

Using Critical Evaluation and Peer-Review Writing Assignments in a Chemical Process Safety Course

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Introduction

In preparing engineers for the future there are increasing demands on engineering educators to teach writing, oral communication, critical thinking and problem-solving skills in addition to the discipline content. An important skill that engineers can develop is the ability to find out what has been done before so as not to waste time duplicating previous work. This background development is typically done through library research and by keeping up-to-date with current publications. One of the most difficult aspects of developing this skill, however, is learning to **critically evaluate** this previous work. It is of little value to know what has been done before if the engineer cannot evaluate the quality or importance of the work.

Critical evaluation can also be developed through the process of peer review. The value of peer review in developing both critical thinking and student writing skills is well documented¹⁻⁵. Lessons are learned on both sides of the peer review, both by those who are critically evaluating someone else's work and by those whose work is evaluated. The first drafts tend to be improved because the students realize that their peers will be reading their writing. The final drafts improve since the students are provided with a formalized method to revise the original report in response to the review. The reviewer benefits from being forced to evaluate someone else's writing and to consider the elements that lead to an effective report. Of course, the instructor must provide sufficient structure and guidance to prevent students from giving entirely negative or hierarchical evaluations.

This paper presents two techniques to help students develop their critical thinking and communication skills. In the first, students are asked to critically review a journal article and to prepare a brief evaluation of the journal article. The second technique described is to allow the students to practice the anonymous refereeing process with their peers⁵. Each of these techniques will be described in turn.

Critical Evaluation of Journal articles

An important component of an engineering education is the ability to communicate effectively⁶⁻⁸, to have efficient technical literacy⁹⁻¹², and to be able to critically evaluate what we read^{4,13,14}. As we train students to be design engineers or to work in product development, we need to help them develop the ability to find out what has been done before so as not to waste time

“reinventing the wheel.” G.C Quarderer of the Dow Chemical Co. summed up this idea nicely when he said “Four to six weeks in the lab can save you an hour in the library”¹⁵ and by Samuel Johnson (1709-1784) who said “The next best thing to knowing something is knowing where to find it.” Just as important as finding the information, the ability to critically assess the information found in technical journals and from vendor literature is even more important. It is of little value to know what has been done before if you cannot evaluate the quality or the importance of the work. Another way of putting this is “Don't believe everything you read.”

I have assigned journal article critique assignments for the last couple of years in both a senior level chemical reactor design course and in a senior level chemical process safety course. The nature of the assignment has evolved over the semesters and I will present the current assignments.

I first began using the “journal article critique” assignments in the popular chemical engineering text *Elements of Chemical Reaction Engineering*, 3rd Edition by H. Scott Fogler¹⁵. In these assignments, the students are asked to review a specific journal article and respond to questions that help them to evaluate the article's content in terms of concepts they have learned from the textbook. The students are asked to write a short (1-2 page) summary of their analysis. I gave the students the choice of several different articles to review (there are over 20 articles to choose from in the text) so that I received a mixture of different articles. These assignments worked quite well and the students generally enjoyed them, especially when they could point out the errors in the published work. Although these are excellent assignments and I have used them several times, I have the problem with the ubiquitous “student file system” so that now, several of the student analyses seem familiar. I would suggest that if you are starting this for the first time out of Fogler's book, that you assign only one or two journal critiques each semester, and rotate through the articles so that the students have a more difficult time developing a file of journal critiques.

Recently I have modified the assignment so that the students need to find a scientific or technical journal article published in a given year (for instance I require an article published during 1999 for the Winter Semester 2001 course) that deals with some aspect of the course. I have used this assignment in the chemical reactor design course and in the chemical process safety course. I give the students a list of journals that they can look for their articles. The list varies between the two courses. This form of the assignment thwarts the development of files of old reports by the students since each assignment is based on a new year of archival journals. I have also modified the assignment in that I tell the students to look up and read some of the related articles that are cited in the article that they chose. I have them turn in a photocopy of the primary article being critiqued (but not copies of the secondary articles that they looked at) plus have them turn in a 1-2 page word processed summary that addresses each of the following points^{13,16}:

- 1) What is the problem being studied?
- 2) Is this an important problem? Why or why not?
- 3) What are the main results? 4) What method is used to produce the results?
- 5) What are the assumptions in the paper? Are they realistic?
- 6) How sensitive are the results to the assumptions?
- 7) What did you learn from this paper?
- 8) Describe the similarities and differences of this paper compared to other related papers?

