Journal of Science Education and Technology, Vol. 3, No. 4, 1994

Darwin, Dogs and DNA: Freshman Writing About Biology

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We describe a successful interdepartmental program at a major research-oriented university that melds freshman writing with freshman biology to the significant benefit of both disciplines. Extensive, repeated feedback on individual student writing projects from two instructors, one a humanities professor, one a biology professor, appears to work synergistically so that learning by the students is significantly enhanced. Particulars derived from five years of experience with this intensive, student-centered strategy are included.

KEY WORDS: Writing; science; biology; integrated assignments.

INTRODUCTION

One of the principal drawbacks for science students attending a large, research-oriented university is the paucity of personal faculty attention. Large class sizes, multiple-choice exams, and the virtual disappearance of individual assignments have contributed to educational deficiencies in our students, particularly in the areas of critical thinking and writing. Further, there is general agreement among faculty at colleges and universities that a lack of writing skill is unfortunately characteristic of present day students (Stewart, 1989). Many schools have recognized these issues and implemented strategies to remedy the problem (e.g., Emig, 1971; Stewart, 1989; Nekvasil, 1991). In the following, we share a model we have used for the last five years, which combines the goals of improved writing and critical thinking along with content acquisition in freshman biology at a large research-oriented university.

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THE ASSIGNMENTS

Since it is quite common for science students to have a strong dislike for writing assignments (Jewett, 1991), the topics are chosen to reflect student interest. While this may not always be possible, experience has allowed us to develop a fairly productive list of 10–12 options. These topics always relate to the content of the General Biology course in a direct manner. Some examples:

1. Do you find Darwinism convincing?
2. Why do domesticated dogs and cats differ so much in their behavior?
3. Is recombinant DNA a disaster or panacea?
4. If Mendel was right, why aren't humans either short or tall?
5. Do non-human species engage in chemical warfare?

More importantly, we have structured the writing assignments to be integrative and argumentative in content since such an emphasis clearly enhances learning (Fiasca, 1970; Bicak and Bicak, 1989). Such writing also represents a higher level of writing than purely descriptive work. The student is expected to provide, at a minimum, a logical, coherent, clearly written explanation, but we always push for more: a well-reasoned, precisely articulated argument utiliz-

1059-0145/94/1200-0259$07.00/0

ing specific biological information and principles. The students are specifically discouraged from extensively using others' work or basing their arguments on a great deal of library research. Rather, one or two outside sources plus their general biology text are adequate to provide the biological content needed. We do not require the students to labor extensively over research materials in the library because we want them to spend their precious time focused directly on their writing.

Each student will write three, sometimes four, papers during the semester, three to five pages in length. Since improvement with practice typically occurs only when outside (other than self) critique and revision options are available as an integral part of the writing (Gratz, 1989), we strongly emphasize the drafting process, i.e., the secret to good writing is rewriting. The schedule typically will be as follows. The first paper undergoes three revisions, each critiqued by both instructors, followed by one final version, graded by both instructors (50% on writing, 50% on biology). Paper number two undergoes two revisions before a final copy, again critiqued at each stage of the drafting process, and then graded. The third paper requires one draft, then a final copy.

Through our experience we have found that the following practices work well. It is best to allow the students two weeks between the first and second drafts. Most often this is where the greatest revision will take place and the extra time allows them to make significant progress. Furthermore, we always return their drafts to them within two days (one day for each instructor), so that their writing is still fresh in their minds and the critique makes impact.

THE CRITIQUE

The critique is an in-depth appraisal covering two areas: the writing and the science. The writing instructor reads the papers first, not only commenting on mechanics, usage, and such elements as sentence structure, paragraphing, etc., but also on the shape of the paper. In fact we have made it a major writing requirement of the essay. Typically students have a very poorly developed sense of how to shape their thinking into writing. Without this emphasis, papers often resemble a compilation of notes in prose form, or a ramble of disjointed ideas, and sometimes we even get a stream of consciousness "freewrite." Therefore, we demand through the revision process that they take one idea and sustain an analysis of it beginning to end.

The first paragraph is key to our system because it sets up the structure for the entire paper. Paragraph one becomes a "roadmap" containing three elements: (1) *an occasion* — the issue, or statement of the problem; (2) *a thesis* — the one idea the paper will cover; and (3) *a projected organization* — a list of reasons that will become the body, the paragraph material to follow the introduction (Norgaard, 1994).

Our experience has shown that by using this form, our students do not as easily wander off among their ideas, haul in irrelevant data, or endlessly repeat themselves. We want them to make an assertion about a particular concept, then logically support it. True, the writing instructor may not understand all of the scientific information being presented, but he actually becomes the perfect "foil," for the paper should be shaped well enough that the instructor, if he had the inclination, could ask the right questions to help him understand. In sum, then, the writing instructor critiques on two levels: basic composition skills and shape.

