Instructor Feedback in Upper-Division Biology Courses: Moving from Spelling and Syntax to Scientific Discourse

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Abstract: In this study, I present an analysis of instructor comments on assignments written for upper-division courses in the biological sciences as a window into current practices around teaching science writing to major students. My results demonstrate that, while the overwhelming majority of instructors respond primarily to lower-order issues of grammar and other surface mechanics, a minority comment primarily on concerns specific to scientific discourse with a corresponding decrease in focus on lower-order issues. What discriminates between these two groups is that the minority assign genres that closely mimic fully-developed professional writing in the appropriate field; the majority assign conventional undergraduate genres such as the research paper that do not explicitly reference the writing students who continue in the field can expect to perform following graduation. Interviewing several of the professors in this minority, I find that their attitudes toward teaching with writing are closely coupled with envisioning student writing as apprentice-professional work, suggesting that encouraging faculty in such attitudes may, in addition to other benefits, improve their feedback practices.

How and to what end instructors provide feedback on student writing is an area of explosive recent development in terms both of composition theory and praxis, and for good reason. Feedback on student writing is perhaps the most direct, specific, and personal way students receive writing instruction, a role not limited by the kind or context of the writing. And yet, the vast majority of study into feedback practice and efficacy, even in writing across the curriculum (WAC) contexts, has been situated in general education courses, leaving under-studied upper-division, major-specific courses. This deficit is particularly meaningful in the natural sciences where students are asked to write in specialized scientific discourses that can seem far removed from the writing they performed in first year composition and other lower-division general education courses.

In this study, I examine instructor feedback on assignments written for upper-division biology courses specifically to the end of investigating whether and how they use feedback to instruct students in scientific discourse. My results demonstrate that the majority of faculty in my sample comment not on issues pertinent to disciplinary writing but, disproportionately, on lower-order concerns. A distinct minority, however, focus their commentary on concerns specific to scientific discourse with a corresponding decrease in attention to superficial errors. That this minority explicitly ask students to write in apprentice-professional ways mimicking professional scientific work suggests a connection between assignments with explicit goals and more directed feedback. Interviewing several faculty belonging to this minority, I find that their attitudes toward teaching

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with writing are tightly tied to student writing as apprentice-professional work, suggesting that encouraging faculty to frame student writing experiences in this way may, beside other benefits, improve feedback practices.

Seminal work by Richard Straub and Ronald Lunsford's (1995) *12 Readers Reading* brought attention to the importance of instructor comments on student writing, proposed a taxonomy of comments, and offered a system for analyzing them within the context of an introductory composition course. Subsequent work has evaluated how students feel about the type of feedback instructors provide, the difference in quantity and quality of feedback provided by different kinds of reviewers, and the efficacy of various commenting protocols in improving student's understanding or in prompting effective revision. Toward the first end, Cho, Schunn, and Charney (2006) found that instructors provide mostly directive (calling for a specific change) as opposed to summative (restating points from the paper) or praise comments, while students reported that directive and praise comments were most helpful. A similar survey showed that composition students had decidedly mixed opinions on whether correction-oriented professor feedback was helpful or not (Lynch and Klemans, 1978). Evaluating the utility of non-corrective — that is, reader-based or coaching — feedback, numerous studies and commentaries cited in *12 Readers Reading* suggest that students learn more from this sort of more facilitative, less critical instructor commentary (Straub and Lunsford, 1995).

Importantly, the vast majority of these studies have been framed within composition and lower-division general education or introductory courses. Instructors in the natural sciences, especially in upper-division major courses, are faced with a different and perhaps more complex task than composition and general education instructors. Scientific discourse involves specific lexicons and genres that may differ dramatically from those used in the writing students produce in other contexts. To succeed as graduate or professional students and later in their careers, apprentice scientists must become proficient in what amount to new and foreign languages. Simultaneously, however, many undergraduate science majors continue to grapple with the foundations of effective writing: argument, organization, support, grammar, and surface mechanics, among other issues. These foundations become even greater challenges when coupled with the need to write in the specialized discourse of the student's major. How instructors are to handle providing feedback in this complex situation receives little attention in the literature.