They need to have read a couple of the papers cited in the first article in order to answer question number 8.

I have placed this assignment near the end of the first third of the course so that the students have some background to evaluate and offer a critique. Since I give this assignment in conjunction with a group research paper described below, many of students chose to analyze and critique articles that will relate to their group research project. The journal critiques are an individual assignment and I do not allow homework team members to review the same article. Often times the various group members will review articles that relate to different aspects of their group project

Homework team's group project and peer review

Early in the semester I divide the class up into homework/study teams that have three group members. After the homework teams are formed, each homework team turns in one set of homework for the entire group. Each member needs to initial (or sign) the homework assignment handed in as an indication that they worked on the problem and agreed with the solution. All members of the homework team are expected to participate and work together in the homework/study group. The motivation for forming homework teams is two fold. First, numerous studies have shown that "collaborative learning" (i.e. working as a group) is an effective way to learn material. Second, as students move out into industry they find that most engineering projects are group projects and that they need to learn to work with people in a group or team setting. I stress to the students that the purpose of the working in teams is *not* to "spread the work around," but to enable each team member to learn and benefit from the knowledge and perspective of others. All students are responsible for understanding all aspects of each assignment.

One of the assigned activities of the homework/study group is to prepare a research paper that delves more deeply into one of the topics covered in the course. The students prepare a research paper with the style and format of a submission to a technical journal for publication. Each group turns in four copies (one for the instructor and three for peer review). Each paper is then reviewed by three of their classmates from different groups. Every student completes a peer review of another group's paper. I give the students approximately one and a half to two weeks to complete the peer review. The students turn in two copies of their review, one which is anonymous (i.e. without the reviewer's name) which is returned to the group that wrote the paper plus a second signed copy along with a cover letter to the instructor which is used to assign the grade. However, there is no grade assigned to the first draft of the homework group's paper, it is only given a peer review.

Each homework group then reworks and improves their report in light of the three peer reviews that they received. This final draft of the paper is then handed in and graded.

An important aspect of the peer review assignment is to give the students a structured format on how to review an article. Appendix A gives the assignment sheet given to the students and includes a "Reviewer Report Form," that I have found to be very useful. Using the "Reviewer Report Form" helps the students to formalize their thought processes as they review and evaluate someone else's work.

Observations and Conclusions

I have included technical journal critiques in my courses for the last few years and have found them helpful for the students to develop critical reading skills. The students take the assignments seriously and usually get a kick out of being able to find some problems with a published journal article. Another benefit of the assignment is that it gets the undergraduates more familiar with scientific and technical articles that they are often not exposed to as undergraduates. An additional benefit of this assignment is that it supports the pedagogical concept of “writing across the curriculum” and gives the students an opportunity to practice their communication skills with a meaningful assignment.

I have been using the peer review assignments for over four years as part of my lecture courses and I have used it in two different courses, chemical reactor engineering and chemical process safety. A noticeable increase in the quality of writing was immediately apparent. It seems the students are concerned that they produce a polished document when they know that their classmate peers will review it. The final revised reports were substantially better than term research papers from previous years. However, these results are both subjective and anecdotal. I have also found that the students almost uniformly have taken the peer reviewing task very seriously and offer more suggestions, grammar, style corrections, and editing, than I ever would when grading a draft paper. Several students have indicated that writing the review made them recognize weaknesses in their own writing. In the end-of-the-course student evaluations, the students have had positive comments about both assignments and the only negative comment was to reduce the number of journal critique assignments (I initially assigned five critiques associated with different chapters). Overall, the incorporation of critical journal reviews and peer reviews of student papers, seem to have been very effective in improving the critical thought and communication skills of the students.

I believe that similar assignments can be incorporated into any lecture course. The peer review process can also be used even if you have individual writing assignments. In that case, the students would only receive one review, but they would still benefit from both the review of their writing and the development that comes through evaluating someone else's writing. I am very happy with both assignments and plan to continue to incorporate them into my courses.

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Dr. Douglas K. Ludlow is Prof. and Chair of Chemical Engineering at the University of Missouri-Rolla. He earned a BS (1982) from Brigham Young University and a PhD (1986) from Arizona State University. He taught at the Univ. of North Dakota from 1986 to 1996. He was a Fulbright Senior Scholar at the Hebrew University of Jerusalem (1992-93). Ludlow has published several articles about incorporating communication skills into the curriculum.

