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Writing in the Natural Science Department

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The Natural Science Department is a diverse department with four major disciplines (biology, meteorology, science education and chemistry arranged in decreasing numbers of majors) and it is difficult to summarize all of the types of writing assignments. Nonetheless, the most common type of writing experience shared by each of these majors is "the" scientific paper. We use the article "the" advisedly because in reality scientific papers are generally written in discipline and/or journal specific formats. Writing assignments that we give students are outlined below by discipline.

Biology Writing Assignments

Biology faculty have attempted to integrate writing throughout our introductory and upper-level courses. We begin early: we have the advantage of requiring all of our (declared) first year majors to enroll in sections of IAC taught by two biologists. In this section, we focus primarily on writing "good" paragraphs addressing biological issues. Last year we had the students purchase a book, *Ever Since Darwin* by Stephen Jay Gould, containing a series of biological essays. We asked them to read one assigned chapter and to write a well-constructed paragraph based on a question about an important biological principle

illustrated by the chapter. We graded these paragraphs primarily on structure and content. We also ask the students to purchase a published "writing guide" for biologists which discusses a number of discipline-specific writing assignments. We encourage our majors to use this guide as a reference for any written work that they submit. Lastly, in General Biology Laboratory they are asked to write a free-verse description of a particular animal or plant group—the students exhibit a great deal of creativity here and the faculty lave to read (and share) them!

There are four sophomore level biology classes, and all of our majors are required to take at least one of these. In Vertebrate Biology, the students are required to submit an extensively annotated laboratory notebook which "tells a story" about the organisms illustrated. Feedback is given at least once during mid-semester and the students are expected to correct any writing problems that were noted by the instructor. In another course, Invertebrate Biology, biweekly writing assignments of various forms are required (often as a laboratory report or a scientific paper). They are graded as satisfactory or unsatisfactory. Those labeled unsatisfactory must be re-submitted until they are acceptable.

We have eight upper-level courses that have significant writing components (the other nine upper-level courses require little writing). All of our majors must take at least two of these courses and most of our majors take an additional one or two. The writing assignments here are primarily based on scientific papers which have a specific form (Title, Abstract, Introduction, Methods, Results, Discussion, Literature Cited). An approach similar to the WAC model is used which includes submission of more than one draft, peer reviewing and editing sessions, revisions based on both peer and instructor's comments. Most of us take a section-by-section approach to these papers so that by the time the students' first complete scientific paper is due they have written and re-written each of the sections at least once. Several specific assignments that deviate from this general model are worthy of note:

1) In several of these courses students write scientific papers based on hypotheses they construct and experiments they carry-out. These hypotheses are generally based on course lectures, assigned or independent readings, and much discussion with the professor. This is a very time-consuming method for the professor but it allows the student to participate first-hand in the scientific method. One of the best ways for a student to discover the short-comings of an experiment is to try to present the results in a written and graphical format. We require that the students submit this written work early in the process to allow them to see the potential deficiencies in the experimental design for themselves.

2) Another useful technique embraced by a few of us is a take-home exam in which the students are required to write paragraphs which describe a series of tables and/or graphs from the scientific literature. We require that they be both concise and precise in their descriptions and we encourage them to work on the analysis of the figures (but not the writing) together.

3) In another class, students are required to work together to produce a standardized "Technical Report" on a body of water chosen by the students in the Plymouth area. There are many specific details but in essence the students must visit the body of water several times during the semester, collect data on that body of water and submit a group report. This report is in the general form that might be expected at a government agency and includes the typical scientific paper sections as well as a cost analysis and a list of necessary supplies and vendor names and addresses.

In addition, Biology majors are required to take General Chemistry, Organic Chemistry, and (many take) Biochemistry. The writing assignments required for these classes are included in the "Writing in Chemistry" section below.

Finally, biology students are required to take Bioseminar, and most of them take this class during their senior year. The focus

of this class is for the students to investigate specific areas in biology and to give an oral report on original scientific literature in those areas. They generally are asked to submit an abstract of their talk, an annotated bibliography, as well as two drafts of their talk outline. Organizational writing that the students have been previously exposed to—outlining, good paragraph construction, argumentative writing—seems to help the Bioseminar students to carry out this endeavor well.

Meteorology Writing Assignments

Most of the writing within the major is done in the "W" designated course Meteorological Instrumentation and Observation, a sophomore level class. There are weekly in-class writing assignments given early in the semester designed to develop and hone writing skills before tackling longer papers. These in-class writing assignments are usually focused around interpretation of data tables and/or graphs. Occasionally they are asked to take a paragraph of scrambled sentences and make logical sense out of it. The raw material for these brief exercises comes from scientific texts and journals. In addition, students are asked to keep a journal which should contain weather-related observations, but the professor also encourages the students to write down other general thoughts that come to mind (free-writes). These journals are examined 3-4 times/semester for style and continuity of entries. The in-class assignments and journal writing are designed to improve skills in order to write three two-page "summary papers." Much of the work on writing skills is focused here. Students are asked to select a pertinent article from specific meteorological journals and are then expected to address a few specific questions regarding the purpose and the objectives of the study. They type up a draft and enter into a peer review session with 3-4 other students. The students take turns reading their drafts aloud to one another to attempt to catch problems with syntax, spelling, organization, etc. The students revise their drafts and re-submit their work this time to the professor for review. The professor provides

written feedback on this draft and then returns it to the student who is expected to turn in a final draft for grading. Towards the end of the semester the students are asked to present one of their three summaries orally to the class and then be able to field questions.

