Because critical analysis of published information is an essential component of scientific life, it is important that students be trained in its practice. Undergraduate students who are more accustomed to reading textbooks and taking lecture notes find it difficult to appreciate primary publications. To help such students, we have developed a checklist that helps them analyze different components of a research article in basic biomedical sciences. Students used the checklist to analyze critically a published article. The students were assigned an article and asked to write a paper (maximum 2 pages of single-spaced type) assessing it. This assignment has been found useful to both undergraduate and graduate students in pharmacology and physiology. Student responses to a questionnaire were highly favorable; students thought the exercise provided them with some of the essential skills for life-long learning.


**Key words.** critical analysis, publications

Because critical analysis of published information is an integral component of scientific life, it is important that students be trained in its practice. This is particularly important for students who are enrolled in problem-based courses, inasmuch as they are expected to become proficient in seeking, synthesizing, and integrating information (9, 10). Because problem-based learning is often associated with professional training, critical appraisal packages have been developed to guide students enrolled in such programs. Thus clinicians and methodologists at McMaster University have provided “reader’s guides” for evaluating articles dealing with diagnostic tests, course and prognosis of a disease, etiology and causation, and therapeus (3–7). A spate of articles has appeared in recent years dealing with the challenge of burgeoning information from the perspective of health professionals, and a number of other guidelines have been published to help them (8, 11, 12). Such packages are, however, of limited use for students in the experimental sciences. Undergraduate science students find critical analysis of publications to be a daunting task, they are more accustomed to reading textbooks and taking lecture notes. To help such students, we developed a checklist and used it to teach critical analysis of published articles.

In this brief report, we present the checklist, explain how it was used at two different institutions, and comment on the perception of the students.

**PROCEDURE**

Students were given a handout that gave a brief description of the different components of a standard paper in the experimental biomedical sciences.
They were then given a checklist that gave a series of questions related to each component of a research publication. This checklist was initially developed using student input.

At McMaster University, the handouts and the checklists were given to students in a 3rd-yr, problem-based, undergraduate course in pharmacology that forms part of the Honours Biology/Pharmacology Co-op Programme (9). Critical analysis of a published report forms an integral component of this course. To help them in this, the students were given both handouts. They were then asked to evaluate a brief publication, usually selected from a recent issue of the British Journal of Pharmacology, the European Journal of Pharmacology, or the Canadian Journal of Physiology and Pharmacology. These journals were chosen because they publish either rapid communications or brief reports. We deliberately selected brief reports because we did not want to overwhelm the students with longer papers at this stage. Furthermore, to avoid undue anxiety on the part of the students, an attempt was made to select papers using methods with which they had some familiarity.

Students were given the handouts and the checklist (see APPENDIX) and a short paper to analyze. They were told to read through the paper carefully and use the checklist to document key issues. They were required to submit a brief report that consisted of a critical evaluation of the objectives of the study, the methods used, the results, and the conclusions. Reports were graded and accounted for 5% of the total grades in the course. The tutor prepared a brief commentary on the same paper. Because this exercise was a novel one for these undergraduates, a trial run was held. A different paper was used for this purpose and no marks were given, although verbal feedback was provided. For the exercise proper, students were given adequate time (2–3 wk). The amount of time required was negotiable, depending on the workload of the students in a given year.

At the University of Delaware, the exercise was used in a Mammalian Physiology course taken by both seniors and graduate students. This course forms part of the University of Delaware Medical Scholars Program (2). The procedure used was slightly different from that at McMaster University. Students were asked to “brainstorm” as a group to develop the criteria they would use to evaluate a paper and then were given both handouts as aids. The students were then given a short article from a physiology journal to analyze. Students were permitted to discuss their analysis with each other before writing their individual reports. In their submitted reports, they were required to acknowledge the ideas they had obtained from their peers, much as scientists acknowledge help from colleagues.

