

Cleveland State University  
**EngagedScholarship@CSU**



---

Biological, Geological, and Environmental Faculty Publications      Biological, Geological, and Environmental Sciences Department

---

10-2011

# Primary Literature Across the Undergraduate Curriculum: Teaching Science Process Skills and Content

Emily S.J. Rauschert  
*Cleveland State University, [e.rauschert@csuohio.edu](mailto:e.rauschert@csuohio.edu)*

Joseph Dauer  
*Michigan State University*

Jennifer L. Momsen  
*North Dakota State University*

Ariana Sutton-Grier  
*National Oceanic and Atmospheric Administration*

Follow this and additional works at: [https://engagedscholarship.csuohio.edu/scibges\\_facpub](https://engagedscholarship.csuohio.edu/scibges_facpub)

 Part of the [Biology Commons](#), and the [Science and Mathematics Education Commons](#)

**How does access to this work benefit you? Let us know!**

*Publisher's Statement*

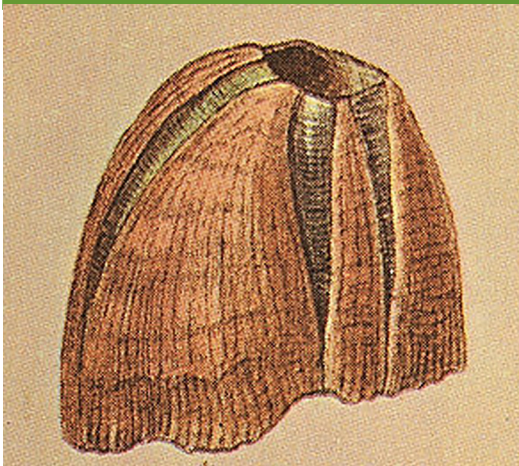
Copyright by the Ecological Society of America

---

## Recommended Citation

Rauschert, E. S. J., Dauer, J., Momsen, J. L. and Sutton-Grier, A. (2011), Primary literature across the undergraduate curriculum: teaching science process skills and content. *The Bulletin of the Ecological Society of America*, 92: 396–405. doi:10.1890/0012-9623-92.4.396

This Article is brought to you for free and open access by the Biological, Geological, and Environmental Sciences Department at EngagedScholarship@CSU. It has been accepted for inclusion in Biological, Geological, and Environmental Faculty Publications by an authorized administrator of EngagedScholarship@CSU. For more information, please contact [library.es@csuohio.edu](mailto:library.es@csuohio.edu).



---

# ECO 101

---

Note: William Bromer is the editor of **Ecology 101**. Anyone wishing to contribute articles or reviews to this section should contact him at the Department of Natural Sciences, University of St. Francis, 500 N. Wilcox, Joliet, IL 60435, (815) 740-3467, e-mail: [wbromer@stfrancis.edu](mailto:wbromer@stfrancis.edu).

## Editor's Note

ECO 101 is highlighting some of the ecological education workshops and presentations from the 2011 ESA Annual Meeting. Because of travel or concurrent sessions, some of you may have missed these, so here are summaries from two workshops and one presentation. Other interested presenters are encouraged to submit summaries to Bill Bromer.

Emily Rauschert, Joseph Dauer, Jennifer L. Momsen, and Ariana Sutton-Grier presented a workshop titled “101 Ways to Effectively Use Journal Articles as Teaching Tools.” They show us a number (not sure there are exactly 101 but who is counting) of ways to use primary literature to meet a multitude of learning objectives, primarily in the undergraduate classroom, but many of the approaches can be used in other settings. They also present some feedback and comments from the participants, so it is almost as if you were there.

David Grisé, Courtney Lee, Caitlin Bailey, and Mariela Rivera summarize their workshop “Understanding and Implementing Team-Based Learning in Large Lecture Courses.” This workshop actually engaged the participants in a Team-Based Learning (TBL) activity to demonstrate the use of TBL in both large and small classes.

