Teaching Entering Graduate Students

THE ROLE OF JOURNAL ARTICLES IN RESEARCH

PRISCILLA J. HILL
Mississippi State University • Mississippi State, MS 39762

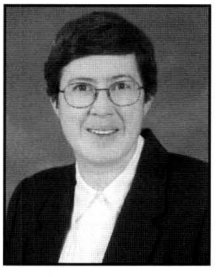
Students entering graduate school have a variety of backgrounds. While some have actively participated in research as an undergraduate, many have no research experience at all. Although they may have read assigned technical articles, few are in the habit of searching journal articles for information or reading articles critically. These skills, however, are essential to being successful as a graduate student. Lilja[1] states that good researchers must perform literature searches to determine what is already known, and to avoid repeating existing work. Included in this approach is the need to develop skills to critically evaluate research articles. Lilja further states that these are skills that must be taught.

Although technical articles have long been used in graduate courses to convey technical information, they aren't always used to develop critical-thinking and technical-writing skills. To develop critical-thinking skills, several educators have required students to summarize the main points of journal articles, and critically evaluate the research.[1-4] Others have required undergraduate students to list the sections of a journal article to develop technical writing skills.[5]

A similar view is taken at Michigan Technological University, where chemical engineering graduate students are required to take a course entitled, "Theory and Methods of Research."[6] The purpose of this course is to provide formal training in skills that students need to be successful in graduate school. This includes a wide range of subjects from how to present professionally to guidelines on research notebooks. One major goal of the course is to improve paper writing, taught through lectures on the subject and writing assignments. These lectures discuss the purpose of journal articles, types of journal articles, and the journal submission process. Later in the semester, students are required to review a journal article of their choice and present their critique.

One chemical engineering textbook on reaction engineering includes "journal article critiques"[7] as exercises at the end of selected chapters. These exercises use chapter concepts to test claims made in selected papers. Each exercise presents the point being questioned, and gives hints on how to test the claim. The goal of these exercises is to teach students how to critically evaluate what they read.

Priscilla J. Hill *is currently an assistant professor at Mississippi State University. Her research interests include solids processing, crystallization, and particle technology. She received her B.S. and M.S. degrees from Clemson University and her Ph.D. degree from the University of Massachusetts at Amherst. She has taught design and thermodynamics courses at the undergraduate level and a graduate course on thermodynamics.*



At the University of Michigan, students in the graduate chemical reaction engineering course are required to analyze and critique a related journal article.[8] This consists of a detailed analysis in which students are encouraged to critically evaluate the assumptions, methods, and conclusions in the article. They are asked to determine if there is another explanation for the paper's results. The students are also given evaluation guidelines used by reviewers of *AIChE Journal* and *Transactions of the Institution of Chemical Engineers*.

At the University of Massachusetts in Amherst, students in a graduate-level chemical engineering kinetics class[9] were required to present or discuss assigned technical articles in class. On the day of presentation, a student was selected at random to summarize the key points of the paper, while the other students joined the discussion. At the beginning of the semester, students were given guidelines as to what questions they should ask about each article they read.

The goal is to teach entering graduate students the role of journal articles in research. This includes teaching students to search journal articles when looking for information, to critically evaluate journal articles, to summarize the key points of an article, and to evaluate the applicability of the research. These methods are implemented by classroom discussion of technical articles.

The class discussion method is chosen because it encourages active participation, and research has shown that teaching is more effective when active learning is involved.[10, 11]

INSTRUCTIONAL OBJECTIVES

The objective of journal-related instruction is to better prepare students for research. Meeting this objective consists of two parts:

1) *Giving students a better understanding of the role of technical articles in research*
2) *Introducing students to the paper submission and review process*

Although students will learn this information during their research projects, it is often helpful for students to hear this information from two different sources. In addition, it begins the transition from an undergraduate student to a researcher.

IMPLEMENTATION

Throughout the semester, 10 papers are distributed to the class for reading. At the beginning of the semester, the class is told that they are expected to read the assigned technical articles and be prepared to discuss each paper. An in-class discussion session of approximately 15 minutes is set aside for each paper. The instructor moderates the discussion and asks questions to encourage class participation. This participation includes a discussion of the paper's technical points and other issues, such as the type of paper. The class discussion method is chosen because it encourages active participation, and research has shown that teaching is more effective when active learning is involved.[10, 11]

This approach was implemented in a graduate-level thermodynamics course at Mississippi State University. The graduate thermodynamics class was chosen because it is one of the core courses entering students take during the first semester. During the fall semesters of 2003 and 2004, there were 10 and 12 students, respectively. Generally, graduate classes are small enough to allow all students to participate in the discussion.