ChE 258 - Chemical Process Safety Peer Review Assignment¹

Objective:

The ability to write with clarity and efficiency is an indication of clear thinking and is an important component of an engineering education²⁻⁴. The value of peer review in developing both critical thinking and student writing skills has been demonstrated^{1,5-10} and this assignment will give you the opportunity to practice as an anonymous peer reviewer. Almost no journal articles are published in their original form. External readers often can offer new insights and perspectives, detect areas of weak or faulty reasoning, and address ambiguous or incorrect writing issues. Thus, when an editor of a technical journal receives a submission from a researcher, the editor sends the article to another expert in the researcher's field. This peer reviewer identifies strengths and weaknesses of the paper, locates inconsistencies in reasoning or argument, evaluates the technical merit of the paper, and makes two specific recommendations that change the paper. First, the reviewer makes a general assessment of the paper and recommends one of four courses of action. Specifically,

1. Publish the paper as is (This seldom happens)
2. Publish the paper after minor revisions are made
3. Have the author make the suggested major revisions and I'll review it again
4. Do not publish the paper

Next, the reviewer makes a detailed series of recommendations for improving the paper. These may include, but are not limited to, suggesting additional experiments, requesting additional explanation or analysis, challenging conclusions or premises, and providing proofreading and flow suggestions. The peer reviewer is the guardian of quality for technical journals and his or her role is every bit as important as that of the article's authors.

Assignment:

You will receive a copy of another homework/study group's *Group Project Report* and you will have approximately one and a half weeks to complete the peer review. This is an individual assignment. You will turn in two copies of the attached **Reviewer Report Form**¹ along with the original manuscript submitted for review and a letter to the journal editor (Dr. Ludlow). Grammatical and typographical errors should be marked directly on the original manuscript. The letter to the editor should include a brief greeting, a statement of purpose (Why are you writing this letter?), a short summary of your publication recommendation (Publish it or not) and a brief justification of your recommendation.

The **Reviewer Report Form**¹ provides an area for overall evaluation and specific criticisms and suggestions. Direct questions are asked and explanations for your answers should be included in the comment section, which comprises the rest of the review. The comments should be specific and informative with direct questions, observations, or recommendations being made.

Your grade will be based on the following issues:

1. Depth of analysis, including recommendations (50%)
2. Demonstration of technical understanding (25%)
3. Clarity of expression (25%)

Please note that your peer review will not affect the grade of the original manuscript's authors (except in that hopefully your comments will help them to improve their manuscript).

Miscellaneous Observations:

1. Criticisms of the manuscript should be constructive in nature. Comments like “this is awful” will not lead to a better paper (or a better grade).
2. In addition to criticizing the manuscript, your review should point out what was good about it.
3. It is not enough to say what is wrong; you must also suggest what can be done about it.
4. Look for areas that are unclear. Often the authors will present useful information but is lost in rhetoric or hyperbole.
5. Your suggestions must be reasonable. You could recommend further analysis or more citations, but you cannot tell them to derive everything from first principles or to perform an exhaustive literature search.
6. While critiquing the manuscript, consider the things that make it stronger or weaker. Look for these strengths and weaknesses in your own writing.

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Reviewer Report Form¹

Reviewer's Name (1 copy only): _____

Title: _____

Authors: _____

1. Does this manuscript warrant publication in this journal?

- _____ Acceptable in present form
- _____ Acceptable with minor revision, no further review necessary
- _____ Major revision and a second review is required
- _____ Not acceptable (provide detail explanation under comments)

2. Is the Title satisfactory? _____

3. Does the abstract adequately summarize the paper? _____

Could it be more complete or concise? _____

Indicate suggested revision on the manuscript or under comments

4. Are sufficient references provided? _____

Are they appropriate and free from obvious omissions? _____

If not, Explain _____

5. Does the paper present material efficiently? Indicate suggested changes on the manuscript or under comments.

a) Could the clarity or efficiency be improved by changes in the order of the paper? _____

b) Should the language or grammar be improved? _____

c) Are there portions of the text that could be omitted? _____

6. Are there errors in factual information, logic, analysis, statistics or mathematics? _____

Address these issues in detail in the comments. Suggest improvements.

7. Mechanical Errors (address on manuscript)

_____ Figures or Tables improperly or incompletely labeled or titled or not cited

_____ Misuse of References (Failure to cite, reference needed and not provided)

_____ Other: _____

8: Comments: (Attach additional pages as necessary)