

ARTICLE

“Brevity is the Soul of Wit”: Use of a Stepwise Project to Teach Concise Scientific Writing

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Skillful writing is essential for professionals in science and medicine. Consequently, many undergraduate institutions have adjusted their curriculum to include in-depth instruction and practice in writing for students majoring in the sciences. In neuroscience, students are often asked to write a laboratory report in the style of a primary scientific article or a term paper structured like a review article. Typically, students write section by section and build up to the final draft of a complete paper. In this way, students learn how to write a scientific paper. While learning to

write such a paper is important, this is not the only type of written communication relevant to scientific careers. Here, I describe a stepwise writing project aimed to improve editing, succinctness, and the ability to synthesize the literature. Furthermore, I provide feedback from the students, and discuss the advantages and challenges of this project.

Key words: undergraduate; science writing; editing; peer review; and poster presentations

Learning to write well is extremely important for undergraduate students majoring in Neuroscience. For example, neuroscientists must be able to explain their work clearly and effectively in publications and grants. Consequently, proficient writing is a skill that many graduate programs seek in a candidate (Appleby et al., 1999; Appleby and Appleby, 2006; Fischer and Zigmond, 2004). Neuroscience majors going on to other careers such as medicine will also benefit from learning to write well (Holmes et al., 1992; Chur-Hansen, 2000). Given the importance of early training in scientific writing, College and University undergraduate curricula often emphasize writing in the sciences. For example, many students receive initial instruction in a “writing in the disciplines” course and/or in an introductory laboratory course. For introductory laboratory courses, students are typically asked to write up a laboratory report in the style of a primary scientific article. Model papers are given as examples to follow, and students write each section of the paper individually then build up to the completed report. Extending time and focus on each section can be a successful teaching technique. For example, Holstein et al. (2015) demonstrated an improvement in science writing, specifically genre knowledge, with the use of a scaffolding approach that incorporated repeated writing assignments, substantial focus on each section, and consistent feedback from the instructor. Others have also shown repeated practice in writing to be particularly helpful in improving science writing (Birol et al., 2013).

At Stonehill College, Neuroscience majors are asked to write in early science courses including a first-year introductory biology laboratory and a second-year “writing in the disciplines” course. The introductory laboratory course uses a structured and scaffolding approach. The paper is a write-up of a standard lab that all students conduct. Students are given explicit instruction on how to write each section, and students practice writing individual sections. After receiving instructor feedback on practice

sections, students combine all sections of their lab write up as a rough draft that is subject to peer review and graded for feedback by the instructor before the final draft is completed. The “writing in the disciplines” course is set up in a similar fashion. Thus, students have had practice with science writing before entering their upper-level courses. Despite this preparation, students often continue to struggle with science literacy and writing, especially the ability to analyze and synthesize the literature. Therefore, I designed a stepwise writing project in my mid/upper-level Neuroscience/Biology course that gives students practice writing in a way that differs from the structure of their previous courses. Specifically, I focus on guiding the students to use fewer words, yet add more in-depth content to their writing. I intentionally incorporate practices proven to be effective strategies for teaching science writing to undergraduates such as repetition (Birol et al., 2013; Holstein et al., 2015), team work (Singh and Mayer, 2014), and peer review (Prichard, 2005; Senkevitch et al., 2011; Stellmack et al., 2012).

MATERIALS AND METHODS

Course Description

The current paper describes the stepwise writing project that took place in Endocrinology (BIO 324) at Stonehill College over two semesters (spring 2016 and spring 2017). Enrollment in the course was 15 students in 2016 and 22 students in 2017. I was the instructor for the course each semester. At Stonehill, Endocrinology is taught as an upper-level “cluster course” for second-fourth year students majoring in Neuroscience and Biology. For Neuroscience majors, this course is an option among three other courses that focus on physiology and behavior. Biology majors can choose the Endocrinology course among eight others for their Molecular/Cellular course requirement. Although most students in the course are Neuroscience or Biology

