Preparing Undergraduates for Professional Writing

Evidence Supporting the Benefits of Scientific Writing within the Biology Curriculum

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The inability to write scientific papers effectively remains a problem for many college students. To identify pedagogical constructs that help undergraduates write well in scientific formats, we evaluated the effect of the number and type of college composition courses previously taken, science writing experience, and tutorial services. In our study, the only significant factor influencing scientific writing performance was prior scientific writing experience. This suggests that more emphasis should be placed on scientific writing within the undergraduate science curriculum.

In our experience, undergraduates—even seniors—have not learned to write effectively in scientific formats (including reports, proposals, and reviews). The majority of scientific writing problems we have observed are in a document's organization, professional tone, clarity, and concision. These observations and concerns are consistent with the literature (Labianca and Reeves 1985; Moore 1994; Samsa and Oddone 1994). General writing skills such as spelling, punctuation,

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and sentence structure are sufficient in most cases.

In typical North American undergraduate science curricula, writing courses are usually recommended within the first 2 years of a program. This is in keeping with the emphasis on introducing a broad overview of "tools" such as calculus, statistics, and general sciences in the freshman and sophomore years. Discipline-specific courses are taken during the junior and senior years. The intent is that, having learned these fundamental skills early on, a student can then develop the specialization required to complete a degree in the sciences (Ost 1987). An implicit assumption in this conjecture is that during the junior and senior years, students will also be exposed to the style of writing characteristic of their discipline (Nekvasil 1991).

Most juniors have completed the writing and communication requirements for their degrees. Additionally, junior-level courses (such as ecology) have prerequisites of introductory biology courses, so that students have presumably read samples of scientific writing through presentations, projects, and assigned reading. Thus, the third-year ecology course at Montana State University (MSU) was an ideal setting to test the writing proficiency developed by the school's undergraduate curriculum, as the course was required at the time for all students in the biological sciences.

At MSU, writing development opportunities are available to students at the Writing Center. The Writing Center provides a counseling service to undergraduates who need help with any writing project, and it is staffed with senior undergraduate and graduate students supervised by the university's English department. The Writing Center is advertised to professors across disciplines as an appropriate place to which to refer students who are struggling with writing.

Knowing that these resources all contribute to a student's academic success, we analyzed student writing in Ecology 303 by asking the following questions:

- Does the number of undergraduate English composition courses a student has taken correlate with his or her scientific writing ability?
- Does a general technical writing course improve a student's scientific writing?
- How much exposure do students receive to scientific writing during their lower-division courses?
- Does composition tutoring at the campus Writing Center improve student scientific writing?

Methods

In 1996, we surveyed students from the Ecology 303 course at MSU to determine their writing and science background. The survey elicited which English composition and communications courses they had taken as well as their exposure to scientific writing through research, course work, and study. The survey also requested permission to use students' responses in research for this article and to cross-tabulate the responses with each student's assignment and final overall score.

During the semester, students were assigned two writing projects. Each project was weighted as 15 percent of the total course grade. The first project was a persuasive paper, written for the general public, providing insight into an ecological problem. The requirements (length, format, tone, and context) were similar to that of a well-written letter to the editor of a local newspaper. At MSU, first- and second-year English composition courses often require a similar assignment.

The second assignment was a research proposal. The requirements were based on those for National Science Foundation proposals, although obviously scaled down in length, complexity, and detail. A formal assignment sheet detailing all requirements with expectations (including the distribution of points) was presented to the class. Example papers and proposals were placed on reserve in the library for viewing.

The first step in each assignment required students to submit a detailed outline that reflected the paper's structure, including the main points of all paragraphs and citations. Our evaluation criteria focused on the structure, tone, and completeness of a scientific argument. Outlining allowed us to evaluate and offer suggestions on these critical points while only minimally addressing standard spelling, punctuation, and grammatical concerns. The outline was weighted as 25 percent of the final assignment grade; this both encouraged thoroughness in the outline and allowed the bulk of the grade to reward improvement in the final version. Upon the return of the outline, students had 2 weeks to produce the final paper.

We used a grading sheet designating all points possible in each assignment. The points were distributed into categories of physical requirements of the presentation, grammatical correctness, scientific style, and subject matter (including the subject of discussion and consistent and accurate facts). The majority of points were in subject matter and scientific style. The same grading sheets were used to calculate the scores for both the outline and the final paper.

To evaluate the effectiveness of the MSU Writing Center, we measured the change in score (percentage of points possible) from the outline stage to the paper stage of students who used the center and those who did not. All statistical analyses were carried out using SYSTAT v.10.

Student Results

Of the 103 students enrolled in the course, 82 completed the survey. These 82 consisted of no freshmen,

14 sophomores (17 percent), 44 juniors (54 percent), and 24 seniors (29 percent). Biology majors dominated the ecology course (general biology, botany, horticulture, bio-medicine, fish and wildlife management, range science, and environmental science). However, 29 students (35 percent) completing the survey indicated other fields of study such as engineering, education, and economics. In general, most fields of study were either in the sciences or, in the case of education and engineering majors, had biology as an area of specialization. Differences in sample size for statistical tests were the result of incomplete surveys and course requirements.