Although all papers assigned relate to thermodynamics, they are also chosen to provide students with a sample of various types of papers and journals. For example, the papers assigned for the fall 2004 semester are given in References 12–21. They ranged from traditional papers on fundamental concepts to papers on recent developments. While most of the papers were published within the last five years, one[13] was published in 1914 and another[18] in 1958.

Since most entering graduate students are unsure what to look for when reading a paper, they are instructed to address the following items.

- *Fundamental issue addressed: What concerns are the authors addressing? What problem is being solved?*
- *Motivation, perspective: Why are the authors writing this paper? How does this paper fit into other work in the area? Is there a need for this research? Is the research novel?*
- *Main ideas: What are the key points? What are the assumptions, methods used, limitations, and applications? For example, is the work limited to a certain pressure range or a certain class of compounds?*
- *Relation to course: How does this paper fit into the course?*

The discussion is conducted in a manner to elicit volunteer responses. Since part of the grade depends on discussion, a record is kept of participation. The discussion is largely guided

TABLE 1
Importance of Reading Technical Articles

Question	1	2	3	4	5	Initial Survey	Final Survey
1. What sources do you use for technical information?	books only	mainly books	books and articles	mainly articles	articles only	2.92	3.20
2. What sources do you use for current technical information?	books only	mainly books	books and articles	mainly articles	articles only	3.83	4.3
3. Rank the importance of reading technical articles for conducting research.	not necessary	slightly useful	useful	very useful	crucial	4.75	4.8

by the questions given above. The purpose of the assignment is to give students practice reading technical articles, particularly to aid students in developing the ability to understand the main points in technical articles outside their research area.

CLASS DISCUSSIONS

At the beginning of the semester, the instructor explains that graduate students should become more familiar with journal articles. Students usually agree that their undergraduate work relied heavily on textbooks and handbooks, and rarely involved searching journal articles for information. The purpose of the explanation is to help students understand the reason for reading assignments.

To aid students in understanding the role of technical papers, many concepts can be discussed in addition to the items given in the student guidelines. Topics discussed in class include the following.

- *It is emphasized that the purpose of journal articles is to disseminate research results in a timely manner, to bring attention to research needs, or to encourage research in certain areas. The paper on applying thermodynamics to biotechnology[17] is used to demonstrate the last two items.*
- *Discussion of journal types includes journals written for various audiences. Class examples include scientific periodicals such as* Scientific American*[16] for the scientific layman,* Chemical Engineering Progress *for the practicing chemical engineer, and other journals, e.g.,* Chemical Engineering Science,*[12, 15, 21]* Industrial and Engineering Chemistry,*[18] and* Industrial and Engineering Chemistry Research*[20] for researchers. Other examples include disciplinary journals such as* Chemical Engineering Science*[12, 15, 21] and* Pure and Applied Chemistry*[17] for chemical engineers and chemists, respectively. Further examples such as* Fluid Phase Equilibria,*[14, 19] demonstrate journals that are highly specialized.*
- *The students are told that research articles can be categorized as theoretical, computational, experimental, or as a combination of these types. One paper is included to show how experimental papers may present new techniques or devices.[21] Discussion also mentions other types of articles, such as published plenary lectures and review articles. Also discussed is how articles are categorized by length as letters or full research articles.*
- *Classroom discussion on article structure emphasizes the purpose of each section in the paper, showing how sections of a paper vary depending on article type.*
- *The students are told that although acceptance criteria varies among journals, they share many common criteria, including determining whether a paper is appropriate for the journal, presents new material, and is well-written. Each publication has its own specific submission guidelines.*
- *The mechanics of journal submission are also discussed, and students are encouraged to check the submission and acceptance dates on published articles.*

ASSESSMENT AND DISCUSSION

The first time this teaching method was implemented, no formal assessment was used. In 2004, an anonymous assessment was performed by using brief surveys on the first day of class and at the end of the semester. The purpose of the first survey was to determine the students' knowledge entering the class, while the second survey determined how much the students learned from class discussions. The final survey had additional questions to determine the students' perception of what they had learned through the discussions.