Date	Assignment	Description
Week 3	- Choosing groups	<i>Collaboration and group work:</i> Groups consist of 2-3 students and students will work in their chosen groups throughout the semester.
	- Choosing a hormone and researching that hormone	<i>Research:</i> During lab time, groups chose a hormone that must be unique from the other groups. The groups begin their literature search in lab that day. These tasks are often difficult even for upper level students. Thus, the instructor should facilitate the process of choosing a topic and researching the literature.
Week 5	- Writing assignment 1 is due: Each <u>student</u> hands in their own independent essay	<i>Independent writing:</i> Each student writes a description of their chosen hormone that is no more than <u>500</u> words. This essay provides background of the hormone addressing questions such as: What is the biology of the hormone and why it is important to understand this hormone?
	- Peer-review	<i>Reviewing and editing:</i> Members of each group switch papers and provide constructive criticism during lab. Students receive instructions on how to perform an effective peer review. This assignment serves many purposes one of which is that students learn how to edit their peer's work in a professional manner. Another, is that the members of a group will learn more about their chosen hormone by reading their peer's description, which will help to transition to the next aspect of the stepwise project.
	- Choosing an aspect of research about your hormone on which to focus	<i>Narrowing the focus:</i> During lab, each group works together to narrow the focus to one aspect of research on their chosen hormone. Having read each other's description of the hormone helps to determine what aspect might be of interest to the group. Again, the instructor should facilitate this decision in lab and help to initiate the research on this newly focused topic.
Week 9	- Writing assignment 2 is due: Each <u>group</u> hands in a new paper	<i>Writing concisely and synthesizing the literature:</i> Each group writes a description of their hormone, which synthesizes the literature germane to the aspect of research the group chose to study. This assignment must be no more than <u>250</u> words. Interpreting and synthesizing the literature is extremely challenging for students, especially with a 250-word limit. However, this assignment teaches the students how to write succinctly. To facilitate the process, the instructor should provide feedback on early drafts.
Week 10	- Writing assignment 2 is graded and returned	<i>Instructor feedback:</i> The writing assignment is handed back so that the students receive written feedback to help with the next part of the project.
	- Poster guidelines	<i>Poster information:</i> Students receive instructions and a handout that describes how to approach creating and presenting their posters. For posters, students use the knowledge of their topics to develop a hypothesis, design a test of that hypothesis, and present data as though they had run that experiment (they do not actually perform experiments). The students are also given examples of different posters that will help to understand expectations.
Week 15	- Poster presentations	<i>Final written and oral communication:</i> In groups, students present their posters to the other student groups, the instructor, and other faculty members of the Neuroscience program and Biology department.
	- Peer-review	<i>Consistency in peer-review:</i> During rounds in which a group is not presenting, members of that group will listen to poster presentations from other groups and fill out an evaluation of the poster and the presentation.

Table 1. Timetable and description of assignments for the stepwise project. See Supplemental Material for samples of the 500-word essay, the 250-word essay, and the poster. Samples of early drafts of the 500-word essay and peer reviews are available upon request.

majors, students majoring in other disciplines (e.g., Biochemistry and Interdisciplinary Studies) have chosen to take it as an elective. The course is four credits and has a lecture and laboratory component. Content focuses heavily on neuroendocrinology. In the laboratory, students learn relevant neuroanatomy, and lecture emphasizes topics such as neuroendocrine axes as well as the neuroendocrinology of obesity and stress. Most students in the course are interested in attending medical school, or graduate school for research or an allied health profession after graduating from Stonehill.

Timetable and Grades for the Stepwise Project

Students work on the stepwise project at various times throughout the semester. Some of the work is done during

the laboratory period while other aspects are completed outside of class time. The laboratory meets 1 day/week for 2 hours and 50 min. Table 1 summarizes each assignment and provides a timetable throughout the semester. The project is introduced during the third laboratory meeting and culminates in a poster presentation during the last week of laboratory. The students work in groups for the duration of the project; however, writing begins as an independent assignment. The peer review, 250-word essay, and poster are graded. Rubrics for these assignments can be found in Supplemental Material. In total, the project is worth 50% of the lab grade. The lab grade comprises 25% of the total course grade. Thus, the project accounts for 12.5% of the course grade. Grades and evaluation scores are provided as the mean \pm the

standard deviation of the mean in the Results section.

RESULTS

What Students Learn from the Stepwise Writing Assignment

Some assignments of the stepwise project are familiar to students whereas others are new. The first part of the stepwise project is to choose a topic, which is often new to students. In earlier Stonehill classes, students are given the topic or lab about which they write. The stepwise project is designed to help students learn to choose an interesting topic by starting with a broad topic. In small groups, the students chose a unique hormone. I facilitate this process by providing a list of hormones and their general actions in the body (Norris and Carr, 2013). I also encourage the students to explore titles and abstracts of papers describing hormones in journals such as *Hormones and Behavior*, *Endocrinology*, and the *Journal of Neuroendocrinology*. Each student is asked to write a 500-word essay about the hormone using the literature. This gives all students an opportunity to learn about their hormone and to practice writing.