Finally, Bryan Dewsbury summarizes his presentation of “The Teaching Pentagon: A Quantitative, Integrative Approach to Teaching Ecology.” Bryan describes a curricular structure that integrates a laboratory course, journal club, peer-led team learning, and a mathematics course, with a traditional biology lecture course, in order to make connections among a variety of disciplines and provide a holistic educational experience for students.

---

## Primary literature across the undergraduate curriculum: teaching science process skills and content

*Summary and comments from the workshop “101 ways to effectively use journal articles as teaching tools” presented at the 2011 ESA Annual Meeting*

Emily S. J. Rauschert, The Pennsylvania State University  
Joseph Dauer, Michigan State University  
Jennifer L. Momsen, North Dakota State University  
Ariana Sutton-Grier, National Oceanic and Atmospheric Administration

A major goal of biology education is that students learn the tools and skill of the profession; in other words, they learn to think and act like biologists (AAAS 2011). Arguably, one of the most important skills in becoming a biologist is the ability to comprehend, analyze, and evaluate primary literature. However, even upper-division students find this challenging. Integrating primary literature into a science course is an essential opportunity to prepare students to function as scientists. There are a variety of ways to use the primary literature beyond having students read articles and discuss results, and some of these methods are especially relevant for introductory students or nonmajors courses.

Our primary workshop goals for participants included (1) examining the breadth of learning objectives that can be met by using primary literature in the classroom, and (2) discovering the numerous ways in which journal articles can be used to meet these objectives. We also sought to help faculty become self-sufficient in finding suitable articles to meet their classroom needs. Here we detail the results of our literature analysis on the use of primary literature in the undergraduate classroom and summarize the ideas generated by workshop participants for finding and using primary literature. While not exhaustive, we believe these ideas form a response to the broad call to teach biology as biology is practiced.



## Why is it important to use primary literature? What learning objectives can students achieve with primary literature?

There is strong agreement among faculty that the primary literature should be used with undergraduate students. In a survey of 150 faculty members, the importance of reading and understanding the primary literature received an average score of 4.5/5 (between “important” and “very important”; Coil et al. 2010). Science process skills, including reading the primary literature, are viewed as a critical part of the undergraduate curriculum, but relatively little time may be spent on this due to an emphasis on covering content (Coil et al. 2010). Many undergraduate science classes follow a textbook and use the textbook to guide the content of the class, but using a textbook to support the content of a course does not necessarily help the students learn these important science skills they need. Articles have more rich dimensions and are a more direct reflection of what scientists do and how the scientific process works.

This workshop was aimed at instructors who want to incorporate primary literature and are unsure how to do it. As with all activities in the course, the use of primary literature should be guided by explicit learning goals that can be achieved by the incorporation of literature. In order to align learning goals and activities with primary literature, we had participants in our workshop explicitly brainstorm learning goals that could be met using articles. Participants reviewed the AAAS Vision and Change in Undergraduate Education report (AAAS 2011) that suggests that science students, in addition to learning content, need to develop six core competencies or *skills* important for being a successful scientist. Many, if not all, of these competencies, including “Ability to apply the process of science,” “Ability to use quantitative reasoning,” “Ability to tap into the interdisciplinary nature of science,” and “Ability to understand the relationship between science and society,” can be addressed in the classroom using primary literature. For example, workshop participants used the article, “Altering turbine speed reduces bat mortality at wind-energy facilities” (Arnett et al. 2011) and brainstormed ways to use this article to teach the Core Competencies (see Box 1).

## How to identify the relevant primary literature

One difficulty with using primary literature can be selecting suitable articles to use in the classroom (see Box 2). It is important to know what learning goal you want to achieve so that you can find an article that matches that goal. For example, if the learning goal is to get students to work with data and graph interpretation, and if the students are in an introductory course, it is important to begin with simpler articles with bold conclusions and obvious implications to help them achieve this learning goal (Muench 2000). An article that is relatively broad in focus and avoids jargon is a good choice. Sometimes you can find good ideas for articles to use in the classroom by looking in the news, such as *Science News* or *National Geographic News*. Journals that are written for a broad audience are also a good place to look for articles, including *Science*, *Nature*, *Frontiers in Ecology and the Environment*, and *BioScience*. The journal *Science* also has summaries of some of its research articles that can be easier for students to digest than the actual articles.

