Integrating Writing into an Introductory Environmental Science Curriculum: Perspectives from Biology and Physics

P.A. Selkin*, **E.T. Cline**, and **A. Beaufort**

Interdisciplinary Arts and Sciences, University of Washington, Tacoma

*paselkin@u.washington.edu

ED31A-0587

ABSTRACT

In the University of Washington, Tacoma's Environmental Science program, we are implementing a curriculum-wide, scaffolded strategy to teach scientific writing. Writing in an introductory science course is a powerful means to make students feel part of the scientific community, an important goal in our environmental science curriculum. Writing is already an important component of the UW Tacoma environmental science program at the upper levels: our approach is designed to prepare students for the writing-intensive junior- and senior-level seminars. The approach is currently being tested in introductory biology and physics before it is incorporated in the rest of the introductory environmental science curriculum. The centerpiece of our approach is a set of research and writing assignments woven throughout the biology and physics course sequences. The assignments progress in their degree of complexity and freedom through the sequence of introductory science courses. Each assignment is supported by a number of worksheets and short written exercises designed to teach writing and critical thought skills. The worksheets are focused on skills identified both by research in science writing and the instructors' experience with student writing. Students see the assignments as a way to personalize their understanding of basic science concepts, and to think critically about ideas that interest them. We find that these assignments provide a good way to assess student comprehension of some of the more difficult ideas in the basic sciences, as well as a means to engage students with the challenging concepts of introductory science courses. Our experience designing these courses can inform efforts to integrate writing throughout a geoscience curriculum, as opposed to on a course-by-course basis.

CONTEXT / GOALS

The University of Washington, Tacoma is a small (~3000 student), undergraduate-focused campus of the University of Washington that began as a transfer-only school. In 2006, the campus began accepting freshmen and thus needed to develop lower-division courses.

The environmental science B.S. degree, part of the Interdisciplinary Arts and Sciences program, is writing intensive. Majors take a pair of upper level (junior / senior year) seminars designed to develop students' writing, research, data analysis and presentation skills. Students also typically write a substantial paper as a part of their capstone research or internship project.

Ideally, lower-division courses should prepare students for the challenges of scientific writing. Science and engineering students on the UW Seattle campus identified the following challenges in scientific writing [*Beyer* et al. 2007]:

> Mastering styles and conventions of scientific writing ("genre knowledge" of *Beaufort* [2005]).
>
> Thinking critically about the subject of their writing (in particular, experimental results).
>
> Engaging with the scientific literature.

We are currently testing a scaffolded approach to teaching writing in the UW Tacoma introductory biology and physics sequences (Fig. 1). Here we outlne how our strategy overcomes some of the challenges faced by science faculty who teach writing.

Fig. 1 Lower division requirements for a "typical" environmental science student, with writing assignments

Year	Autumn	Winter	Spring
I	**Biology 1** Group experiment and analysis in "real" research project; independent primary research paper (*Forestry Research*)	Chemistry I	**Biology II** Literature review paper (written to explain topic to struggling fellow student)
II	Chemistry II **Physics I** *Nature* summaries of laboratory experiments	**Biology III** Proposal; Independent analysis, independent primary research paper **Physics II** Primary research paper with group analysis and literature search; Cover letter	Chemistry III **Physics III** Review paper of interdisciplinary topic (active research)

Challenges in teaching scientific writing for the instructor

Designing Clear Assignments

Consider simpler genres that emphasize same educational goals (e.g. cover letter, summary paragraph)

Break complex task into focused worksheets (see examples)

Provide models or templates

Providing Timely Feedback

Simplify grading rubrics to target specific problems in student papers (but not too specific)

Allow time for peer editing or review (provide models and specific instructions)

Require drafts

Engaging Students in Material

Allow for low-stakes or ungraded writing

Vary assignments to give students practice with multiple forms and purposes of scientific writing

Discuss current research and role of publication

Challenges in learning scientific writing for the student

Emphasizing Critical Thought

Ask students to state question to be answered

Discuss "most surprising" idea from research, or "things you still don't understand"

Use exploratory writing / journaling (choose prompts wisely)

Developing Genre Familiarity

Discuss scientific literature(s) as much as possible

Students' stumbling blocks include

- ☐ Paraphrasing sources
- ☐ Emphasis on sequence
- ☐ Over-personalization
- ☐ Wordiness
- ☐ Tyranny of the 5-paragraph☐