Of several writing-intensive biology curricula proposed since the 1970's WAC revolution, none adequately address the criteria that are to be used in assessing student writing, how instructors are to be trained in writing assessment, or how the selected criteria relate to professional competencies. Alan Holyoak (1998) describes student writing assignments in detail, but makes no comment on instructor feedback or assessment. Margie Krest and Daria Carle's "content-based [science] writing course" focuses on "writing (style, grammar, mechanics), library research, and critical thinking," (1999, p. 224) but offers no suggestions on the relative weight or importance of these elements; furthermore, Krest and Carle place biology professors in the position of teaching style, grammar, and mechanics with no discussion of whether they need training in this arena or, if they do need it, how they are to obtain such training. Liberating science faculty from needing to attend to style concerns is equally unsatisfactory, as the line between what constitutes subject knowledge and genre or style knowledge when writing in disciplinary ways is far from definitive (Patchan, Schunn, & Clark, 2011). John Bean and colleagues come closest in offering science instructors a framework for assessing student writing (Bean, Carrithers, & Earenfight, 2005). Nonetheless, that so little attention is given to helping faculty negotiate the complex task of providing feedback on science writing *qua* science writing suggests that current instructor practices are likely neither coordinated nor optimized.

Larry Beason (1993) examined feedback and revision in four intermediate-level "writing-enriched" courses, beginning with the tacit assumption that students should be asked to write in the same way

in classes across the curriculum. I begin with a very different assumption: that different disciplinary discourses "work" in different ways (Jones & Comprone, 1993) and that a primary function — indeed, *the* primary function — of writing in upper-division courses is to inculcate students in these unique discourses. Rather than evaluating the efficacy of feedback in generating understanding or revision, my goal is evaluating the extent to which biology professors use feedback to instruct students in the unique features of professional writing in the discipline that can only be addressed in these major courses.

I've chosen to examine feedback practices specifically in the biological sciences for three principle reasons. First, coming from a background in microbiology, these are the non-English disciplinary genres whose conventions I best understand. Second, undergraduate and graduate study in biology led me to suspect that purposeful, directive feedback was uncommon in the discipline. Coming to composition studies, the ideas of facilitative rather than directive feedback, of attending mostly to big-picture issues rather than minutia, and of using comments to strategically guide revision rather than to correct errors was all new to me; I had never seen these tactics appear on my own papers in biology. Third, programs of study in the biological sciences are often designed with the assumption that many students will continue with additional graduate or professional training in various schools of medicine, nursing, or physical therapy, research degrees, or professional certifications in agricultural or environmental sciences. When upper-division (that is, majors only) courses include writing, then, that writing should be frequently and even primarily aimed at teaching students the professional genres they will continue to see later in their studies and their careers.

Study methods

Teasing instructor practice away from instructor attitudes towards writing feedback is difficult without examining graded writing assignments directly. Towards that end, I catalogued professor comments on 237 individual writing assignments from upper-division undergraduate courses in biology-related disciplines at Washington State University (WSU). WSU hosts a well-developed writing program of which undergraduate and graduate writing centers, the writing placement program, and writing in the major courses are part. Though it has no independent WAC program as such, WAC functions are integrated under the general writing program umbrella. All students are required to complete two writing in the major courses, WSU's descriptor for upper-division writing-intensive courses across the curriculum. To receive the designation, a course must meet specific writing-related criteria including having course objectives related to writing, providing at least some opportunity for revision, and awarding a significant percentage of total course credit based on writing assignments. M-course syllabi are subjected to periodic review and writing pedagogy workshops are made available to the teaching community, but faculty who teach M-courses have not historically been required to participate in any particular faculty development program.

WSU requires all undergraduates to complete a mid-career writing evaluation — the Junior Writing Portfolio — consisting of three exemplary writing assignments from three different courses that may include essays, research papers, lab reports, creative works, or any other writing produced for course credit, plus two writing samples produced in a two-hour timed writing examination. The course instructor must agree that the student's response to the assignment is "acceptable" or "outstanding" for the course. Students are encouraged to complete the portfolio around the conclusion of their second year of study, though many fail to complete the process until well into their third or even their fourth year; thus, upper-division coursework is well-represented in the work collected for these portfolios. At submission, students are offered the option of making their portfolios accessible for research purposes and the writing program therefore houses a physical database holding thousands of student writing samples.

From this database I randomly selected 237 papers written between 2001 and 2011 (most between 2007 and 2011) for upper-division courses in biology, molecular biosciences, natural resource sciences, crop and soil sciences, horticulture, entomology, pharmacology, neuroscience, animal sciences, and zoology. Because WSU is a land-grant institution whose mission and structure emphasize the agricultural sciences, the writing samples I selected from disciplines under the general umbrella of biology were necessarily skewed towards applied plant and animal sciences. Some of the courses from which I drew samples, though by far not all, carry the writing in the major designation. Papers varied in length from single-page essays to project reports exceeding 20 pages.