Indeed, finding primary literature that meets specific learning goals and objectives can be challenging. One goal of the workshop at ESA was to enable participants to discover, use, and adapt existing and future



---

scientific articles to meet their classroom learning objectives. To reach that goal, we asked participants to reflect on (1) what features or traits make an article usable in the undergraduate classroom, and (2) how one can find new articles. Participants focused on data representations, language, and relevance as key factors in determining the usability of an article for undergraduate instruction (Box 2), but recognized the importance of clearly articulating learning goals and outcomes before choosing an article for class. Sources for potential articles for the undergraduate classroom are as diverse as the students we teach, including traditional journals, news media, and podcasts (Box 2).

**What are the challenges associated with using primary literature, and how can we begin to overcome them?**

One of the major reasons that faculty avoid using the primary literature is that students have a difficult time understanding the format, terminology, and scientific reasoning in the primary literature (Janick-Buckner 1997). To address this, we suggest an approach of building up the understanding of a paper through focusing on separate pieces. For example, focusing on understanding figures separately can help students build critical data interpretation skills.

Smith (2001) solved the problem of students being overwhelmed by research articles by scaffolding articles for students. Early in the semester, Smith heavily edited articles, focusing largely on figures and tables, to help students understand the results and draw valid conclusions. As the semester progressed, the scaffolding was removed and students read more sections of the paper and answered increasingly sophisticated questions. Through this process, students developed the requisite skills to effectively analyze key articles in the field. Janick-Buckner (1997) provided students with detailed questions to guide their reading of articles before class so that they could have a productive class discussion about the article. During these discussions students often realized that parts of the article were difficult for everyone to understand, which helped them feel less intimidated.

A major barrier to using primary literature in our classroom is the technical nature of many articles. These articles may contain results or conclusions that we want to highlight, but we recognize that students may get lost in the details. It may be methods detailing extensive mathematical or statistical tools, results incorporating multiple interacting factors, or discipline-specific jargon. While these articles provide the basis for our science scholarship, they can be a barrier for students trying to engage the literature.

Instead of assigning these articles as a whole, it may be advantageous to scaffold student learning with these articles. During the workshop, we practiced using a difficult article from *Science* (Lobell et al. 2011). Participants suggested that instructors provide a glossary of difficult scientific terms or, better yet, have students build a glossary of terms and work in pairs or groups to build and clarify this glossary of terms. Participants suggested having students focus on particular portions of the paper. Students could decompose the methods or work with only the figures. For many articles, the main points are highlighted in figures and students are more likely to engage the figures when they investigate them in detail. Students could decompose figures into single factors (e.g., change of one variable through time) or translate the results into new tables or figures.

If the learning goal is to help students understand the scientific process of discovery and the way scientific ideas can evolve, textbooks usually do not do a good job of demonstrating the evolution of scientific ideas and the role of peer criticism in the development of ideas. A good way to demonstrate the evolution of ideas is to pair two papers together that build on each other or that show the change in ideas as more data were gathered (Muench 2000). If the learning goal is about helping students understand the role of science and society, you could pair a primary literature article with some of the secondary literature (such as news articles or blog entries) about that article. By reviewing both, students can come to understand the importance of translating science so that it is more easily understandable by the public.

### Case studies of effective ways to use primary literature

#### *Creating a virtual laboratory*

One of the problems students may have in understanding articles is that they do not understand the methods used. Jacques-Fricke et al. (2009) determined that students were struggling to understand primary scientific literature in molecular biology because they did not understand the differences between the different molecular techniques. They developed a module for a capstone course involving having student groups teach each other about a particular technique used in a paper the class was reading. Students learned the steps involved in common molecular techniques, chose the appropriate technique to address a particular question, applied knowledge of techniques in new contexts, interpreted data from techniques, and drew conclusions. This activity could be a good substitute for a lab at a school where labs are not available or in a course where there is no accompanying lab, as was the case in this paper.