The 500-word essay is not graded, but I do provide written and oral feedback. In addition, feedback is given by peers. In their small groups, students swap papers and perform a peer review. This teaches students to develop analytical skills, to become better proofreaders, and to become more comfortable with the kinds of editorial processes that might be encountered in their academic or professional career such as a reviewing an article or book. Peer reviews are done during lab time thereby allowing me, as the instructor, the opportunity to answer technical questions (e.g., corrections on citation style), writing questions (e.g., verb tense, flow, and use of citations), and project questions (inquires specific to the hormone chosen by the group). A unique feature of this project is that the peer review encourages students to use the knowledge garnered from revising each other's papers not only to improve their own writing but also to further develop their project as a group. Hence, the information and perspective of each individual paper helps to shape the future of the project, which is often how professional projects evolve.

Directly after the peer review, students are given the next assignment of the stepwise project, which guides them to advance the project. For this assignment, students must narrow their focus to a specific aspect of study about their chosen hormone and review the literature. Additionally, they are required to use more scientific articles and fewer words (250-word limit). The 250-word essay is the most novel aspect of the stepwise project and arguably the most challenging assignment. Rather than building up section by section, students must cut the number of words in half. Moreover, students must change the way they approach describing the literature. In their early writing, students tend to describe one study at a time rather than synthesizing the literature. For this assignment, however, students must analyze the literature, choose the studies essential to their new topic, and synthesize those studies. Students are given four weeks

to complete this assignment, which allows time to meet with me for feedback as they are writing. These meetings occur during lab time (especially during assay incubations) and time outside of lab. As a result, the writing becomes more mature and demonstrates a deeper understanding of the literature, which is reflected in their titles (Table 2) and their grades (2016 average grade was 92.7% \pm 3.56; 2017 average grade was 90.7% \pm 3.77).

Final Project Title
The Relationship Between Epinephrine and Stress-Induced Cardiomyopathy: A Characterization Study
Kisspeptin Stimulates Luteinizing Hormone and Follicle Stimulating Hormone Release Through Hypothalamic-Pituitary Projection That Helps Initiate Puberty
Effect of Estradiol on Attention and Focus
A Therapeutic Potential of Prolactin on Postpartum Depression
Dosing Patterns of Biosynthetic Human Growth Hormone on the Occurrence and Severity of Hypertension
Melatonin Agonist as Treatment for Insomnia
Mutations of the Human Chorionic Gonadotrophin (hCG) Pathway that Lead to Hyperemesis Gravidarum

Table 2. Examples of final poster titles for the stepwise project.

The authors of the book "How Learning Works: Seven Research-based Principles for Smart Teaching" (Ambrose et al., 2010) describe choice and flexibility as powerful factors for motivating student learning. The stepwise project applies this concept in its design and provides the students with time, choice, and flexibility throughout the project. The most dramatic decisions usually happen over the course of the four weeks while the students are working on their 250-word essay. Students will often take advantage of the given time, choice, and flexibility by changing the focus of their topic (see samples in the Supplemental Material). Sometimes students will change to a new topic involving an entirely new hormone. This provides the opportunity for students to learn more from their research and to take ownership of the project as a team.

The final assignment of the stepwise project enables students to apply what they learned from reviewing the literature and to be critical and creative by developing a novel hypothesis about their topic, designing how to test that hypothesis, and sharing their ideas in a poster presentation. Thus, students must evaluate the significance of the studies they have read and determine how the research should progress. This means that the students are going beyond simply summarizing the literature. Furthermore, students perform a written evaluation of their peers' posters and are asked to evaluate their own work. Therefore, students learn the importance of consistency in self and peer evaluation. Students are given ample time (five weeks after receiving written feedback on the 250-word essay) to work on their poster. During this time, students are encouraged to meet with me for feedback on early drafts of the poster. Like the 250-word writing assignment, students typically perform well on their poster presentation (2016 average grade was 93.2%

± 3.88; 2017 average grade was 95.3% ± 2.19).

Student evaluations of the stepwise project

Students were asked to complete a voluntary and anonymous survey to evaluate the stepwise writing project at the end of each semester. Surveys were intended to learn student attitudes toward the project and student opinion about the effectiveness of the project.