For each paper, I catalogued all instructor comments as either "praise" or "criticism;" neutral comments proved insignificant in number. In addition, I classified each comment as related to "content" — a comment which could have been made only by someone with specific subject knowledge — "low prose" — pertaining to grammar or spelling within a single sentence — "high prose" — pertaining to grammar or structure across multiple sentences — or "scientific discourse" — pertaining to the use of terminology or the conventions of science writing (an extension of the comment classification system of Patchan, Schunn, & Clark, 2011, p. 378). Scientific discourse comments were operationally defined as those that would not have been made by someone outside the sciences or that would not likely have been marked were the paper written for an English composition course rather than a science course. Praise comments were sufficiently few in number and sufficiently vague — "good" next to a paragraph could be a comment on content, structure, or both, for example — to warrant consolidating all praise comments into a single category.

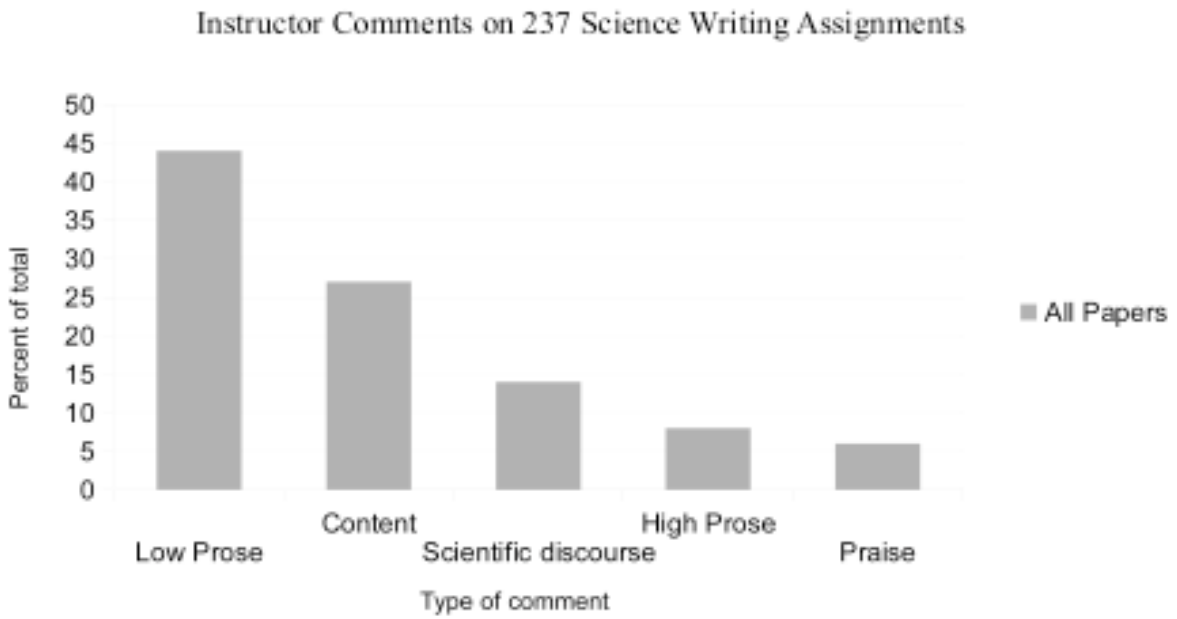
This taxonomy — topical, rather than functional — reflects distinctions in scope and purpose between lower-order concerns with surface mechanics and higher-order concerns surrounding such matters as argumentation, focus, organization, and development. Comments on content could function either on the lower order if, for example, a matter of a single mis-stated fact or an error in terminology, or the higher order in the case of major conceptual misunderstandings or theoretical gaps. While attempting to dissect content comments into these two categories might have been useful for understanding the extent to which instructors attend to large versus small issues, doing so would have required an impractically detailed understanding of both the course material and the instructor's understanding of that material. Moreover, content comments are most likely to stem from a need to correct conceptual misunderstandings and to reliably prompt correction, independent of their lower- or higher-order scope. Similarly, comments I classified as pertaining to scientific discourse — specific to the sciences, but *not* a matter of correcting content errors — could function either on lower or higher orders. A comment on the proper use of scientific terminology addresses a relatively minor genre convention with sentence-level ramifications (though one that still reflects a crucial and central feature of how biologists look at the world); a note on the need to frame a thesis as hypothesis-driven bears upon the structure and focus of the assignment as a whole. Separating out these comments from the low prose and high prose categories to which they would otherwise belong allows me to examine the extent to which professors are using feedback as an opportunity to provide students with instruction in the unique features of disciplinary discourse that can be taught only in these upper-division major courses.

