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CLOSING THE GAP: A PRACTICAL GUIDE TO SCIENCE IN THE WRITING CENTER

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At the undergraduate level, science writing can be perceived as technical, dense, and even incompatible with the pedagogy of Writing Centers. Students are often unaware of the power and necessity of scientific writing as a tool for communication and conceptual understanding, despite a wealth of theoretical work that highlights the importance of clear communication, argument, and rhetoric in science. Our effort to create a science-specific program within the Erica Mann Jong '63 Writing Center at Barnard College has indicated that Writing Centers can play a strong role in reframing scientific communication, and that doing so can lead to positive outcomes for students. Writing centers can and should take advantage of their ability to build students' confidence in communicating and creating a bridge between rhetorical skills learned across disciplines. In a successful science conference, the student is given space to discuss their writing, and is able to come to her own conclusions about how best to improve the communication of ideas. In creating this experience for science students, writing centers can broadly support the development of science literacy skills, creating a future generation of competent scientists, and moreover a generation that is able to better understand the implications of science communication in day-to-day life. This paper details our specific approach to science writing in the writing center, with the hope that it can provide a blueprint for others looking to diversify the ways in which they serve students across disciplines.

In order to support undergraduate science students, it is important to understand that science writing is taught primarily through mimicry. Students are presented with example lab reports/review articles along with a rubric and often expected to stitch the two together to formulate a mental schema for successful science writing. Intentional writing instruction is much less common, despite research showing that science students benefit from writing instruction at primary and undergraduate levels (Brownell et al. E9). In one analysis, the only factor found to influence performance on scientific writing metrics was previous experience, indicating that students require practice and experience in this area in order to be successful at writing required in undergraduate academia and eventual careers in scientific fields (Jerde 37). This pedagogical 'gap' can be filled by Writing Centers; we can create space to think about writing more intentionally (both within and beyond their curriculum), and promote scientific literacy skills rooted in critical reading and writing. By working across disciplines, we can provide students with a toolkit to understand evidence of all kinds (numerical or written data), create sound conclusions, and make rhetorical choices that support and empower their arguments (Brownell et al. E6).

In order to achieve these goals, we have recently implemented a program made up of trained undergraduate writing tutors with an academic background in science. We held open dialogues with science professors, science students, and current writing tutors in order to best support students in developing the communication skills required in scientific disciplines. Our "Science Fellows" now work with students on introductory lab reports, mid-level reports and reviews, and upper level thesis work. We have chosen to partner with a small selection of classes longitudinally and work on all assignments for the semester via one-on-one conferences. We have also performed workshops for science and non-science courses in order to promote data literacy and discipline specific writing skills. Additionally, we have introduced open hours (some by appointment and some drop-in) specifically for science assignments, with the intention of creating trust between students and the Writing Center, and to combat the notion that science does not belong in writing center spaces. Our goals are ambitious. We want nothing less than a cultural change at our institution, wherein writing is prioritized and even enjoyed by students. We hope to see writing assignments as components of our curricula that are valued by instructors and students alike for their capacity to improve knowledge and create necessary toolkits for communication. Students should be able to look at their experimental data and feel confident in their own analysis and its presentation, as well as their ability to evaluate and execute ways to improve it. By conferencing with students and emphasizing the process of writing as something dynamic and collaborative that requires time and self-criticism, we are beginning this shift. We hope to convey that our Writing Center is capable of handling the discipline-

specific issues in science and supporting all students. In a short time, we have seen a huge increase in students using our services, with more science students attending writing conferences every semester.

Our experiences indicate that Writing Center pedagogy, with a focus on non-directive and inclusive pedagogy that emphasizes the writer's agency, can be applied to scientific writing (with some minor modifications) in order to improve writing performance, and create important interdisciplinary connections for students. Science-specific writing tutors are not practical at all institutions. Instead, Writing Centers should aim to offer services that are useful and accessible to science students. This requires a flexible pedagogical approach, recruiting tutors from varied academic backgrounds, and an understanding of science pedagogy at the undergraduate level.

An Explanation of Scientific Writing Structure

Science writing and other academic writing have much in common. Both emphasize structure as a way to direct and guide readership. However, science writing is often viewed (by students and academics alike) to be more rigid, uncreative, and limited than other academic writing. However, this is not necessarily the case. Like all academic writing, scientific writing strives to draw accurate conclusions based on evidence. Instead of a claim rooted in textual analysis, science uses more numerical/empirical data to draw conclusions. Students should be encouraged to use a common set of rhetorical skills to analyze evidence across disciplines and create sound conclusions. However, it would be remiss to purport that scientific writing is structured identically to all types of academic writing. Scientific writing tends to follow a more prescriptive structure, though the general flow of information follows a similar pattern: general context and knowledge from the field narrows to the writer's own evidence and analysis, then its importance is explained to provide context. The specific sections of a scientific report outlined in Appendix B show the rhetorical purpose of each section.