Effect of English composition courses. Our first question investigated the influence of the number of English composition courses on the final score for the persuasive paper and the research proposal. Students were grouped into levels of 0–1, 2, and 3 or more courses. Categories were binned to allow for analysis of variance (ANOVA) testing. The distribution of number of courses was 0 (1 percent), 1 (39 percent), 2 (48 percent), 3 (11 percent), and 4 (1 percent). There was not a significant association between the number of college-level writing courses completed and the final score on the persuasive paper (ANOVA: n = 80 students, R^2 = 0.027, df = 2/77, p = 0.348), or similarly, between the number of college-level writing courses completed and the final score on the research proposal (ANOVA: n = 57 students, R^2 = 0.030, df = 2/54, p = 0.444).

Effect of a technical writing course. We also compared the research proposal grade of those individuals who had completed a technical writing course [14 students (25 percent)] with those who had not [42 students (75 percent)]. The results suggest that a technical writing course had no significant influence on student performance (two-sample t test: n = 56 students, α = 0.05, p = 0.339).

Effect of scientific writing exposure. We expected that the number of years the students had attended university, during which they had presumably been exposed to samples of scientific writing, would affect their performance. However, we found no significant association between the number of years at university (factor levels sophomore, junior, and senior years) and the performance on either the persuasive paper or research proposal (persuasive paper ANOVA: n = 80 students, R^2 = 0.022, df = 2/77, F = 0.856, p = 0.429; research proposal ANOVA: n = 57 students, R^2 = 0.057, df = 2/54, F = 1.623, p = 0.207).

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The above analysis is valid concerning the assumption that students receive increased exposure to scientific writing as an increasing function of the number of years of education. However, we also asked specifically whether a student had experience writing a research proposal. The 11 students (20 percent) with previous experience in proposal writing did significantly better on the research proposal assignment than did the 45 students (80 percent) without experience (two-sample t test: n = 56 students, α = 0.05, p = 0.015). Of these 11 students, there were 3 sophomores (27 percent), 5 juniors (45 percent), and 3 seniors (27 percent).

We also asked students whether following freshmen year they had been assigned to write scientific papers in any courses of specialization. More than 75 percent (61 out of 81) said they had not. Of the remaining approximately 25 percent of students (20 out of 81), 55 percent (11 out of 20) were those exposed to writing a research proposal.

Effects of the Writing Center. Before investigating the influence of the Writing Center, we tested for a selection bias that might invalidate such a comparison. However, we could detect no significant difference in outline scores between students who subsequently visited the Writing Center (approximately 20 percent of the students) and those who did not (two-sample t tests: persuasive essay, t = 0.642, df = 73, p = 0.52; proposal, t = –0.73, df = 51, p = 0.47). We then compared the two groups, but found no statistically detectable differences in improvement for either assignment (two-sample t tests: persuasive essay, t = 0.476, df = 73, p = 0.67; proposal, t = –0.086, df = 51, p = 0.932). We provided feedback to all students (similar to groups 3 and 4 in Moore 1993) through comments on the outline grading sheet. The survey asked if the outlining and feedback method was helpful in developing the final paper. Fifty-six of 81 (69 percent) students replied that it was.

Both groups improved from the outline to the paper for both projects. We attribute the improvement to instructor feedback rather than to the Writing Center. However, because feedback was not withheld from any student, we could

not test this assumption explicitly (see Moore 1993).

Discussion

Our analysis makes a disheartening statement of how we are preparing students to write scientifically. Three surprising results were that the number of English composition courses taken, the year of study, and use of the Writing Center did not significantly enhance our students' scientific writing ability. This does not indict the first- and second-year English composition courses or resources such as the Writing Center. This study does not in any way measure the effectiveness of these courses or facilities in improving general college writing. The study does, however, suggest that scientific writing is not being developed adequately by the present curriculum or student services.

Furthermore, experience in a technical writing course also does not significantly contribute to increased scores in scientific writing. But these types of courses are designed to support engineers and business professionals as well as scientists. Technical writing is a broad genre, ranging from the proper formatting of a memo to dissertation structure, and it is perhaps unrealistic to expect that scientific writing could be fully developed in such an all-inclusive syllabus.

Writing Center services may have the potential to enhance scientific writing, but our survey, with its admittedly small sample size, indicates that they currently do not. We suggest that Writing Centers be staffed with tutors who specialize in scientific and other technical writing. This has the potential to greatly enhance the value of a Writing Center to students and faculty.

So where should we put our efforts in helping students to write scientifically? Our synthesis suggests that scientific writing needs to be integrated directly into specialized courses and student research. Prior experience writing a scientific research proposal was the only factor identified to improve research proposal scores. The students demonstrating this skill were from sophomore, junior, and senior levels. This illustrates that incorporating scientific writing assignments into the curriculum is possible (Holyoak 1998). However, as we must reiterate, 75 percent of our surveyed students have not had this opportunity. Our students are ill served by the lack of opportunity to read and write in the scientific style.

Simply incorporating more scientific writing into the junior- and senior-level classroom is not enough (Holyoak 1998; Krest and Carle 1999). For both the persuasive paper and the research proposal, we provided feedback on the outline which we believe led to improved scores. The majority of students found the feedback helpful in developing the final paper. This interaction between the instructor and the student regarding writing in the scientific style seems critical (Brillhart and Debs 1981; Moore 1993 and 1994). Holyoak (1998) and Krest and Carle (1999) provide examples of implementing writing programs, including feedback, into the biology curriculum. Our results support their positions and programs.

Scientific writing in specialization courses is the training ground for the next generation of scientists and scholars. Incorporating opportunities for students to practice and improve scientific writing enhances their skills and improves the communication of science. It is our responsibility as science educators to work with existing courses and faculties and to develop our curricula to ensure that this occurs.

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