Results and discussion

Figure 1 quantitatively summarizes my observations. My corpus of 237 papers yielded 1950 comments in total: an average of 8.23 comments per paper. 44.15 percent of professors' comments concerned low prose issues of grammar, spelling, punctuation, and (non-scientific) word choice. 14.46 percent related to the conventions of writing scientific discourse: use of preferred terminology, citation style, appropriate level of detail, appropriate level of voice, and the like. 27.49 percent

concerned errors in or issues with content. Very few comments — 6.00 percent — related to high prose issues of focus, organization, flow, transitions, etc. The remaining 7.9 percent of comments offered praise. I classified comments related to citation style — one of the most frequent occasions of professor commenting (or, more precisely, correction) — as scientific discourse comments, but counted all citation errors of the same type as a single comment per paper. Similarly, I counted correction of the same misspelled word multiple times throughout a paper as a single comment upon that paper because all of the comments represented only a single, specific issue. Thus, the 1950 comment total reflects the total number of discrete subjects of commentary per paper, but is less than the sum of all individual comments.

Figure 1. Instructor Comments on 237 Science Writing Assignments



While the percentages offer a useful summary, they mask the inconsistency in feedback practices I observed across papers. About 15 percent had few or no comments but were covered in the tell-tale red check marks of a skimmer searching for key words. At the other extreme, several different instructors edited heavily for style, marking both indisputable errors and non-erroneous stylistic preferences without distinction. Some professors marked sentences as awkward; others made no comment even on sentences that I was unable to parse even after several readings. Among papers with marginal comments, the number varied widely with as many as 100 distinct comments in the case of a mock-case report for an entomology course, 75 of which concerned sentence-level errors. Some professors clearly chose to ignore the bulk of errors when faced with papers strongly disfigured by spelling, grammar, and usage issues. In multiple instances of papers graded without rubrics, the only way I could make sense of a student's grade was by assuming that word choice, usage, and idiom as well as grammar and punctuation had been completely ignored; that is, the grade was very high while my reading of the paper was actively impeded by disfluency and sentence-level errors. Many professors did use rubrics for grading, and these rubrics were included as part of the portfolio submission. Some of these rubrics indicated as much as 27 percent of the total score assigned to issues of proofreading and mechanics. Most rubrics assigned credit to grammar, mechanics, and style in some form, though some did not. Considering that a majority of professors assigned one to six out

of 20 to 100 total points for some version of "spelling/grammar/syntax" on grading rubrics, most then made a disproportionately large number of comments on an element worth so few points. With such a variety of practices, it seems no wonder that many undergraduates are confused about what constitutes "good writing" in the sciences.

Bean argues for commenting along "a hierarchy of concerns, descending from higher-order issues (ideas, organization, development, and overall clarity) to lower-order issues (sentence correctness, style, mechanics, spelling, and so forth" (2011, p. 322). Before addressing lower-order issues, it behooves professors to focus on higher-order issues. Both Haswell's (1983) study on "minimal marking" of student errors and Bartholomae's 1980 study on student's self-correcting behaviors when reading aloud suggest that a majority of students' surface errors arise from laziness or sloppiness, not from lack of knowledge. While few deny that these errors are still problematic, they do not necessarily reflect areas in which students need correction or instruction as much as, perhaps, convincing of the value of proofreading and professionalism, or revealing incidences of cognitive overload (Schwalm, 1985).

My limited survey suggests that science professors are spending a great deal of time and energy on lower-order concerns that distract from their ability to instruct on the higher-order issues of organization and reasoning and, moreover, issues of scientific discourse that can be taught uniquely in these classes. Important though clean surface mechanics are to professional science writing, they are not the areas in which students most need instruction in their upper-division major courses. Haswell's (1983) report on "minimal marking" famously showed that his students could locate and correct sixty to seventy percent of their surface mechanical errors when prompted to revise. I suspect that the percentage of self-correctable errors could be even higher in the papers I have studied, as students are increasingly likely to commit superficial linguistic errors when challenged with increasingly difficult and complex writing tasks (Schwalm, 1985, p. 631). Given the challenge of writing in an unfamiliar genre while employing complex scientific language and discussing difficult concepts, errors in language use and sentence structure are likely to increase as compared with a student's best efforts in a more familiar, less-specialized genre, but students are likely to recognize these "silly mistakes" as incorrect. In other words, if students are failing to understand something, it is almost certainly not low-prose language issues but scientific concepts and scientific discourse. And while the importance of clean mechanics is likely to be reinforced in lower- and upper-division classes across the curriculum, scientific concepts and discourse are not. Independent courses in science writing are becoming more common either as electives or requirements in undergraduate science curricula, but are far from universal; even were they universal, the expectation that students will learn the complexities of scientific writing in a single class is unfounded. Professors cannot assume that students will learn how to write as scientists outside of their upper-division major courses.