Hoskins et al. (2007) designed a new method for teaching science and the nature of science using primary literature called CREATE (consider, read, elucidate hypotheses, analyze and interpret the data, and think of the next experiment). This method uses modules containing several articles from one research lab over time to show students the process of scientific inquiry, how scientific knowledge is generated, how projects progress through time, and the evolution of scientific ideas, helping students “think like a scientist.” Students worked with an earlier paper first, then discussed what experiments they might do next and compared to what the research group actually did. The original implementation of this technique also involved having the students contact the scientists. The focus on interpreting data and thinking of the next experiment is particularly important for students to understand the creative, dynamic nature of science and scientific discovery.

#### *The journey from science to popular science to blogs*

The ability to understand the relationship between science and society is one of the six core competencies listed as essential for undergraduate biology education (AAAS 2011). There has long been a gap between how scientists publish peer-reviewed papers and how the media reports on them; in today’s world, public perception of science is also increasingly shaped by reading blogs. Commenting on articles and blogs is also where an increasing large portion of public dialogue is occurring. Often by

---

the time it filters down to the comments, the science has been somewhat distorted. To better understand this process, students could examine how a particular piece of science progresses through these filters.

### *What's my hypothesis?*

Once students have worked through a paper, we usually move on to the next topic. This is a missed moment; having worked so hard to get students to understand the system and the experiments, this is the perfect opportunity to have students think about the next step. In the workshop, we split participants into small groups and had them come up with what their next experiment would be in the bat system mentioned above (Arnett et al. 2011). Participants had to come up with a concrete hypothesis and draw a graph of hypothetical data supporting their hypothesis. Groups then exchanged just the graph, and they had to guess what the hypothesis was that the other group was trying to test. Even in a room full of professional ecologists, a few axis labels were missing and some aspects of the hypothesis were not extractable from the graphs. In a classroom setting, it would be especially important to allow the original group a chance to revise their graph and see if that helped clarify the issues. This activity took only about 15 minutes and was very well received by the participants, with several commenting that they plan to try this approach.

### *Other approaches*

Harrod (2009) described allowing students to browse through several leading sociology journals on the first day of class as a way of facilitating insight into what a field is about. Using a grid to focus the information collected, students examined factors such as journal publication frequency, number of authors, topics, and methods used. This could also be used in a biological context to highlight differences between fields within biology.

Faculty at UCLA Howard Hughes designed a whole program for honors undergraduates around reading primary literature (Kozeracki et al. 2006). The students did a guided research project during their junior and senior year as well as a weekly literature seminar. Students read papers, presented papers, and presented their own research over the course of two years. The student survey results postgraduation suggested that students felt their ability to read and interpret research increased and that their confidence discussing science increased; faculty advisors agreed. Students also felt that the literature club facilitated their transition to graduate school. The journal club also provided opportunities for specific faculty mentoring.

*Pathways to Scientific Teaching* (Ebert-May and Hodder 2008), originally a series in *Frontiers in Ecology and the Environment* (August 2004–June 2006), focused on the use of primary literature for teaching and learning ecology. Each *Pathways* article, using a research article published concurrently in *Frontiers*, identified learning goals and instructional approaches to teach ecology using the primary literature. Ideas included using open-ended inquiry to explore the process of science, peer assessment, jigsaws, Just-in-Time Teaching (JiT), and concept mapping. Although each *Pathways* article was tied to a specific *Frontiers* article, the ideas and approaches with the *Pathways* article were easily extracted and adapted to fit different readings.

ESA workshop participants readily identified many additional uses for scholarly articles in the undergraduate classroom, which spanned a range of functions, from teaching content and the scientific method to crossing disciplinary boundaries (Box 1). Many of the approaches identified by workshop participants represented authentic activities; that is, they required students to behave like scientists. For example, several activities focused on scientific writing and others asked students to manipulate published data. These approaches to using articles in instruction are applicable across a wide range of courses, including introductory courses for majors and nonmajors, and upper-division courses and seminars within the major.

