USING PEER REVIEW IN THE UNDERGRADUATE LABORATORY

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The value of peer review in developing both critical thinking and student writing skills has been well documented[1-4] and is best demonstrated by better laboratory reports. First drafts are often improved because students realize that their peers will be reading their writing.[5] Additionally, students are given an opportunity to revise their original report in response to the reviews.

Reviewers benefit by being forced to consider the various elements that result in an effective report. They must be given some guidelines, however. The instructor should provide sufficient structure and guidance to prevent students from giving entirely negative or hierarchal evaluations.[5] Providing a structured report sheet for the students to use, similar to a referee report, is advantageous for this purpose (see Table 2).

At the University of North Dakota, peer review has been incorporated into the undergraduate research lab as part of an ongoing effort to develop the oral and written communication skills of our chemical engineering undergraduates.[6,7] A student is required to submit a technical journal "article," similar in scope to an extended abstract, based on his or her lab experiment. A copy of the report is then given to some student in the class who has *not* run the experiment. This "reviewer" must learn the details of the experiment, evaluate the technical report, make specific suggestions for revision, and identify both the strengths and the weaknesses of the report. While the peer review does not affect the grade of the original journal author, the review itself *is* graded.

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Finally, the original report writer receives the peer review along with a faculty review and is given an opportunity to return to the lab to gather any additional data that is required before submitting a revised report in response to the reviews. The revised report is graded separately from the original report.

Each student writes one technical journal article, one peer review, one operations manual, one oral presentation, and one revised final report during the course. Tables 1 and 2 show the handouts given to students and the referee report they are asked to use with their review.

RESULTS

Peer review was used for the first time in the undergraduate laboratory in the fall semester of 1996, and a noticeable increase in the quality of writing was immediately apparent. The original technical journal reports were better than they had been in previous years.

Although it is difficult to quantify this improvement, it

TABLE 1
Peer-Review Handout

Chemical Engineering Lab II
The Peer Review

Objective

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 a 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.

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

Format

The peer reviewer will submit three copies of the "Reviewer Report" form along with the original journal article and a letter to the journal editor (the professor). 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 you are writing this letter), a short summary of your publication recommendation (publish or don't publish), and a brief justification of your recommendation. Regardless of which recommendation you make, you will not be asked to perform a second review of the paper.

The first page of the review 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:

- Depth of analysis, including recommendations (50%)
- Demonstration of technical understanding (25%)
- Clarity of expression (25%)

Note: Your peer review will **not** affect the grade of the technical journal article author.

Miscellaneous Observations

- Criticisms of articles should be constructive in nature. Comments such as "This is awful" will not lead to a better paper (or a better grade).
- In addition to criticizing the article, your review should point out what was good about it.
- It is not enough to say what is wrong; you must also suggest what can be done about it.
- Look for areas that are unclear. Often the author will present useful information, but it will be lost in rhetoric or hyperbole.
- Your suggestions must be reasonable. You could recommend running more trials, but you cannot tell the writer to run 30 or more or to buy more sophisticated equipment.
- While critiquing the paper, consider the things that make a journal article stronger or weaker. Look for these strengths and weaknesses in your own writing.

was unmistakable, and in fact, the truly atrocious papers disappeared altogether. It appears that students are reluctant to give inferior work to their classmates.

Students took the reviewing task seriously. They avoided simple hierarchial judgments and focused on what made the paper either effective or ineffective. They did an outstanding job of identifying grammatical and mechanical problems in the reports, while still identifying strengths and weaknesses in the data analysis.

The final revised reports were substantially better than technical journals from previous years. Grammatical errors were essentially eliminated. More impressively, both the level of analysis and demonstrated technical understanding were much greater.

The forced revision provided important feedback that helped the student improve both the writing and the analysis. The students also spoke of their increased confidence in writing the revised paper.

Additionally, student feedback concerning the peer reviews has been uniformly positive. The students indicate that writing a review led them to recognize weaknesses in their own writing. This improvement in writing skills has been evident in subsequent laboratory classes.

Since these results were presented at the 1997 American Society for Engineering Education conference,[8] chemical

TABLE 2
Review Report Form

Reviewer Name (1 copy only) _____

Title _____

Author _____

1. Does this article 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 detailed 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, statistical analysis, 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

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Overall, the use of peer reviews appears to be successful in the undergraduate laboratory.

SUMMARY

Student peer reviews seem to be an effective and comparatively simple means of enhancing student writing and data-analysis skills. Key factors in operating an effective peer-review system in the lab include.

- ▷ Providing the student with a template to help focus the review.
- ▷ Grading the reviewer.
- ▷ Making sure the original author revises the paper to address the reviewer's concerns.
- ▷ Keeping the reviewer anonymous.

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