A major goal of the stepwise project was to teach succinct writing. Using a standard Likert-format scale, students were asked to evaluate whether they thought the stepwise project accomplished this goal. Over the two semesters, 84% (n = 31) of students responded. Ninety-four percent of respondents agreed or strongly agreed that the stepwise project improved their ability to write succinctly. Student responses were similar between 2016 and 2017. On the standard 5-point scale where 1 indicated strongly disagree and 5 indicated strongly agree, the average score in 2016 was 4.38 ± 0.65 and the average score in 2017 was 4.41 ± 0.52. Figure 1 shows the distribution of answer choices in 2016 and 2017.

Furthermore, students were asked to reflect on their experience with the stepwise project. Students were also asked to compare the stepwise writing project to other writing assignments in the past, particularly the lab report of the introductory lab and the “writing in the disciplines” course. Seventy-six percent of students from both semesters (n = 28) responded to this question. Ninety-three percent of respondents stated that they preferred their experience with the stepwise writing project to previous writing assignments. For example, one student wrote “I would prefer the use of the step-wise project because many other classes use a longer term paper, preventing students the chance to expose themselves to other types of writing that allow for the development of different key skills. This particular step-wise assignment

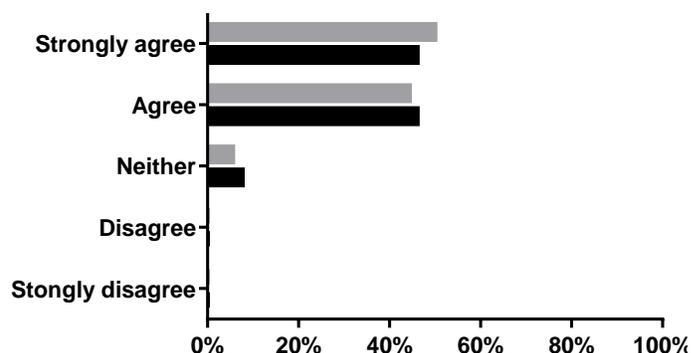


Figure 1. Student responses to whether they thought the stepwise project improved their ability to write succinctly. The figure depicts the percent of respondents making each choice in 2017 (grey bars) and 2016 (black bars).

was more elaborate and advanced than some similar projects in other classes because it allowed for students to become more critical, analytical, and learn how to be succinct. From this project, I felt trained to understand that there is a vast majority of information about a particular topic, but I need to sift through what's valuable and important for my particular research aims which is a skill I really wasn't able to expound upon in any other class.”, and another student commented “The step wise project prevented me from procrastinating. I was able to work overtime instead of rushing, leading to a better final product.” Interestingly, another student wrote “I personally love both ideas.”, which indicates that this student realized value in both approaches. Common themes arose among comments about the stepwise writing project, and included: (1) It helped to guide ideas; (2) it promoted in-depth learning of a topic; (3) group work facilitated learning; (4) consistent feedback was very helpful; and (5) the timeline of the project fostered learning. Table 3 provides example quotes from the students for each theme.

Theme	Quotes from student comments
Helped guide ideas	“... it [the stepwise project] helped guide our ideas of what we wanted to do and really learn a lot about one specific topic.”
Promoted in-depth learning of a topic	“The stepwise project helped me understand the topic. In order to be very succinct in giving a summary of my topic and just provide the necessary details I had to really understand the topic. After reading scientific papers I had to be able to select the most important details and put these into my own, abbreviated words. I would prefer the step wise project instead of a term paper because not only did it hold me accountable to keep up with the project, it also made me understand the topic to a deeper level and prevented me from simply regurgitating things I read in the papers.”
Group work facilitated learning	“The step-wise project allowed my group members and [me] to preform our own research and then come together as a group and talk about what we found. By doing this we were able to learn from each other.”
Consistent feedback was very helpful	“I like the stepwise writing assignment because it was a good structure that allowed for constant feedback”
Timeline of the project fostered learning	“I think doing it in steps really helps with stress of doing a large project but also gives us more time to really learn more about the hormone we chose and all the effects of it. I would prefer to do a step-wise project because then it forces you to do everything in a timely manner. When I am tasked in writing a long term paper it is usually done by the last second and reads terribly. In the step wise manner, we gained a lot of feedback every step of the way and it improved our writing in science...”

Table 3. Common themes and examples of student comments about each theme.