### How to assess learning when using primary literature

No matter what learning goals you want to meet using primary literature in the classroom, you need to assess whether the students meet the learning goals. For example, if your learning goal is that students will be able to apply models and interpret model results, it would be useful to do a class activity using model results from an article. Based on the students' interactions and comments in class, you can assess whether they can apply models better, having participated in the activity (formative assessment). You may decide that they made progress but are still struggling with particular aspects of modeling, so that you want to do an additional activity with another article. Once they have had time to practice this new skill, you may choose to include a question about interpreting model data on an exam (summative assessment) to test how well students have learned to interpret model data. It is critical to remember that students are likely to be much more successful at demonstrating a skill (such as model data interpretation) on summative assessments if they have had adequate time to learn and practice that skill in class (formative assessment). It may also be valuable to incorporate primary literature throughout the semester to assess whether students' abilities to work with primary literature improve over time. For the purposes of assigning a letter grade, using a rubric can make assessment more objective and rapid. A number of rubrics have already been developed, including the Valid Assessment of Learning in Undergraduate Education (VALUE) rubrics. Developed by the Association of American Colleges and Universities (AACU), VALUE rubrics target Essential Learning Outcomes for undergraduate education, as defined by the AACU, and these rubrics are currently undergoing testing for reliability (< <http://www.aacu.org/value/index.cfm> >).

### Copyright issues to keep in mind

One cautionary note about using primary literature in the classroom is that the rules for how an article can be shared vary from publisher to publisher. You may want to check with your librarians for guidance on how best to share articles with students. When in doubt, it is always the safest and best practice to share an article by linking directly to the journal. However, this is not always possible. Some articles may only be available through interlibrary loan, and it is impractical to ask every student to individually request the article. Some institutions allow faculty access to more journals than students have access to; posting a link that worked for you may not work for your students. In these cases, it is best to post a pdf copy of the article to a course management site or on a class website if that website is secure with closed access (i.e., content is available only to students in your course). Posting pdf articles to open websites is a clear violation of many journals' copyright.



---

## Conclusions

There are many effective ways to integrate the primary literature into the undergraduate curriculum, and it can be incredibly effective for working on science process skills, such as those outlined in the Vision and Change Report (AAAS 2011). At the workshop, there was broad consensus among faculty members teaching across the full range of institutions that it is possible and desirable to include primary literature at all levels of undergraduate education. Primary literature can also be a great way to motivate students by helping them connect science to their own lives and the real world and potentially link to policy or management implications.

One of the new ideas that we, as organizers, learned from the participants is that there are also many benefits for the instructor when using primary literature in the classroom. First of all, challenging yourself to keep using current literature in the classroom helps instructors stay current in their own fields and has many opportunities for synergisms between research and teaching interests. Particularly for faculty members teaching the same class every semester, using the primary literature can also be an important way to keep your own enthusiasm for teaching high; bring in the latest, coolest results, and share this energy with your students. Finally, there is always a lot to be learned from students. Students can make many interesting connections when discussing primary literature in ways that can also shape our thinking.

## Acknowledgments

Many thanks to the enthusiastic participants who shared many great ideas at the workshop “101 ways to effectively use journal articles as teaching tools” at the ESA meeting in Austin, Texas, in August 2011.

## Literature Cited

- AAAS. 2011. Vision and change in undergraduate biology education: a call to action.
- Arnett, E. B., M. M. Huso, M. R. Schimacher, and J. Hayes. 2011. Altering turbine speed reduces bat mortality at wind-energy facilities. *Frontiers in Ecology and the Environment* 9:209–214.
- Coil, D., M. P. Wenderoth, M. Cunningham, and C. Dirks. 2010. Teaching the process of science: faculty perceptions and an effective methodology. *CBE—Life Sciences Education* 9:524–535.
- Ebert-May, D., and J. Hodder. 2008. *Pathways to scientific teaching*. Sinauer Associates, Sunderland, Massachusetts, USA.
- Harrod, W. J. 2009. Using journals to show students what social psychology is all about. *Teaching Sociology* 37:390–401.
- Hoskins, S. G., L. M. Stevens, and R. H. Nehm. 2007. Selective use of the primary literature transforms the classroom into a virtual laboratory. *Genetics* 176:1381–1389.
- Jacques-Fricke, B. T., A. Hubert, and S. Miller. 2009. A versatile module to improve understanding of scientific literature through peer instruction. *Journal of College Science Teaching* 39:24–32.
- Janick-Buckner, D. 1997. Getting undergraduates to critically read and discuss primary literature: cultivating students’ analytical abilities in an advanced cell biology course. *Journal of College Science Teaching* 27:29–32.

