

ARTICLE

Using Blogs as Practice Writing About Original Neuroscience Papers Enhances Students' Confidence in Their Critical Analysis of Research

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Increasing emphasis is being put on providing students with opportunities to read and write about primary scientific literature in undergraduate neuroscience education. Extensive research has indicated that students' attitudes and self-efficacy as well as writing quality improve when they are provided with opportunities for practice and feedback. Here we tested the value of using a blog format to practice writing about scientific research articles. Students were assigned small groups and did work on their own individual schedules to build toward time allotted in class to discuss the articles with their groups. Our goal was to build confidence in the students' ability to read and analyze original research articles. We found that the students in the junior-level Systems Neuroscience course had high confidence in their ability to read and analyze papers at the end of the blogging experience. Surprisingly, however, this

did not manifest in a change in quality of final, higher stakes, written reports on original research articles when compared to a control sample from a previous year that did not include the blog assignments. We conclude that blogs provide a useful format for students to discuss research articles collaboratively while building confidence in their ability to analyze and discuss original neuroscience articles. Although the final reports' quality did not change compared to the earlier offering of the course, we believe that the blog experience is a valuable tool for building confidence and creating a positive experience for students in learning to read and analyze original neuroscience research articles.

Key words: systems neuroscience; primary literature; assignment scaffolding; blogging; essay writing; STEM education; scientific analysis; critical reading; self-efficacy

There is increasing awareness that skills in scientific writing and critical analysis of scientific research are vital for students finishing with college degrees in science (Osborne, 2010; Hoskins et al., 2011; White et al., 2013; Verkade and Lim, 2016) and can help prepare them for future academic work (Kozeracki et al., 2006). In addition, as facts become increasingly available to students, there is growing need to teach students to critically analyze scientific methods and data rather than just teach by conveying and testing factual information (Hoskins and Stevens, 2009; Hoskins et al., 2011; Verkade, 2015; Krauss, 2017). Undergraduate students still find engaging lectures to be valuable, despite the significant amount of time they spend immersed in information online when not in class (O'Keefe et al., 2017).

The questions we face as educators include: first, how to best make material taught in class relevant in a world where factual information is easily accessible to most students on devices that are always within arm's reach; second, and how to help students build the skills to be critical readers of data (Aoun, 2017). We believe that an important part of this is to challenge students with reading and analyzing primary literature. However, as this requires different skills than just memorization, it raises a new challenge: how to help students build these skills while also learning about neuroscience.

We have previously used small-scale introductory seminar courses to teach students neuroscience facts in conjunction with analysis of primary literature (Willard and Brasier, 2014; Brasier's contribution in Harrington et al., 2015; O'Keefe & McCarthy, 2017; Brasier, 2017). Here, we sought to understand how a scaffolded approach involving multiple small-stakes assignments in which students

critically analyze original research articles in the form of blog posts (see: Kestigan, 2017) would impact final, high-stakes, critical analysis reports on an original research article. We also sought to relate students' self-perceptions of their ability to read and understand original neuroscience research articles to their completion of the blog assignments.

Extensive research indicates that students' ability to succeed at difficult tasks benefits from instructional scaffolding: a process by which larger tasks such as reading and comprehending a scientific article is practiced in smaller, directed assignments with feedback before students are required to work independently and produce a final product (Ambrose et al., 2010; Sato et al., 2014; Köver et al., 2014).

Humanities disciplines, such as philosophy, have traditionally focused heavily on critical analysis and written discourse; however, recent years have seen an increase in primary-literature-based pedagogical programs in neuroscience and other life sciences (Hoskins et al., 2011; Willard and Brasier, 2014; Sato et al., 2014; Köver et al., 2014; Harrington et al., 2015; Verkade and Lim, 2016; O'Keefe & McCarthy, 2017; Brasier, 2017). In addition to classroom settings, these literature-based approaches can supplement laboratory courses (Carter et al., 2017). However, studies into students' approaches to read and write about primary literature reveal that many students are inefficient and not systematic (Verkade and Lim, 2016). This highlights the need to systematically teach students to interpret data effectively (Aoun, 2017; Cammack, 2017).

A variety of methods have been employed to help students to better approach scientific reading and writing

including: facilitated classroom discussions of research articles (Hoskins et al., 2011; Willard and Brasier, 2014; Sato et al., 2014), scaffolded grant proposal assignments (Köver et al., 2014), and editing Wikipedia articles about neuroscience topics (Burdo, 2012). We chose to use blog assignments for low-stakes practice and feedback providing students with the opportunity to do most of the work on their own schedule (posting and responding to blog posts at their convenience within the constraints of the assignment deadlines). This allows collaboration with peers. Blog and web forum posts in general are formats that are likely familiar to a generation of students who engage regularly online (O’Keeffe et al., 2017).