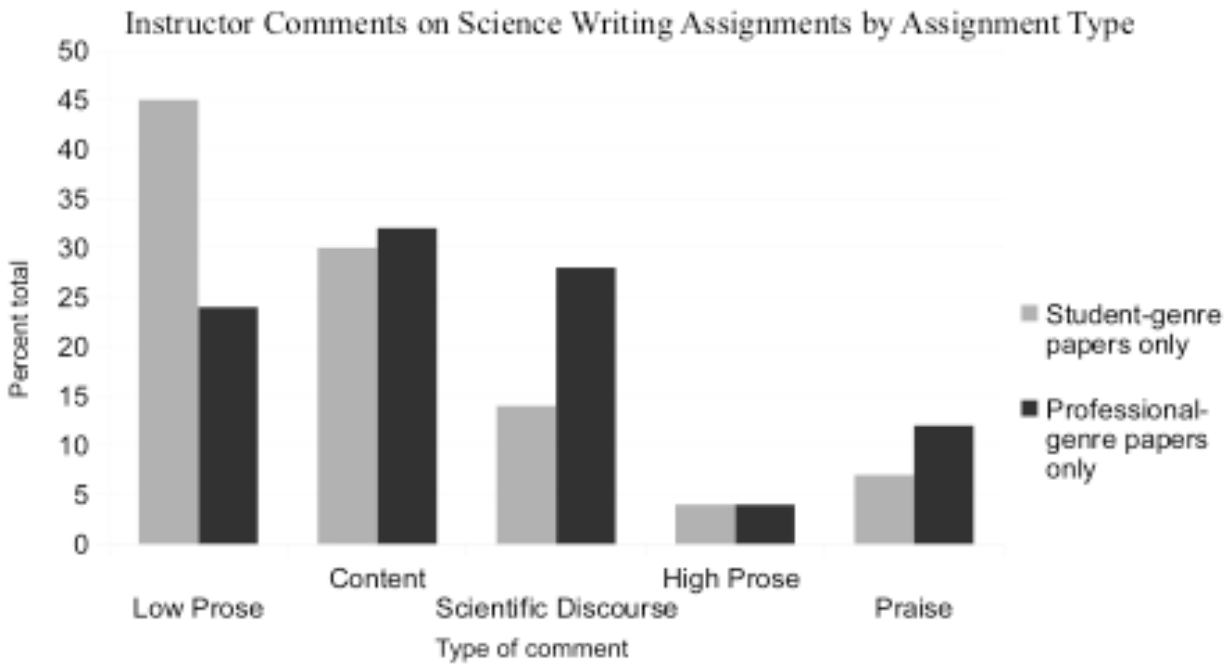
Several stand-out papers, notable first of all for the quality of the student's writing, led me to realize that not only were these papers unlike the majority, but they were like each other. Every assignment in my corpus could be classified as either a professional-genre or a student-genre paper. 215 out of the 237 papers I evaluated were written in the made-up genres that dominate undergraduate writing: the research essay (brief or long, with or without citations), student-styled lab reports — designed to demonstrate a student's understanding the function of a lab exercise rather than to present and interpret new findings, also brief or long, most often without citations — and short-answer homework questions. These genres disappear after graduation, whether students are headed for graduate school or industry employment. The remaining 22 papers — 9.28 percent — were deliberately constructed to mimic types of writing done by professional scientists: wildlife management plans, a case history written as for a medical journal, several manuscripts prepared

exactly as for submission to the journal *Genetics*, and lab reports closely mimicking the style of a professional experimental report complete with an appropriate number of references, for example. (Anson and Dannels make a similar distinction, in their assessment of communication assignments in a food science department, between "industry simulation assignments" and "academic/graduate school preparation assignments," 2009.)

The comments on these few mock-professional assignments were by far the most interesting. A representative example amongst the mock-*Genetics* manuscripts showed evidence of the writer making a real effort to try on the scientist's role; though the writing suggested an undergraduate's still-incomplete conception of how to situate an experiment in the body of existing research, could have been better organized, and included some errors in terminology, it showed far more development in all of these areas than did even the best of the student-genre lab reports. Taking on the role of imaginary editor, perhaps, the professor focused feedback on those areas in which only an "expert insider" could comment. Out of 35 comments, five related to content, 14 to scientific discourse — matters of terminology, notation, formatting of figures, or organization of methods and results — and 14 to "low prose." Unlike the sentence-level comments on most papers, however, even these low prose comments largely concerned spelling and capitalization of species and gene names or proper italicization and similar style points germane specifically to scientific writing.