- Kozeracki, C. A., M. F. Carey, J. Colicelli, and M. Levis-Fitzgerald. 2006. An intensive primary-literature-based teaching program directly benefits undergraduate science majors and facilitates their transition to doctoral programs. *CBE—Life Sciences Education* 5:340–347.
- Lobell, D. B., W. Schlenker, and J. Costa-Roberts. 2011. Climate trends and global crop production since 1980. *Science*. [doi:10.1126/science.1204531]
- Muench, S. B. 2000. Choosing primary literature in biology to achieve specific educational goals. *Journal of College Science Teaching* 29:2550–260.
- Smith, G. R. 2001. Guided literature explorations. *Journal of College Science Teaching* 30:465–469.

Box 1. (Almost) 101 uses for a scholarly article in the undergraduate classroom.

Science and society

1. Write a press release, newspaper article, or letter to the editor summarizing the research.
2. Find a popular press summary of the article and critique.
3. Link to a podcast that links paper results to current societal challenges.
4. Use a citizen science article as an entry to working with citizen-generated data.
5. Use an article to exemplify the impact of science on policy.

Scientific method

6. Use virtual laboratories (Jacques-Fricke et al. 2009).
7. Use journals to understand norms of the discipline (Harrod 2009).
8. Ask students to generate the hypothesis for a follow-up study.
9. Ask students to predict a graph from a follow-up study.
10. Jigsaw article elements (e.g., introduction, methods), and have student groups present each element to each other.
11. Use a series of figures from two or more articles to articulate a line of research.
12. Write the abstract.
13. Critique another student group's presentation of the article.
14. Interpret figures, and write figure captions.
15. Explore the methods in detail and use to teach methods of science in situations where laboratories are not feasible.
16. CREATE (Hoskins et al. 2007)

Learning content

17. Make a model of results, experimental design, etc.
18. Combine multiple graphs or figures into a single figure; add time as a variable.
19. Revisualize figures into a new format.

- 
20. Identify jargon and define within the context of the paper.
  21. Abstract and list the main ideas, or write a succinct summary.

Engagement and motivation

22. Use images and figures to engage and generate enthusiasm.
23. Motivate yourself to explore current research by choosing contemporary papers.
24. Use student-written papers and/or journals to demonstrate undergraduates doing good science.

Box 2. Key ideas for identifying usable articles generated by workshop participants.

Traits that make an article usable

Data representation

- Clear, well-made graphs
- Data appropriately complex

Language

- Well-written, engaging to read
- Jargon is appropriate
- Research question(s) apparent
- Methods are well articulated

Relevance

- Article relates to contemporary biology, current events, or is quirky

Approaches to find new articles

1. Remain attentive for potential articles through the course of your normal reading habits.
2. Develop concrete lists of keywords to search.
3. Use familiar, favorite articles or seminal articles in the discipline.
4. Look to citing references for contemporary takes on classic articles.
5. Use suggested references in textbooks.
6. For news media, track the sources behind science articles on NPR, CNN, BBC, etc.
7. Use alternative media, including blogs and podcasts.<sup>1</sup> Track the sources behind the science articles.
8. Use letters and author responses to teach controversies in science.
9. Citizen science publications often include data and are written for the general public.

<sup>1</sup> A list of science-related blogs and podcasts is available at <<https://sites.google.com/site/articlesinclassesa2011/>>