Meteorology students also have two other important opportunities to work on their writing. As first year students they are asked to write up the results of a climatological study done in association with their climatology course. Senior meteorology students must also write up their experimental study in scientific format if they choose to conduct independent research.

Science Education Writing Assignments

Examples of writing assignments are provided for the following General Education science courses: Bio1ogy: Core Concepts, Oceanography, Astronomy, and Earth Science. Although these courses are considered in the General Education program, they are taken by some of the science education majors in our department. Science Education majors take essentially all of the courses listed above in biology or meteorology or below in chemistry. In addition, many of the students in these classes are Elementary Education or Childhood Studies majors. The writing-to-learn and learning-to-write philosophy embedded in the Writing Across the Curriculum effort is an important and vital part of the overall assessment of students in these courses.

Weekly laboratory reports in the Bio1ogy: Core Concepts course are required. The objective of these forms of technical writing is to unpack the notion that students generally have that scientific writing is beyond what they can do or that there is some mystery in how a scientist or in this case a biologist would write about their findings. Students follow the format for a report/paper as presented above in the biology majors section with a developmental focus in mind. Initially, the title, purpose and hypotheses need to be clearly stated with a progression to more emphasis on presentation and analysis of data (tables, graphs and discussion)

and references (bibliography and webliography). A great deal of feedback occurs during the first several weeks and students are encouraged to respond to any suggestions or make corrections. In this way, they are immersed in the writing process. They are encouraged to write what they mean, what they did, or what they observed as clearly as possible. This then involves the learning-to-write component.

The culmination of this writing process is the research paper to support an independent experimental project that is required. The paper goes through a series of drafts and revisions with comments on content, paragraph structure, and spelling from both the instructor and fellow students and then is presented orally in a seminar format. The scientific process and paper is a critical part of the course because students are thinking and acting as scientists with a biological focus.

Research papers in the oceanography, astronomy, and earth science courses are used to accomplish various learning outcomes. In oceanography students are required to write two short research papers, 6-10 pages in length, one that address a scientific topic about the oceans and the second a topic related to the oceans but not a science topic. This topic often is closely aligned to a student's major with papers on ocean poetry, art, music, economics, mathematics, history, and teaching submitted. Drafts are required so there is a good chance of success with these writing assignments.

While the specific writing assignments for the Secondary Science Methods course vary from year to year, they contain a range of writing applications that are appropriate for future educators. The overall goal is to expose students to the language of education and to hone writing skills that they will use as teachers. The students develop their own grading rubrics and peer review assignments. Students usually complete assignments on the following topics: an essay on *The Nature of Science and How It Affects Science Teaching*, an essay on *How Do You Learn Science?*, unit/lesson planning, software reviews, reviews of the

scientific and science education literature, a personal journal of classroom observations, and class presentations on current topics in education such as state-of-the-art class handouts, WWW searches, and reviews of State and National Standards.

The astronomy students do various writing assignments dealing with topics such as Why Study Astronomy?, constellations and mythology, biographies of important astronomers, story summaries for science fiction, and formal reports for night sky observations and sun/moon studies, Content, grammar, spelling, and punctuation are graded in these assignments. It is interesting that some students elect this course because they enjoy writing and realize it is an important part of the course and final grade.

In addition to the usual essay question that addresses application or problem-solving, two-tier multiple choice questions are used in the Biology: Core Concepts, Earth Science, and Oceanography courses. This format includes the typical multiple choice question followed by a question that requires the student to defend their selection or refute the other choices. This gets at more of the students' understanding of the concepts addressed and begins to eliminate guessing at answers. The instructor generally learns a lot about student understanding although the students generally find this type of writing a challenge. They are not often asked why or how they understand a concept.

Open response essays are assigned in the Biology: Core Concepts and Oceanography courses. These questions are derived from critical thinking application questions presented in the textbooks currently used in these courses. Students can submit responses on paper or through e-mail. Immediate feedback is given regarding their opinions on the topics since right or wrong answers generally do not apply.

Finally, all of the above courses require literature and Internet/WWW site reviews. Students are given the opportunity to write a review and critique science content articles in journals, magazines, books and relevant Web sites. Students often use these reviews as background material for research papers or other

reports and build on their process of learning to write.

Chemistry Writing Assignments

Chemistry students are asked to write in several of their courses. As first-year students, they are required to write weekly short essay-type explanations of phenomena in General Chemistry as well as semi-formal laboratory reports in some sections. In their sophomore level class, Organic Chemistry, the students spend the last three weeks of the semester working on a project chosen from a list provided by the instructor and are required to write up the results in a formal laboratory report. They are also required to develop a short write up of the lab procedure before they come to lab. The students also have an option to write a paper to replace an exam grade. In biochemistry, they are asked to submit weekly problem sets which include short-to-medium length essays. The professor provides weekly feedback on these essays. In the laboratory section of Biochemistry, the students must submit five formal laboratory reports, the first of which can be re-written and re-submitted. All chemistry majors take Senior Research, which is a "W' designated course. They are required to write a paper in the style of a Master's Thesis in chemistry. The content includes the following sections: Abstract, Purpose/ Background, Materials and Methods, Data Presentation, Discussion/Conclusions, Full Citation List. Additional writing within the major is done in the "W" designated course Physical Chemistry, an upper level class. There are ten laboratory reports that must be submitted in "Journal of the American Chemical Society" style. These must be word-processed with all spelling and grammar correct. There is also one assigned research paper.

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