Using Author Bylines and Concept Maps to Illustrate the Connectedness of Scientists †

Min-Ken Liao

Biology Department, Furman University, Greenville, SC 29613

INTRODUCTION

Guiding students to read primary articles has become an integral part of many undergraduate science courses. Not only does it enrich students' learning experiences and enhance their critical thinking skills, but learning to demystify primary articles also helps to retain undergraduates as science majors (1). Before engaging students in meaningful discussions about primary articles, we often start by coaching the students to see the big picture in the title and the abstract, to identify the question under investigation and the hypothesis in the introduction, to examine the tables and figures carefully, and to evaluate the results and conclusion critically. While the entire article, sometimes including the acknowledgments and references, is being scrutinized thoroughly, the author byline is often overlooked. However, the author byline can best illustrate the connectedness of scientists and the collaborative nature of the science community. This exercise was thus designed to achieve these objectives. Based on *The Lure of Bacterial Genetics, A Tribute to John Roth* (2), I selected 14 primary articles with authors who, to various degrees, are connected by John Roth (Table 1). I involved students in my first-year seminar class to minimize the confounding effects of previous knowledge about the scientists included in this activity and about reading primary articles, and I used pre- and postactivity questionnaires to evaluate whether these objectives were met. An additional objective of this activity was to introduce concept mapping to first year college students. It is a shared concern of many college educators that a main reason our students' academic potential is not fully realized is their lack of effective study skills. I have been introducing concept mapping to students in upper-level classes as a way to organize massive amounts of information and to connect seemingly unrelated facts (see Appendix 1). I believe that the earlier students learn about concept mapping, the earlier they can reap the benefits of using it.

Corresponding author. Mailing address: Biology Department, Furman University, 3300 Poinsett Highway, Greenville, SC 29613. Phone: 864-294-3246. Fax: 864-294-2058. E-mail: min-ken.liao@furman.edu.

†Supplemental materials available at <http://jmbe.asm.org>

TABLE 1.

List of primary articles and authors for concept mapping.

Papers:

Lysogen and sporulation in *Bacillus* isolates from the Gulf of Mexico. (2010) *Appl. Environ. Microbiol.* **76**:829.

Accumulation of mutants in "aging" bacterial colonies is due to growth under selection, not stress-induced mutagenesis. (2008) *PNAS* **105**:11863.

Human *Salmonella* clinical isolates distinct from those of animal origin. (2008) *J. Infect. Dis.* **197**:1757.

Phylogenetic classification of short environmental DNA fragments. (2008) *Nucleic Acids Res.* **36**:2230.

Ohno's dilemma: Evolution of new genes under continuous selection. (2007) *PNAS* **104**:17004.

Complete genome sequence of FHSIC, a pseudotemperate marine phage of *Listonella pelagia*. (2005) *Appl. Environ. Microbiol.* **71**:3311.

Salmonella DNA adenine methylase mutants confer cross-protective immunity. (2001) *Infect. Immun.* **69**:6725.

Substrate recognition by proline permease in *Salmonella*. (2001) *Amino Acids* **21**:161.

Genomic analysis and growth-phase-dependent regulation of the SEF14 fimbriae of *Salmonella enterica* serovar Enteritidis. (2001) *Microbiology* **147**:2705.

Sensing structural intermediates in bacterial flagellar assembly by export of a negative regulator. (1993) *Science* **262**:1277.

DNA ligase and the pyridine nucleotide cycle in *Salmonella typhimurium*. (1989) *J. Bacteriol.* **171**:2173.

Rearrangement of the bacterial chromosome: forbidden inversions. (1988) *Science* **241**:1314.

Regulation of proline utilization in *Salmonella typhimurium*: characterization of *put::Mu d(Ap, lac)* operon fusions. (1983) *J. Bacteriol.* **154**:561.

Transposon *Tn10* provides a promoter for transcription of adjacent sequences. (1982) *PNAS* **79**:5016.

Authors:

Dan Andersson, Robert Edwards, Karen Gillen, Douglas Heithoff, Diarmaid Hughes, Kelly Hughes, Min-Ken Liao, David Low, Michael Mahan, Stanley Maloy, Forest Rohwer, John Roth, Molly Schmid, Anca Segall.

PROCEDURE

Students were given a preactivity questionnaire of ten questions (Table 2) using SurveyMonkey before class. In class, we started with an introduction session on what is a concept map and how to construct one. Students then worked in pairs to practice constructing a concept map by using “superheroes” as the focus question. For the author byline activity, each pair of students was given a set of 14 primary articles and a list of 14 scientists, and they were asked to demonstrate the connectedness of these scientists using a concept map, with the names of the scientists being the “concepts” and the papers they published being the “links.” Immediately after the activity, we had a question-and-answer session and a class discussion. Students then left to complete the postactivity survey. The entire activity lasted 90 minutes.