Most academic writing contains structure that serves a rhetorical purpose. Scientific writing is similar to other academic writing in this way. So why is the perception of undergraduate scientific writing so negative? It may be attributable to the difference in style expected in different fields, as previously described. Scientific writing is often expected to be concise to the point of sparseness. The voice of the reader is supposed to be nearly undetectable. Instead, the flow of the information in the report is designed to appear unbiased as though it is a self-evident truth from the data at hand. It is worth noting that these conventions are loosening in academic journals (J.T. 33), but undergraduates are still often taught the most rigid version of scientific style. This does not account for the many nuances in scientific data—any conclusions can be biased by how the data was collected, the initial question that was asked, the evidence from the field that was presented, and more. By mischaracterizing the scientific process within the positivist version of writing, this anti-rhetorical writing pedagogy blocks scientific creativity, criticism, and discourse. In writing centers, we should strive to educate students who are critical of rigid communication requirements across disciplines. Working with Writing Center tutors can help students to understand the underlying purpose of science writing conventions, and find ways to have agency within them.

Concerns with Student Writing

In order to best serve our students, we worked to acquire discipline-specific knowledge by understanding of how writing works in science courses across departments. We worked with a group of science, writing, and English professors alongside members of the Writing Center to create the theoretical structure backing our efforts. Our conversations about writing in science yielded some concerns with student work that across scientific disciplines. We now work to identify these concerns when working with students, and help students understand the way to improve their work in terms of the concerns their professors identified. The three most common concerns from these professors, and the ways we work to address them, are as follows:

Clarity

We have worked to formulate ways to discuss both higher-order structural clarity, and more microscopic sentence-level clarity with student writers. We most commonly address issues of structural clarity while working with introductory lab courses. In these conferences, we utilize the 'bowtie' structure (see fig. 1 in Appendix A) as a basic guide to organization. Our conversations with professors have indicated that clarity and the scientific structure posed here are inextricable. This framework provides clarity by organizing the ideas into a universally understandable flow. When discussing the structure in a conference, we prompt students to create an outline (or reverse outline an existing work) according to this framework, while discussing ways to synthesize individual facts

gleaned from research into an organized and rhetorically powerful argument.

We focus most on sentence level clarity when working with upper level students, who have written and read a larger number of scientific articles, and are familiar with basic conventions like the bowtie structure. When discussing these issues, we often use terminology developed in "The Science of Scientific Writing," including the idea of topic and stress positions (Gopen and Swan 552). This framework (see fig. 2) guides students to think about sentence structure and clarity as inextricably linked. It is an attempt to break down the expectations of a reader, and provide a way to structure one's own rhetoric around the reader, thus creating a clearer format to present data.

Finally, the third way we consider clarity in the science conference is by reframing it in terms of the audience. This involves asking the student to consider the audience: what do they need to know? We often ask students to consider an audience of their peers: how would they communicate to peers, and how would that change their work so far? We have found that this framing seems to result in students noticing places where their writing is unclear. Of course, reifying the audience is a fundamental Writing Center strategy, but it has particular utility in science, where students are often overwhelmed by the concepts and therefore struggle to organize their presentation. We particularly developed this model after hearing an emphasis from professors (in our meetings with them, and while conducting joint workshops in their classrooms) on considering the specifics of the audience and how to write for them. This method allows students to address the higher order concerns of both scientists and writers when considering communication.

Organization

While the notion of organization is inextricably tied to clarity, our conversations with science professors indicated that there is a discipline-specific distinction between the two. In order to support students with improving their ability to organize their writing, we first came to our own understanding of the rhetorical structure of a scientific article (see Appendix B). We have found significant value in breaking down the utility of each section with our students. This often gives a foothold in a slippery world, and allows them to evaluate their own work more critically. Moreover, we encourage writers to use it to their own advantage by interesting and convincing their reader of the value and necessity of their work in the introduction and discussion sections.