These observations correlating genre with style of feedback proved generalizable. Considering solely the 22 papers written in professional genres (Figure 2), the percentage of comments pertaining to scientific discourse doubles from 14.46 percent (for all 237 papers) to 28.13 percent, with a near-corresponding decrease in "low prose" comments from 44.15 percent to 23.75 percent and the remaining difference made up by modest increases in content and praise comments.

Figure 2. Instructor Comments on Science Writing Assignments by Assignment Type



Applying Beaufort's schema to the natural sciences, Patchan, Schunn, and Clark describe five types of knowledge necessary for effective science writing: "discourse community knowledge, subject matter

knowledge, genre knowledge, rhetorical knowledge, and writing project knowledge" (2011, p. 166). Alaimo, Bean, and Nichols describe a similar set of knowledges germane to "discourse community knowledge" including "subject matter knowledge," "genre knowledge," "rhetorical knowledge," and "writing process knowledge" (2009, p. 18). The standard undergraduate lab report or term paper does little to prepare students in any of these areas save, perhaps, subject matter knowledge. While the format of an undergraduate lab report gives a nod to the formal scientific research article, the resemblance is superficial. Its content neither requires nor invites critical thinking about scientific literature, nor does it ask students to write for the scientific community: "the problem with lab reports is that they encourage students to think and write like students rather than like professionals" (p. 20). In a study of how public health students develop as professional writers, Clark and Fischbach observe that students are well-trained in writing for a student-teacher dynamic in which their job as students is to regurgitate information upon request (2008, p. 25). This writing is dramatically different from that of a public health professional charged, for example, with convincing a specific audience to exercise more or make dietary changes.

While it is tempting to imagine that qualities inherent in professional-genre assignments facilitate feedback higher on the hierarchy of concerns, nothing in my observations could explain why students and professors were responding differently to professional-genre versus student-genre papers, nor why professors were motivated to assign one versus the other in the first place. Professors who assign professional genres may be more inclined to offer higher-order feedback, independent of the genres they assign. They may spend more time coaching students or give students more time to write the professional-genre papers. Students may be more interested in writing these papers or be motivated, perhaps, by the idea of tongue-lashings from an imaginary journal editor. The uniformity of apparent purpose amongst these assignments — expressly asking students for apprentice-professional scientific work — strongly suggested that intentionality in assignment design carried over to intentionality in responding. Based on my catalogue data, however, I could only speculate on the attitudes and intentions of the professors whose assignments were represented in my sample. To investigate those attitudes and intentions more directly, I interviewed five of the professors who assigned professional-genre papers included in my corpus. What I found is that these faculty did indeed articulate a clear sense of intentionality and value toward how they teach with writing that connected their writing-intensive pedagogies with both their course objectives and their response strategies.

Interview methods

I selected interview subjects via an email query sent to the professors for whom the papers I examined in the first part of my study were written. Though I addressed my query to every professor identified in my initial study still teaching at the university (a few had moved or retired), conspicuously, only members of the minority who assigned professional-genre papers responded positively to my request. I met with three in their campus offices; a fourth interview was held at a local pub and a fifth occurred via email. Interviews took approximately thirty to sixty minutes and were semi-structured: for the four in-person interviews, pre-determined questions served as guides and starting points for conversations that were largely open and driven by what the faculty members felt was worth discussing; for the email interview my initial questions provoked long narrative responses that extended beyond the boundaries of the questions. Two faculty members came from the department of natural resource sciences and one each from entomology, environmental studies, and the college of pharmacy. Interview responses were hand-coded for common themes.

Interview results

Though the five professors I interviewed came from four different departments, taught entirely separate courses, were at different stages of their careers (from young assistant professor to full professor nearing retirement; all were tenure-track), and had all devised their approach to teaching with writing independently, several points of commonality emerged across interviews in terms of how they spoke about writing in their classes that ultimately relate to the feedback they offer students. The following five general principles emerged as common themes.

#1 — Writing is a process that incorporates revision.

> I'll tell the students I'll look at what they write and comment on them as many times as they'd like….If I had the opportunity I would re-give the students every opportunity to revise, and to rewrite, and to improve their writing skills.
>
> [I] start them early with a proposal around week five so that you know where you're going with this is not simple….What makes it successful is that they're starting very early, and they've talked about other projects in the same way.