DISCUSSION

Advantages of the stepwise writing assignment

There are many strengths to the stepwise design. For example, the design incorporates the style of “writing as professionalization” (WAP) in ways that are familiar to the students such as the conference poster (reviewed by Moskovitz and Kellogg, 2011), and in ways new to the students such as the 250-word essay. However, the 250-word assignment also integrates WAP by teaching writing skills that are relevant to different forms of professional communication. For example, being able to synthesize the literature is important for writing primary articles (abstracts, introductions and discussions), review articles, grants, and book chapters. Furthermore, succinctness is useful when writing a lay summary, narrative, personal profile, news brief, or meeting summary. Editing and reviewing skills are valuable for various professions including that of a professional science editor. Students may also gain a more immediate benefit by accruing skills that prepare them for future or concurrent coursework. For example, one student commented that the stepwise assignment “prepares people who have to do post boards for other courses.” Post boards are short online blogs assigned in two upper-level Biology courses, Virology and Developmental Biology.

I am particularly impressed with the depth of the end products produced for this project. Students typically start rough, yet work their way to outstanding 250-word essays and posters. Their skills choosing, analyzing and synthesizing studies improve dramatically over the course of the semester. Poster presentations are known to work well in neuroscience courses (Adams, 2011), and use of the stepwise writing assignment helps to guide students to comprehensive posters. For example, I invite other faculty members of the Neuroscience Program and the Biology Department to the poster session, and I have received enthusiastically positive feedback about the high quality of the students’ work from all attending faculty. At the poster presentation, I ask each student to comment on their favorite aspect of the poster. Most responses reveal their dedication to the project. Common answers include (1) they learned something interesting/important about their topic, (2) they want to conduct their experiment because they sincerely think it will advance science, and (3) the most significant aspect of the project was the process itself, especially working out and revising details within their groups.

Student feedback indicates that the stepwise writing project enhances the course. Ninety-six percent of respondents commented that they enjoyed the project and most thought that it strengthened their writing skills. Furthermore, many students commented that they preferred this writing project to other writing assignments in previous courses. It would be useful to evaluate the degree to which the stepwise project impacts student writing on future writing tasks. Although not done in my course previously, a way to quantify how well the project improves student writing in general could be to compare writing grades on reflective writing pieces or answers to

essay questions on exams given before and after the writing assignments.

Disadvantages of the Stepwise Writing Assignment

The stepwise writing project is not as comprehensive as a writing in Neuroscience course. There are clear benefits to having an entire course dedicated to writing in Neuroscience (Adams, 2011). However, the Neuroscience program at Stonehill College has few faculty members. These faculty members also teach courses for their respective departments such as Biology and Psychology, which leaves little room for a dedicated writing in Neuroscience course. Neuroscience is a growing and evolving program and we may add such a course in the future, but at present Neuroscience majors learn to write in an introductory laboratory course and a “writing in the disciplines” course, which is currently Cell Biology. The stepwise writing project described in the present paper is not intended to replace these Stonehill writing courses, each of which teach critical first steps in learning to write primary science papers (Holstein et al., 2015). Rather, the scope of the stepwise writing project is smaller in nature. It is designed to add to what the students have learned from their previous writing experiences and to enhance a cluster course to meet certain goals. These goals are to provide practice with (1) concise science writing, (2) analysis and synthesis of the literature, (3) developing a hypothesis, and (4) creating and presenting a poster. In addition, the stepwise writing project is potentially the first time in which a Stonehill Neuroscience major can choose to write about a topic in Neuroscience (Neuroendocrinology) in a course taught by a Neuroscience faculty member.

Despite its relatively small scope, the stepwise writing project carries a heavy workload for students and the instructor. Constant instructor feedback is key to the success of the project (see Table 3). Therefore, it is not necessarily a practical choice for a course with many students. I have worked with students on this project in class sizes ranging between 12-22 students. To help with workload and to provide another perspective, I often refer students to the writing center and to the science librarian.

Conclusion

Overall, I think the stepwise project is successful in many ways. I find the students practice editing, writing succinctly, and synthesizing the literature more using this method than any other method that I have used. Moreover, the students enjoy this method. As mentioned in the Results, it gives them choice, time, and flexibility. The freedom of time and choice means that students discover a topic they find interesting and important, which is motivating. The built-in flexibility allows students to modify their choice as they explore the literature. Because the assignments are broken-up and short in terms of word count, they are not overwhelming. This gives students the space to wrestle with editing and synthesis, which makes for more interesting and well-reasoned hypotheses and posters in the end. As a result, most students respond that they enjoyed working on their project and that they enjoyed

learning about the other group projects. I believe that the stepwise writing project described in the current paper can be a valuable addition to a cluster-type course that, among its learning objectives, aims to improve writing and science literacy skills.

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