RESULTS AND DISCUSSION

These exercises have been well received by the students. A brief questionnaire given to students at McMaster University elicited favorable responses. The data shown in Table 1 represent composite information from three different classes. All 30 students given the questionnaire responded to the request. Clearly the students in general thought the exercise to be worthwhile, as can be seen from the distribution of the scores, which tend to cluster at the higher end. Even on question 4, where there was a wider range of responses (1–5), the most frequent score (mode) was still 4.

Samples of both favorable and not so favorable comments are given so that the spectrum of responses can be gauged. The favorable comments are fairly straightforward. Among the negative comments, several deal with the timing of the exercise and the issue of the grades allocated. Perhaps the most interesting

| TABLE 1 |
| Responses to a questionnaire |
| SCORES |
| 1 2 3 4 5 |
| 1) Critical Analysis of published information is an important component of scientific activity. 0 0 1 5 2 1 |
| 2) The exercise provided a formal opportunity to analyze a publication. 0 0 0 15 15 |
| 3) The commentary and the checklist provided a useful framework for the analysis. 0 0 2 3 25 |
| 4) The exercise helped me critically analyze publications subsequently 1 1 7 11 7 |
| 5) The exercise should be an integral component of the course. 0 0 5 11 11 |

Students were asked to rate the strength of their agreement or disagreement with a series of statements on a 5-point scale (1 = strongly disagree, to 5 = strongly agree).
comment was that of the student who reported that giving a checklist biased his/her perceptions.

In the initial stages, this exercise was conducted as a 3-h “exam” at McMaster University, with all students being given the paper to review at the start of the period. Unfortunately, this clearly detracted from the real value of the exercise and provoked undue anxiety on the part of the students. So at present, the exercise is a “take-home” one, and students are given ample time to hand in their reports. At McMaster University, the exercise is an individual one. However, at the University of Delaware, a collaborative element has been included to be consistent with one of the goals of the course, which is to foster team-building skills. The latter procedure attempts to avoid issues of plagiarism, helps students recognize the cooperative nature of science, and sharpens their thinking. It can, however, bring about a uniformity of responses that may make dull reading.

We feel that the procedure is a useful one and can be adapted to other programs quite readily. The checklist was developed largely for undergraduate students. At that stage in their training, it is clearly difficult to include components that would lead them to gauge the heuristic value of a given publication. That would require a deeper understanding of the problems in a particular research area. Thus, for instance, certain papers now recognized to be classics could be found wanting by some of the criteria outlined in the checklist. However, we would argue that if students are trained to recognize different components, they will be better able to judge the “value” of a paper as their knowledge of a particular field increases. Thus the somewhat mechanical nature of the exercise could be tempered and refined with practice.

The numbers of students enrolled in these courses are relatively small (12–16 per year), and we have not “tested” the procedures critically by use of a control group (see Ref. 1). It would be interesting if others who deal with larger classes can adapt this process and assess critically whether students given such a checklist are better able to analyze and appreciate published material. A number of our students certainly felt they could.

STUDENT COMMENTS

Favorable

I think the critical analysis helped me to assess the credibility of some of the papers obtained for the research project. I feel that critical analysis is a crucial part of science and should remain part of the course.

Very helpful

Good experience

Really helped with the lab project.

This exercise I feel is very important since it allows one to realize the strengths and downfalls of a published article.

This exercise was very useful. It made me look at published work in a different manner.

I found the additional commentary and checklist a great contributing factor in my analysis of the publication. The entire exercise has enabled me to evaluate the quality of other publications.

A large part of what we do is evaluate the quality of the papers we read. The checklist gave formal instructions important for someone who has never critically analyzed a paper and allowed it to be broken down into manageable parts. I’ve used the checklist when I needed to analyze papers for other courses and found it to be really helpful. The exercise helps make the point that just because something is published doesn’t mean it’s good or right—a mistake that most people make if they are researching in an area they are unfamiliar with. I would definitely recommend that this component be kept in the course.

I do think that it is important to question the validity of other work; one should not take information on face value; it is important to learn to question and comment.

I think it was an important part of the course. It was important in that it made us realize that you have to be
I N N O V A T I O N S A N D I D E A S

careful of what you read. It allowed us to exercise our critical analytic skills, which are important in science.