Developing Literature Familiarity

Discuss scientific literature(s) as much as possible

Request annotated bibliographies

Remember that citation and reference formats change from task to task

Sample grading rubrics

2007 Physics: Too specific

Physics Lab Report Rubric

	Points	Excellent (100%)	Meets Minimum Standards (80%)	Does not meet standards (60%)
Content			Contains all required sections	Missing one or more sections
	3	Report focuses on correct physical problem	Report mostly focused, with some aspects not completely clear	Report does not focus on correct physical problem
		Clearly articulates theory behind lab, correctly using appropriate terminology (e.g. names of physical laws) and physics quantities	Adequate grasp of theory, with minor mistakes if any	Theoretical background contains abundant mistakes or fundamental misconceptions
		Specific data and trends used in text to support generalizations in discussion	Conclusions supported by data	Significant gaps in logic
		Discusses discrepancies between data and predictions	Refers to data and charts, but specific trends are not identified	No attempt made to interpret data in discussion
		Details are complete, accurate, relevant, and indicate writer's experience and understanding	Details present, but may be incomplete or indicate incomplete understanding	Writer does not speak from experience (e.g. copies from lab handout)
				Important aspects of lab experience missing
Organization		Sections contain appropriate information		Sections contain inappropriate information (e.g. interpretation in results)
	2	Well-organized paragraphs with clear topic sentences	Paragraphs contain overall logical progression of ideas, but may be somewhat choppy	Disorganized sequence of ideas within and between paragraphs makes reading difficult
		Calculations show all logical steps, with equivalent quantities on each side of equals sign	Calculations shown at appropriate places and explained in text	Missing explanation of symbols or calculations
Quantitative		Uses SI units throughout	Units used consistently and correctly	**Units not shown (-1 pt)**
	3	Measurement uncertainty reported and propagated correctly	Uses appropriate significant figures	**Too many or too few significant figures (-1 pt)**
		Double-checked by considering whether numerical answers are reasonable	Calculations overall numerically correct (1-2 minor errors, e.g. sign errors are OK)	Calculations contain abundant mistakes
Presentation		Sections appropriately labeled		Sections not labeled
		Presentation is clever and/or visually interesting without overwhelming content	Includes lab title, student name, date, collaborators	Missing identifying information
		Writing interesting and engaging	Grammar and spelling correct (<5 errors)	Abundant mistakes in grammar and/or spelling
			Sentences are overall complete and do not include run-ons	Bulleted lists used instead of complete sentences
	2	Tone is appropriate for scientific audience	Readable, but too verbose or informal for scientific audience	Unaware of audience
		Vocabulary appropriately used	Some misuse of specialized vocabulary	
		Graphs and diagrams contain maximum information with minimum ink	Diagrams readable	Report is messy
		Information in tables properly labeled	Tables used in appropriate places	No tables, or tables not useful

2008 Physics: Too general

TESC121 – Physics 1 – Mechanics Selkin Autumn 2007

Grading Rubric for Post-Labs
Post-lab grade is the *average* of score in each category

I	4	3	2	1
I	A	B	C	D
Topical Understanding	Goal: Work demonstrates proficiency with skills and physical principles involved in lab.			
	Completely fulfills objectives outlined in lab handouts, demonstrating mastery of physical concepts addressed in lab.	Fulfills most objectives outlined in lab handouts, demonstrating familiarity with key physical concepts.	Fulfills most objectives outlined in lab handouts.	Misunderstanding of key physical principle leads to significant errors in interpretation.
Critical Thought	Goal: Work demonstrates synthesis of principles from course and discoveries from lab.			
	Properly uses concepts from class, tutorials, and reading to analyze lab data. Data used to support discussion. May refer to outside sources of knowledge, though not to exclusion of student's own critical thought about lab data.	Uses concepts from class to analyze lab data. Direct references to data used to support discussion.	Lack of connection between class/reading and lab data OR data do not support discussion.	Does not use data from lab.
Quantitative Skills	Goal: Student applies mathematical reasoning appropriately, clearly, and correctly.			
	Calculations correct overall. Mathematical logic clear. Correct equations appropriately explained. Units and significant figures correct.	Appropriate equations used, with logic clear (one step per line, no calculation until end), appropriate units of measurement shown, and appropriate significant figures.	Logical steps missing, inappropriate equations used, or lack of attention to units / significant figures.	Mathematical logic impossible to follow and arrives at incorrect conclusion. Missing units / significant figures.
Writing / Presentation	Goal: Communication is clear, concise, and uses appropriate scientific conventions.			
	Text is written in a scientific style and is exceptionally clear and/or well-written.	Text is written in scientific style: uses appropriate level of formality, wording is clear and concise, vocabulary is correct, and proper citations are used if necessary. Text is proofread and largely free of spelling, grammar, and punctuation mistakes.	Text uses some conventions of scientific writing, but is not concise (e.g. deadwood) OR informal OR uses vocabulary improperly (demonstrating misunderstanding) OR text is not proofread (or poorly proofread).	Tex is unclear and difficult to follow.
Meta-analysis	Goal: Student reflects on discoveries in lab, including (but not limited to) appropriate error analysis.			
	Discussion of sources of error shows serious thought. Uncertainty calculations clear and largely correct. Contains reflection on what was learned in lab.	Calculates and discusses measurement uncertainty as requested. May have some minor mistakes. Some attempt made to reflect on accomplishments in lab.	Incomplete, unclear, or largely mistaken calculation / discussion of measurement uncertainty.	Missing calculation / discussion of uncertainty.

Other worksheets available on request

REFERENCES

Beaufort, A. (2005), Adapting to New Writing Situations: How Writers Gain New Skills, in *Schreiben am Arbeitsplatz*, edited by E.M. Jacobs *et al*., pp. 201-216, VS Verlag für Sozialwissenschaften, Wiesbaden.

Beyer, C.H., G.M. Gilmore, and A.T. Fisher (2007), *Inside the Undergraduate Experience: The University of Washington Study of Undergraduate Learning*, 406 pp., Anker Publishing, Bolton, MA.