This can be challenging because students often struggle with the guidelines/rubrics provided, and cannot discern just how broad to be when providing general context, how much detail to include, and how/when to integrate evidence from various sources with their own data. Obviously these are difficult questions, and it often falls out of the scope of a Fellow's purview to answer these questions when posed directly. However, prompting students to think about the argument inherent in the structure of the article can sometimes provide a sense of what information to include. Asking students about how they use the framework to communicate, and reflecting the experience of the reader often leads to a productive moment wherein the student sees an area of misunderstanding or friction in her own work. This can sometimes be the most useful part of a conference, since it allows the student to catch and prevent their own errors, without requiring the Fellow to be directive or professor-like.

Scientific Tone

The third major problem that we identified amongst science writing students is a lack of understanding of 'scientific tone'. Much like we did with organizational issues, we wished to break down the vagueness of this term into tangible guidelines that students can apply to their own work. Instructors often focus on the following:

1. Grammar, particularly verb usage
2. A removal of the author via word choice
3. Concision when discussing the scientific style.

The difficulty of discussing grammar in a writing center conference has been well documented (Bibb 92). However, in this context it becomes even more challenging. Within an already rigid framework, the grammatical and stylistic rules governing this type of writing seem like one more arbitrary rule that students feel compelled, by the power of the rubric, to follow. We look to be the student's ally in this: how can we help them catch their own mistakes and promote writerly habits of revision and editing? Science students are notorious for completing their writing assignments at the last minute, possibly trusting that the strength of their science will carry them through their assignments. However, by working with classes on rough drafts, we are automatically promoting revision and self-reflection. During our conferences, we convey these conventions of tone: using the past tense and passive voice to describe their methods, using 'objective' language designed to remove the perception of

authorial bias, and concision as tools to access the scientific discourse community.

The discussion of style is further complicated by the fact that students frequently believe that scientific style requires deft usage of high level vocabulary and conceptual understanding. We find that this fear can be alleviated by prompting students to answer clarifying questions that get to their ideas in simpler terms. In students, this anxiety indicates a deeper misunderstanding of the purpose and form of science writing. Some students feel that they must "write like a scientist" in terms of vocabulary but often ignore the writerly habits of organization and revision that underlying professional writing. In being able to communicate in the standardized language of science and utilize habits of strong writers, we hope that students will access higher-level scientific knowledge, and be able to manipulate these writing conventions to strengthen their rhetoric.

Strategies for Working with Science Students

As we have worked toward building a science-specific program in our writing center, our Science Fellows have developed several strategies to best serve science-writing students. While these are variations of techniques commonly used in conferences and not necessarily specific to a discipline, this practical guide should help writing tutors who are uncomfortable with science writing gain a sense of how to use their existing tools in this context. Like any conferences in our writing center, we emphasize relationship-building with the student, and we promote their agency over the work via non-directive pedagogical strategies. We attempt use specific questions to get to the heart of their ideas, and then create necessary deliverables via an outline or a written plan for work moving forward. These specific strategies provide insight into the ways we have found to create connections with science students.

Our Fellows have found that one of the largest barriers between writing tutors and science students is purely linguistic. The terminology of science is often perceived as dense, dry, and complicated. At times, this can be true, but there is a great value in simply asking the writer to define the terms and explain scientific conceptual underpinnings to a naive reader. This process yields fruitful conversations about the student's understanding of the concepts at hand, provides the tutor with the necessary knowledge, and points our areas requiring growth and development on the part of the student. Students sometimes feel frustrated with this, especially those who hold the notion that writing tutors are unable to support science writing. We have found that explaining our practices and making things transparent to students helps to create trust between student and Fellow, and eases some of these tensions.

Another key component of these conferences is being able to defuse student anxiety. While this can certainly be a part of any conference, we feel that there is a higher level of fear and anxiety around writing in lab courses. This may be due to the lack of formal instruction, leading students to feel adrift. It may also be due to the pressure placed on students who are pre-health in these courses, or on those attempting to meet requirements for certain majors. One way we have found to be effective, beyond providing comfort and connection to other resources at the school, is to ask the student to push the paper away and simply speak about the experiment. Doing so can help disconnect from the perceived flaws in the writing and simply formulate her own thoughts about the experiment and its significance. We also work to frame the way we discuss these assignments in productive terms. We often discuss them as "practice" or "exercises" designed to help understand the structure of more complex science writing. This seems to reduce student anxiety since it emphasizes the role of practice and repetition, instead of making the student feel that it should be a perfected, professional quality report. Reducing student anxiety can often yield a more productive conference, where students are open to feedback and willing to revise their existing draft.