CONCLUSION

Before the activity, only half of the students (six) had examined a research paper closely. Both those who had done so and those who had not could describe what should be included in a research paper, and most students (10) knew that more than one scientist is involved in a research endeavor. However, only those who had the experience of examining a paper closely could list the names of sections (introduction, materials and methods, results, and conclusion) that appear in a paper. Neither group had a clear idea about what brings scientists together or the collaborative nature of research. Before the activity, only half of the students (six) had heard of a concept map, and only two had used one. After this activity, most students (11) claimed that they now have examined a research paper closely, all (12) could list the sections of a paper, and all knew that research endeavor is a task of a team. As a class, they could better articulate the advantages and disadvantages of collaborative research and had a clearer idea of how scientists are connected. Furthermore, they all knew what a concept map is and how to construct one (Fig. 1.)

Although students were only asked to focus on the author bylines and make connections between the scientists, most spent time going through the entire paper and asked questions such as why there is not a “hypothesis” section and why figures and tables are not right next to the texts where they are mentioned. To answer the questions about how scientists meet and what scientists do, I talked about graduate schools (e.g., how to get in, expectations, and stories about mentors and graduate students that ranged from the funny and uplifting to the dark and depressing), scientific meetings (seminars, poster presentations, social networking), and career options (academia, private sector, government agencies) for scientists. We also discussed how research ideas develop and evolve, the advantages and necessity of collaboration, potential disadvantages of collaboration, and the ethics of authorship. Students also

TABLE 2.
Pre- and postactivity questions.

Preactivity questions:

1. Have you examined a research paper closely?
2. If you were a scientist trying to report a scientific breakthrough to the scientific community, what should you include in your paper? List all the information you want to include.
3. All the information about a research project is often organized in sections in a research paper. In order for your fellow scientists to follow the story of your discovery easily, what are the sections you would use to organize the information? List as many sections as you can think of.
4. A research paper is in essence a story about a research project. How many author(s) should there be?
One author because there is only one narrator for a story.
More than one because a research endeavor is a task of a team.
5. Well, as it turns out, a research paper often has multiple authors. What are the advantages and disadvantages of having multiple scientists involved in a research project?
6. What connects scientists who collaborate and publish papers together? List as many types of connections as you can.
7. If you were to create a diagram to illustrate the connectedness of scientists, how would you do it? Propose an idea.
8. Do you know what a concept map is?
9. Have you used a concept map before?
10. If yes, how?

Postactivity questions:

1. Have you examined a research paper closely?
2. If you were a scientist trying to report a scientific breakthrough to the scientific community, what should you include in your paper? List all the information you want to include.
3. All the information about a research project is often organized in sections in a research paper. In order for your fellow scientists to follow the story of your discovery easily, what are the sections you would use to organize the information? List as many sections as you can think of.
4. A research paper is in essence a story about a research project. How many author(s) should there be?
5. Well, as it turns out, a research paper often has multiple authors. What are the advantages and disadvantages of having multiple scientists involved in a research project?
6. What connects scientists who collaborate and publish papers together? List as many types of connections as you can.
7. If you were to create a diagram to illustrate the connectedness of scientists, how would you do it? Propose an idea.
8. Has this activity changed your notion of how scientists connect?
9. Has this activity changed your notion of how science is done?
10. Tell me (at least) one thing that you didn't know before the activity but do now.

wanted to know whether “M.-K. Liao” in one of the papers was really me. One commented in the survey, “Scientists frequently collaborate together to present data, and many

FIGURE 1. A concept map generated from this activity.

are connected because of this (much like the “Six degrees of Kevin Bacon”).” Another student noted, “Scientists write papers with many different people, not just the same ones over and over again.” Also, because of the stories I shared, one student wrote, “Scientists are connected by what other scientists they know and spend time with, not just by what they research and what they specialize in.” All six groups completed the activity (examining the papers and constructing a concept map) in 20 minutes. All students stated that they could see themselves using concept maps to study in the future. Although we did not discuss the issues of resource distribution among big and small research groups, the current trend of interdisciplinary research as evidenced by joint publications of biologists and non-biologists, and the ethics of all-inclusive author lists in genomics and metagenomics

publications, these, and more, are potential interesting topics to explore. In summary, the objectives of the activity were met. I believe that while learning the content of a primary article can excite students about scientific advancements, perceiving the authors as real people in a social network and science as the collaborative efforts of a scientific community may help students see themselves being a part of the scientific progress and inspire them to pursue careers in science.

SUPPLEMENTAL MATERIALS

Appendix I: Combined use of a conference program book and concept maps for student exploration of the diversity of microbiology subdisciplines

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