This was a very effective exercise, both in terms of analysis of a paper and as a help in writing your own papers.

Critical analysis of published information is very important to science. This exercise was a good opportunity to do this. However, one exercise will not provide enough exposure. Maybe two or three exercises, worth 5% each, might give more experience and better skills with which to analyze publications subsequently.

The exercise was well explained, and I appreciated the sample that was provided.

This exercise was useful and helpful.

Comments Not So Favorable

Critical analysis arises from an overall perception, and I believe that the formality of the process, complete with checklist, biases perception. Upon reflection, I think everybody was too critical at the time. However, the checklist was very helpful in giving students a sense of what to look for, so I wouldn’t necessarily remove it. The important point of the exercise was, and should be, to think critically about the articles, rather than to learn how to think critically.

I think the exercise was extremely relevant, yet I feel that I did not benefit as much as I could have. This is because the paper I was given concerned a topic I had absolutely no knowledge of. Whether this “block” was a result of my nervousness, or I simply didn’t catch on, I don’t know.

This exercise was useful to a point.

I believe the critical analysis was conducted a little too early in the year, when students are only beginning to read and understand scientific papers. Furthermore, I don’t think that the students have (at the time of this exercise) a good understanding of pharmacological techniques to critically analyze the methods and results sections. Ideally this analysis should be conducted at the very end of the 3rd year or at the beginning of the 4th year.

I would have liked to have more feedback from this exercise. The group should have discussed the paper afterwards.

Being able to analyze published information is a very important aspect of scientific activity. The paper was due at a very busy part of the year, and we might have taken it seriously if it had been due a couple of weeks earlier, to prevent conflicts in the workload. The area most people had trouble with related to the interpretation of the statistical analysis because it is hard to adapt the statistics course to concepts in a pharmacological environment.

APPENDIX

Critical Evaluation of a Published Paper

The objective of this exercise is to evaluate your abilities to critically assess a published paper in Pharmacology. Each one of you will be given copies of the same publication. You will be expected to read the paper carefully and write a brief report (up to 400 words). The report should consist of a critical evaluation of the objectives of the study, the methods used, the results, and the conclusions. To help you, we have developed a checklist that follows closely the format of a scientific report, which is conventionally divided into the following sections: Introduction, Methods and Materials, Results, Discussion, a list of References, and a short Abstract or summary. Although the checklist has been designed for papers in Pharmacology, it can be used with minor variations to evaluate papers in related disciplines. Please use the checklist and make comments where necessary.

Introduction

1. Did the authors indicate why the study was undertaken?

2. Was the background information provided sufficient to understand the aims of the study?

Methods

1) Were the methods described in sufficient detail for others to repeat or extend the study?

2) If standard methods were used, were adequate references given?

3) If methods were modified, were the modifications described carefully?

4) Have the authors indicated the reasons why particular procedures were used?
5) Have the authors indicated clearly the potential problems with the methods used?

6) Have the authors indicated the limitations of the methods used?

7) Have the sources of the drugs been given?

8) Have the authors specified the statistical procedures used?

9) Are the statistical methods used appropriate?

Results

1) Were the experiments done appropriate with respect to objectives of the study?

2) Do the results obtained make sense?

3) Do the legends to the figures describe clearly the data obtained?

4) Are the data presented in tabular form clear?

5) Are the legends to the tables clear?

6) Has appropriate statistical analysis been performed on the data?

Discussion

1) Were the objectives of the study met?

2) Do the authors discuss their results in relation to available information?

3) Do the authors indulge in needless speculation?

4) If the results obtained were statistically significant, were they also biologically significant?

5) If the objectives were not met, do the authors have any explanation?

6) Do the authors adequately interpret their data?

7) Do the authors discuss the limitations of the methods used?

8) Do the authors discuss only data presented or do they refer consistently to unpublished work?

References

1) Do the authors cite appropriate papers for comments made?

2) Are the statistical methods used appropriate?

3) Do the authors cite their own publications needlessly?

Abstract

1) Is the abstract intelligible?