The biology instructor, of course, critiques the biology, the science within the paper. First, the paper should stand as a demonstration that the students understand the concepts, ideas, and terminology they use in their presentations. Essentially this means that the biology instructor checks for student grasp of the currently accepted scientific view of the topic at hand. Students who write on topic four, above, for example, clearly must understand the simplest genetic case — the Mendelian model of single gene inheritance — as a basis upon which to build an understanding of more complicated cases. In particular, the students must extend their knowledge of the one gene case to the logical consequences of simultaneous, multiple gene traits (polygenic inheritance) in order to understand human height variation. From there, they can continue on to grasp even higher level genetic complexities, which entail both types of genetic characteristics.

Second, the biology instructor examines the sequence of arguments presented in the paper and makes evaluations as to their scientific coherence, effectiveness, and logical soundness. As an illustration, we cite the (astonishing!) case of a student who argued that the reason we do not have only tall and short people in the world is because our society is now modern, up-to-date, broad minded, and toler-

ant. This student argued that the modern perspective stands in contrast to the society of which Gregor Mendel was a part wherein people tended to think in simplistic ways; people (then) were thus categorized as either tall or short. Our response was to direct the student toward biologically relevant points of argument. In particular, we suggested the presentation should use the concepts symbolized by such terms as locus, polygenic inheritance, allele, phenotypic distributions, etc., as elements in their explanatory argument for the existence of continuous human height variation.

Third, the revision process encourages students to support their thesis statements with scientifically defensible arguments. This means that the instructor steers the students toward a grasp of current scientific thought and agreement always with the caveats that such views remain subject to future revision, modification, or even eventual abandonment (Pollak, 1993).

TYPICAL PROBLEMS

The most common problem found in first drafts is the tendency for students to over-generalize, both in writing style and in science content. For example, sweeping statements such as, "Ever since the dawn of time, scientists have been worrying about the causes of sickle cell anemia," show up regularly. In this particular case, we would suggest that the student revise the sentence to incorporate specific, defensible information such as the fact that sickle cell anemia was first recognized in 1910; consequently, efforts to understand the disease scientifically must have occurred only within the last 80 years or so.

Similarly, students writing on biological topics that touch on contemporary issues of environmental activism show a strong inclination to use scientifically indefensible levels of generalization: "If the northern spotted owl is not protected, then mankind will be truly lost forever." Our strategy for revision always emphasizes a need for specific, supportable elements, which typically enhance both student understanding of the science aspects of the topic and the effectiveness of their argumentation. This tendency to over-generalization is deeply ingrained and shows considerable resistance to change. The writing assignments, however, provide the most effective tool we have yet employed to sharpen students' awareness of what constitutes scientifically defensible argumentation and what does not. We have also received a number of papers that were well organized, clearly written, and mechanically "perfect" but were "dead wrong" with respect to the biological science. Conversely, papers that contain a genuine understanding of the science may be so poorly written as to be unintelligible to anyone but another biologist. Effective writing and concept mastery sometimes show themselves to be discrete, separable entities; consequently, we clearly do a much better job for the student together than either of us could do alone.

In fact, one of the most interesting and unexpected facets to our program has been the dynamic tension between the respective outlooks of each instructor. The biologist, for example, may view a very clearly and soundly written explanation as a job well done, while the humanities professor may view the writing as flat, uninteresting, and lacking in personal input from the writer. In such cases, the writing instructor tends to urge the student to use the active voice, sentence rhythm, metaphor, and perhaps offer a personal conclusion to enliven the writing. The biologist urges the student to stay focused on the data and restrict the writing to scientifically defensible conclusions.

At their worst, these seemingly arbitrary preferences of the two instructors can cause frustration for students. This is not what we've typically found, however. More often the dynamic tension produces a positive reaction encouraging students to offer opinions when appropriate (e.g., in my opinion, the evidence for concluding that malaria prevalence determines sickle cell gene frequencies is not convincing), to rework the material on a sentence level, and to explore a rethinking of their logic.

While we believe the program has been quite successful, it is not without significant drawbacks. One is certainly the cost, as every version of each student paper undergoes careful, detailed examination by two faculty members. Even with our small class size (20 in each of two classes), the project translates into a major commitment of faculty time for a comparatively small number of students. Similarly, the demands on student time and energy are great. Weekly papers on top of normal reading assignments and examinations result in a rather heavy work load for the amount of academic credit.

In our case, we have been able to overcome these problems through the Honors Program, which

not only contributes funding, but attracts the highly motivated students with above average abilities. Honors students are quite enthusiastic about their experiences in the course . . . once completed! Former students now in law school, medical school, and other graduate programs have taken the time to communicate with us, always referring to this course as one of the most important and effective in their undergraduate careers.

CONCLUSION

By combining elements of practice, critique, revision, connection, integration, intrinsic student interest, and structured guidance, we believe the writing component to our Honors General Biology course has resulted in major improvements in student writing, thinking ability, and concept retention, paralleling the results reported by others (e.g. Emig, 1971; Shulman *et al.*, 1993) The students learn the science in a manner decidedly different from lecture, lab, or exam. In fact, they learn the material in such a way that they must probe, question, and argue. In addition, they are developing their writing skills through a demanding revision schedule. It may be safe to say that at no point in the future will they ever receive so much individual faculty input on their written work. In summary, we believe an intensive, demanding writing component can significantly enhance the overall educational value of freshman science courses.

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