All of these professors spoke of writing as a process that extended through the length of the course and involved multiple scaffolded elements. Four out of five professors spontaneously mentioned providing students with the opportunity to revise (the fifth mentioned revision when asked), even though only two of the four teach designated writing-in-the-major courses for which they are officially required to integrate revision. Bean notes that, in the many WAC faculty development workshops he facilitates, attendees tend to have one of two approaches toward providing feedback on student writing: the majority mark surface errors with an "editing orientation… the more numerous the errors, the less apt the teacher is to comment on anything else," while a minority make comments "oriented toward revision" (82). These are not overlapping philosophies; instructors tend to have one or the other. The professors I interviewed have clearly interiorized the revision orientation as a philosophy underlying their response to student writing including the feedback I analyzed.

#2 — Writing students do in class is connected to the writing professional scientists do in the field.

> The whole course is designed around professional development…so that you can walk the walk and talk the talk.
>
> My point is they need to have something — so it's a capstone class for our major, and it's required for graduate students — so they have an example of their writing that they can show to someone when they're trying to get a job.
>
> If you're a silviculturist and you can't write, you're never going to get your prescriptions accepted…writing is crucial

All of the professors clearly articulated that effective professional writing is important to their students' immediate and long-term future success and talked about communicating that point to their students. The persuasiveness with which these instructors made this connection and the

passion with which they infused their assertions supports the hypothesis that students may indeed be motivated to invest more time and effort into the writing they produce for these instructors out of a belief that doing so will improve their ability to function as professionals. Moreover, the faculty are responding to student writing with apprentice-professional writing as an express outlook.

Susan Peck MacDonald argues that students move through four stages en route from high school to professional writing: first, "nonacademic writing," then "generalized academic writing concerned with stating claims, offering evidence, respecting others' opinions, and learning how to write with authority" (which Bean argues is the goal of first year composition), thirdly "novice approximations of particular disciplinary ways of making knowledge," and finally "expert, insider prose" (MacDonald, 1994, p. 187; Bean, 2011, p. 228). These professors are transparent about presenting writing assignments to their students as an opportunity to work with "novice approximations" toward "expert insider prose," constructing writing as a bridge from college-level to professional work. They described employing problem-oriented writing assignments that expressly asked students to engage with "discipline-appropriate research questions" (Bean, 2011, p. 229) in a way that forces students to put on the role of apprentice-scientist rather than master student.

#3 — Good writing is connected to good thinking.

> I feel really strongly about the need for students to be able to express the ecological observations in writing…it seems to make a difference in how much the students actually develop and retain in the course.
>
> The process of writing consolidates your thoughts and helps to put them in order.

All five professors consistently discussed writing as an integral part of their teaching objectives, not a stand-alone or isolated element tacked on to their pedagogy. The three most senior professors indicated that they continued to emphasize writing in their courses not only because they see writing as an important professional skill, but also because they have seen student learning improve with student writing. Their feedback practices emerge, therefore, out of a strong ethic of valuing writing.

#4 — Writing assignments occupy substantial time and grade value.

> I give quite a bit of credit to students for their writing, and they seem to like that…they seem to think it's easier than taking an exam…I think that the writing reinforces their understanding better than exams.
>
> I feel that students should be writing on a weekly basis, or a semi-monthly basis to keep topics fresh in their mind and to keep writing — expressing.

All of the professors emphasized that their students are required to write frequently and consistently throughout the semester, either on multiple short assignments or on multiple stages of longer and more extensive assignments. They reinforce this message that writing is worthy of time and effort, both on the part of the students and on the part of the instructor, by allocating at least thirty percent of the total course grade — and as much as one hundred percent in the case of one senior capstone course — to writing assignments.

#5 — Feedback does not ignore low prose issues, but is primarily concerned with students' scientific thinking.

> What I tell the students is this…I expect to see a paper with excellent spelling, punctuation, grammar…I simply expect that…I'm not going to go through and red mark all of that…I'm looking for conceptual understanding, organization…Students do tend to rise to that expectation.
>
> [For otherwise good papers with lots of easily correctable surface errors, I'll give] really good scores, but I will comment on the surface error stuff.
>
> I often use essay grading as a time to have a conversation with a student.

It is an academic commonplace that "science teachers are more willing than humanities teachers to excuse stylistic infelicities if the content is accurate," (Haswell, 2006) and yet matters of sentence construction comprised nearly half of the majority of science professors' comments in the corpus I examine above. When asked specifically about what types of feedback they provide on students' papers, the professors I interviewed attested that they comment on everything from content to scientific rhetorical devices to grammar and mechanics, but that grammar and mechanics are minor concerns. The consensus among these professors was that sentence-level errors are a problem and one for which they will lower a student's grade, but that they give higher-order concerns of content, support, and organization much more weight. One, quoted above, remarked that she simply expects students not to submit work marred by surface errors because she assumes that they have already mastered the skills necessary to do so. When pressed to say what she does when students don't "rise to that expectation," she insisted that only a handful of students in her multi-year tenure of teaching the course we discussed had turned in papers she deemed sub-standard. This professor also emphasizes peer-review and multiple drafts as students work on their writing over nearly the entire duration of the semester-long course.