We have also found that using resources during a scientific conference can be more necessary than in others. Our Fellows frequently use published journal articles as reference to help clarify the feel of the scientific style, or to show how the structure of the report mirrors the assignment the writer is working on. We also use handouts showing the bowtie structure explained above, and help students create a visual diagram of how their ideas could fit into it. We hope that creating a bridge between undergraduate and professional work helps students see the value in scientific writing, and their own ability to "write like a scientist."

Conclusions

The power of language to facilitate entrance into discourse communities and access knowledge is significant. Competent scientists must be able to wield scientific writing as a tool to create spaces for collaboration and creation of new knowledge, a necessary part of a career in a variety of fields (Mogull

357), and of a successful student experience (O'Donnell 51).

In the modern world of "fake news" and scientific misinformation, these skills are important for non-science students as well. It is necessary to train writing tutors in skills around science communication, and to help disseminate them on campus. Being able to appropriately understand and analyze data can counteract the current lack of science literacy and fear of data that seems prevalent in certain communities today. Scientific literacy skills are fundamentally compatible with general writing center pedagogy: both encourage critical thinking and self-evaluation. Our experiences simply show the importance and capacity of shifting writing center discourse to empower students across disciplines.

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Appendix A

Figure 1

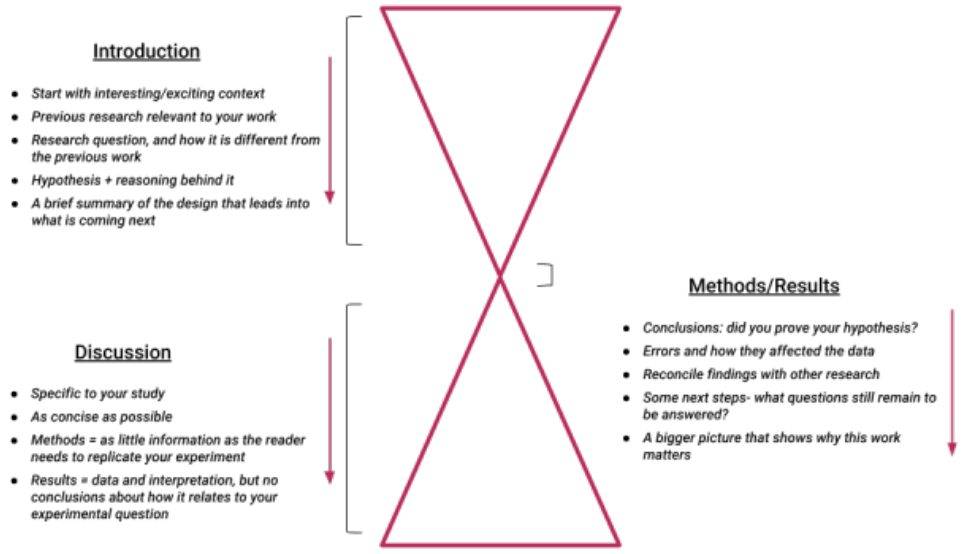

Figure 2

Appendix B
Scientific Writing Structure

The specific sections of a scientific report are outlined below to show the rhetorical purpose of each section.

Abstract
The abstract should provide the reader with a summary of the experiment. The summary should provide broad context for the necessity of the work, a brief sense of the methods and results. It should also clearly state conclusions and implications of the work. Students frequently struggle with deciding what information should be included since concision is highly emphasized in this section.

Introduction
The introduction is intended to provide macroscopic importance for the experiment at hand, present relevant knowledge in the field, and identify a gap in the existing knowledge that the experiment sets out to fill. Then, the writer typically presents a hypothesis (backed by relevant scientific evidence) and a brief summary of the experiment.

Methods
This section is typically the briefest and most technical portion of the report. The writer is obligated to present only the barest minimum of information about how the experiment was performed. It is typically assumed that a reader is similarly educated and can follow the procedure without excessive details.

Results
The results section, like the methods, is typically fairly sparse. The experimenter is expected to present the raw data and statistical analysis. This data is typically reported both in text and via a visual medium such as tables or graphs. In this section, it is generally not expected that any conclusions (particularly with regard to the previously stated hypothesis) will be formed or explained. Some commentary on the accuracy of the data can be included.

Discussion
The discussion section is typically the most verbose section of a report. Here, the writer should form some conclusions about their data and provide evidence for their rational. Any errors in the experiment should be addressed, as well as avenues for further experimentation. This section should also provide macroscopic importance for the experiment and connect to the broader questions being asked in the field at large. Students tend to struggle with the distinction between this and the results section, though professors prefer concise delivery of data in the results, with subsequent explanation and analyses in the discussion.