lesson, which included a fossil activity and discussion of the Simons (2000) article, took place over one 80-minute (double) classroom period. It was conducted by a Cornell graduate student teaching fellow (N. Gift) working in four different classes in a rural middle school, but could easily be taught by a classroom teacher. The lesson began with a short (5 minute) introduction, during which the instructor described a local fossil collection site and students were invited to define fossil. The instructor next divided students into groups of 3-5 and gave each group about 50 small partial or whole fossils to divide into species or groups by features. Students spent between 10 and 15 minutes sorting the fossils, and then drew some of the species they saw on the board. A short identification lesson followed, with an emphasis on how easy it is to mistake one fossil organism for another if only incomplete fossils are available.

The instructor next gave a brief overview of the difficult vocabulary in the Simons (2000) article (Table 1) while introducing the plot of the article. The students then took turns reading 16 paragraphs that the instructor had highlighted in the article, and which emphasized the importance of the peer review process that eventually helped reveal the truth about *Archeoraptor*. (A copy of the complete article with highlighted paragraphs is available at http://ceirp.cornell.edu/review/ngarthlt.html.) The instructor guided the students in reading the excerpts, filling in details about the players in the incident (scientists, authors, fossil collectors), their actions, and motives, and discussing

unfamiliar vocabulary words. More advanced students were observed reading the entire article, leading us to conclude that providing the complete article with highlighted paragraphs was an effective means of engaging students of different reading abilities.

Student Response

Students' answers to the first eight questions in the homework assignment (Table 2) indicated that they generally understood the content of the article, including what the fossil was and how it was created, and which of the players in this incident might have had motives other than seeking the truth about the fossil (e.g., money, fame). In response to question 9, "Why do scientists value peer review?", 76 of 96 students who turned in the homework wrote comments related to helping the author and journal ensure the quality of the article (Table 3). Only 13 students saw the purpose of peer review as supporting a desire to have others affirm their work or agree with them; these responses may reflect students assuming that scientific communities act like classrooms with teachers' (or scientists') comments on assignments affirming the worth of one's efforts. Although question 9 on the homework did not directly address whether peer review is a process among scientific equals, 18 students referred in their comments to scientists wanting feedback from each other or other scientists, whereas only one student wrote that scientists want confirmation from a higher authority. As one student noted, "there are no higher classes to say it's good or not." These results indicate that most students seemed to understand that scientific communities, where there is no ultimate higher authority, function differently than pre-college classrooms where teachers evaluate students' work.

Thus, overall this activity appeared to be highly effective in accurately conveying the role of peer review.

Conclusions

The Fossil Fiasco lesson was successful in generating student enthusiasm and in teaching students that peer review is a way of helping ensure that published articles contain high quality information and are true. Teachers who feel bound by required curricula may feel a one- or two-day lesson on the nature of scientific research is all they can afford. This lesson offers teachers an entrée into teaching one aspect of the nature of scientific research, i.e., peer review, and, if incorporated into lessons on evolution or paleontology, may require little or no sacrifice of "content" time in the classroom.

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Table 1. Definitions of terms used in the National Geographic article.

Fossil. rock imprint or mold of dead plant or animal.

Paleontologist. one who studies fossils.

Archeoraptor liaoningensis. genus and species names given to what scientists thought was a fossil hybrid of a bird and a dinosaur.

Evolution. the study of how ancient organisms (such as dinosaurs) changed over time, sometimes into current day organisms (birds, mammals).

Missing link. a fossil that gives new information about evolution by linking two events or fossils.

Peer review. the process by which scientists judge each other's research to determine whether or not it is of sufficient quality for publication, and to provide feedback to each other to improve the quality of their research.

Scientific journal. a magazine reporting the results of scientific research in which all articles have been peer reviewed before publication.

Red flag. a warning that something is wrong.

Table 2. Homework questions for Fossil Fiasco.

Who found the *Archeoraptor* fossil?

Did the fossil come from one rock or several?

Why did the pieces of rock get put together into one fossil?

What was exciting about this fossil to scientists?

Was the resulting animal "real?" (that is, did all those parts actually belong to one animal?)

Why did the owners of the fossil want it to be a real animal?

Why didn't any scientific journals publish the article about *Archeoraptor*?

Drawing on your experience in looking at parts of fossils, can you suggest a way this mistake could have been avoided?

Why do scientists value peer review?

Table 3. Student responses to question 9: "Why do scientists value peer review?"

Category	Sample Quote(s)	Responses (#)
Helping the writer and/or journal to ensure that articles are true before being published.	*They need to make sure that nothing is incomplete or left out.* *Scientists value peer review because it tells them that what they have written is correct enough to publish or not. This prevents huge mistakes in scientific journals.* *So nothing totally wacko goes in the journals.* *If there is a problem it can get fixed before it gets published*	76
Desire to have other scientists agree with them.	*Because it makes them feel better when someone else judges it good.*	13
Helps scientist make more money.	*The better [the scientists] do, the more money they get.*	2
Want OK from higher authority.	*Scientists value peer review because they are able to have an 'OK' from a higher scientist….*	1
See how good they are as scientists.	*They find out how good they are as a scientist.*	1