Their responses suggest that all of these professors have independently generated a philosophy of commenting resembling Bean's "hierarchy of concerns, descending from higher-order issues (ideas, organization, development, and overall clarity) to lower-order issues (sentence correctness, style, mechanics, spelling, and so forth)" (2011, p. 322). Again, Bean argues that the utility of this hierarchy is that students are encouraged to revise for large-scale conceptual issues rather than focus on editing minutiae. Extrapolating, comments on scientific discourse should likewise focus students' attention on those concerns. While my initial data set provides evidence that this is, in fact, what these professors do, it was not a foregone conclusion that they would consciously articulate this philosophy. They do.

Implications for using writing in upper-division science courses

Genres exist as repeated, similar responses to repeated, similar situations. Smith argues that the end comment to the first-year composition paper exists as a stable genre, and that this is so not because instructors have been trained to generate it, but because of the relatively stable repeated rhetorical situation of responding to student papers (1997). If professors in the natural sciences are highly divergent in their commenting practices, then, perhaps it is not because they have not been trained in effective response techniques but because they do not share a sense of how writing is being used and what it, and feedback, is intended to achieve.

While these data are far too limited to suggest any sort of causal relationship, they do point toward an association between asking students to perform apprentice-professional writing, feedback that supports that transition to discipline-specific writing by focusing on science writing-specific concerns, and attitudes congruent with — though developed independently of — contemporary composition theory. Perhaps this conclusion is not surprising. Condon and Kelly-Riley demonstrated in their 2004 study of the oft-assumed connection between writing and critical thinking competency that writing alone did nothing to improve the sophistication of students' critical thinking. Only when instructors assigned writing deliberately and consciously designed to improve critical thinking (as measured by a broadly-applicable, problem solving-based rubric) did students' writing exhibit corresponding improvements as measured by a corresponding rubric. Students are only likely to produce apprentice-professional scientific work when called upon to do so, and instructors' comments are part of the environment that asks for that type of work.

My study is limited by involving only one institution — a university with a long-standing and well-regarded culture of writing but no formal WAC program independent of the general university writing program. As a case study, however, it suggests that the benefits of working with science faculty to tailor writing exercises to disciplinary discourses — apprentice-professional writing rather than just writing in general — extend to a better environment for responding to student writing. Too, that some science faculty independently develop approaches to writing built around such principles as revision and writing as valuable and integral, expressly aimed at developing disciplinary discourse, offers evidence that this approach can be a good fit in biology.

Scholarly recommendations that professors attend to higher-order concerns above and before sentence-level errors, that they comment more through praise and reader-based observations than through criticism or direct corrections, and that professional genres be used to teach writing in the disciplines are not new — composition has been taking these recommendations seriously since at least the early 1980's and arguably earlier. Nevertheless, this exploratory study suggests that such recommendations are not being effectively communicated to instructors in the sciences even as these instructors are being encouraged by WAC initiatives to incorporate more writing into their teaching. WAC as a movement has directed its majority efforts toward encouraging a general culture of writing, with notable success. That so many papers in my corpus come from classes *not* officially designated as writing-intensive is encouraging: biology faculty are teaching with writing even when not compelled by the constraints of a course distinction. As a movement, however, it may not be equally successful in engendering a coherent sense of the purpose toward which that writing should be directed in the natural sciences, or engaged in the sort of collaborations that would improve understanding both by faculty in composition and in the disciplines of how writing works in disciplinary contexts. But more important than instruction or lack thereof in best practices, the lack of coherence in professors' commenting practices points toward the absence of a shared context for employing writing.

Telling science faculty to change their feedback practices makes feedback one more item on a list of things that composition faculty do "right" and science faculty do "wrong," one more opportunity to reinforce the much-bemoaned "missionary" model of WAC education (Bazerman, 1991; Condon and Rutz, 2012). Helping science faculty teach with writing aimed at disciplinary professionalization — through which more constructive feedback evolves — naturally moves toward a "consultancy" model through which engagement with WAC helps science faculty achieve their writing-related goals while recognizing them as experts in their professional disciplinary writing. Cataloguing comments from similar upper-division science courses at a university where such a consultancy model has been strongly espoused and where WAC programs focus on discipline-specific writing would be useful to

test whether science faculty on a whole comment more on scientific discourse and whether the divide between student- and professional-genre assignments holds true.

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