The initial survey at the beginning of the semester followed the suggestions of Angelo and Cross[22] for a background knowledge probe and a misconception/preconception check on the purpose of technical articles and procedure for publication. Some of the survey questions were drawn from

TABLE 2
Students' Perception of the Technical Reading Assignments *(Rated from 1-strongly disagree to 5-strongly agree)*

Statement	Average Rating
1. During this course, my ability to read technical articles improved.	4.22
2. I have a better understanding of the role of technical articles in research.	3.89
3. As a result of the discussions, I have a better understanding of the types of journals and articles.	4.11
4. I have a better understanding of the acceptance criteria and procedure for getting a journal article published.	3.67
5. I would recommend that the professor repeat the technical article reading assignments and discussions the next time the course is taught.	4.39

misconceptions expressed the first time this approach was taught in 2003. This survey provided a baseline comparison with the second survey.

As shown in Table 1, the first set of questions addressed the importance of reading technical articles. The students were instructed to answer the questions using a rating of one to five, as defined in the table. The initial and final survey columns are the average ratings for each question. A comparison of the final survey results with the initial survey results shows more students became convinced technical articles are the main source for current information. Since students were already aware that reading technical articles is important, this question showed little change.

Other questions asked required short answers. The purpose of using a short-answer format was to avoid leading students to any particular response. The following five questions were asked in this format.

1. *Why do graduate students and faculty read technical papers? The responses to this question were mostly the same on initial and final surveys. The response "to get current information" came from at least half the class. This is probably because most students already realized that articles are a good source of current information. One change between surveys was that on the initial survey 42% of students responded "to find out what has been done" or "avoid repeating work," while on the final survey 70% of the students gave these responses.*

2. *Why are technical articles published? Most students responded either "to disseminate research results" or "to disseminate research results quickly." The main difference between the two surveys was in the second response; the number of students citing this reason increased from 25% to 40%.*

3. *Why is a literature review included in an article? Most students—more than 50%—already realized that the literature review is used to provide background. In the initial survey, 33% of the students stated that the purpose of the review was to give credit to previous researchers, but this response dropped to 10% in the final survey.*

4. *What are the criteria for getting a technical article accepted? The response of "the work being novel or creative" increased from 17 to 50 percent during the semester. Also, while one-third of the students responded "don't know" on the initial survey, only one student responded "don't know" on the final survey.*

5. *How long does it take for a journal article to be reviewed? The initial survey showed that 42% of the students wrote "don't know" for this question, but none of the students used this response on the final survey. In general, on the initial survey most students thought reviews would be received in less than 6 months, while the times became slightly longer on second survey.*

Student perception of the technical article reading assignment was assessed in the final survey using the questions shown in Table 2. For these questions, the students were asked how much they agreed with the statements by rating their agreement on a scale from 1 (strongly disagree) to 5 (strongly agree). In general, students thought the technical reading assignments and class discussions helped their understanding of how to read technical articles and get a journal article published. Furthermore, most of the students recommended this exercise be repeated in future classes.

DISCUSSION AND CONCLUSIONS

Class discussion of journal articles required little additional time to implement. Faculty members commonly use technical papers to provide more information on technical concepts. Although discussing the role of technical papers in research required some time, it provided graduate students with a better understanding of why they should read recent literature. Having reading assignments and class discussions account for 10 percent of the course grade motivated the students to read the assignments. In addition, class participation seemed to encourage the students to be prepared.

The survey assessment was supplemented by faculty observation during class discussion. It was clear from the students' comments and questions that they had read the papers and were able to comprehend the main points. They even commented on some differences in the types of articles. Some of the concepts, however, were new to them. For example, many of the students had not submitted a paper to a journal at this time, so they were not aware of the review and publication timeline. Most students also didn't know that papers frequently list the date the manuscript was received and the date it was accepted.

The response from the students was that they liked reading the papers and discussing them in class. Many of the students regularly contributed to the discussions. Since this assessment has only been performed once with a class of 12 students, it has not been well tested. Future work will include repeating this technique and its assessment.

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