In order to test the impact blog assignments as a form of repeated, low-stakes assignments on students’ attitudes towards reading primary literature and their success in writing about primary literature, we assigned students in an intermediate-level core Systems Neuroscience course to write multiple short blog posts as practice and preparation for a larger final report (Krause, 2005). This has been previously used in philosophy courses (Long, 2010; Skipper, 2011; Kestigan, 2017), but hasn’t been tested to our knowledge in neuroscience or other life sciences courses. We found that students report substantial confidence in their ability to read and analyze neuroscience research articles at the end of our course. Students also performed well on final written reports, but not significantly different from the high performance on the same assignment in an earlier semester taught without blog assignments as a scaffold.

MATERIALS AND METHODS

All human subjects research was approved by the CMU Institutional Review Board (protocol number STUDY2016_00000148).

Course Description and Student Population

This study was conducted in a regularly-offered full-semester (three hours of class-time per week for 15-weeks) course taught in Spring 2017: Systems Neuroscience (03-363, taught by DJB every two years in alternation with other instructors). This course serves as a core requirement in the Neuroscience major and also as an elective in other majors and minors including Biological Sciences, Psychology, and Neural Computation. The course requires students to have completed one of the following prerequisites: introductory neuroscience, human physiology, or cell biology. The course had 60 students who completed the course (7 biology majors, 33 neuroscience majors, 7 psychology majors, 6 cognitive science majors, 3 dual biology/psychology majors, 1 computer science major, 1 math major, 1 statistics major, and 1 undeclared student in humanities and social sciences; 12 seniors, 32 juniors, and 18 sophomores). Final performance on research article reports was evaluated against the same course taught 2 years earlier (also by DJB). That course had 66 students who completed the course (9 biology majors, 25 neuroscience majors, 6 psychology majors, 4 cognitive science majors, 13 dual biology/psychology majors, 3 computer science majors, 2 math majors, 1 electrical

engineering major, 1 social and decision sciences major, 1 business major, 1 undeclared natural science major; 20 seniors, 32 juniors, and 14 sophomores).

Full course descriptions and syllabi for the Systems Neuroscience course Spring 2015 and Spring 2017 offerings can be found as Supplementary Materials 1 and 2. Briefly, the course consisted of the following units: a review of basic cellular neuroscience, sensory systems, motor systems, and motivated behavior. In both offerings, approximately ~50% of class time was spent with traditional lecture material punctuated with ~15% of the time spent active learning including small group discussions of problems and think-pair-share activities related to the lecture material (Freeman et al., 2014). In Spring 2015, the remaining ~35% of the class time was spent on instructor-led discussion of relevant original research articles. By contrast, in Spring 2017, ~30% of the class time was spent on instructor-led discussion of relevant original research articles and the remaining ~5% of class time was spent with students discussing original research articles in their assigned blog groups (see “Blog Assignments” below).

Blog Assignments

In Spring 2017, we adapted a version of the scaffolded blog writing assignment used by Kestigan (2017). Four blog assignments were given during the semester in lieu of four of the traditional homework assignments given in previous years. Students were pseudo-randomly assigned to groups of three, stratified across academic year and major.

	Blog 1	Blog 2	Blog 3	Blog 4
Add'l reading	Sample blogs	Merzenich, 2000	Sherman, 2016	Young and Wang, 2004
Paper 1	Han et al., 2017	Tomita et al., 2013	Crandall et al., 2015	Liu and Wang, 2003
Paper 2	Dantzker and Callaway, 2000	Cooke et al., 2015	Mease et al., 2016	Beery and Zucker, 2010
Paper 3	Celik et al., 2004	von Melchner et al., 2000	Viaene et al., 2011	Lim et al., 2004
Paper 4	N/A	Poo and Isaacson, 2009	Audette et al., 2017	Lim and Young, 2004

Table 1. Articles used in blog assignments. Sample blogs were written from Bender et al. (2006) and Kravitz et al. (2010). Instructors should also see the contributions by Harrington and by Stough in Harrington et al. (2015).

During each of four units in the course, a set of three instructor-chosen research articles (Table 1) was posted to the class Blackboard site (<http://www.blackboard.com/>); due to changes in course enrollment, some groups were shuffled after the first blog leaving a single group of four students who were given a 4th article to use for their group only (this group

didn't like this modification and would have preferred to have been split into two groups of two, see Supplementary Materials 8). The group members determined which among them would write about each of the assigned papers.

Prior to assigning each set of papers, time was spent in class discussing any methods in the papers that had not been previously covered. Supplementary Materials 3 and 4 show the first and last blog assignments and timetables given to students to illustrate the progression of assignments, including breakdown of points used to grade the blog assignments. In addition to the assignments, students were required to evaluate their peers to help build accountability for work in groups (Supplementary Material 5; Millis and Cottell, Jr., 1998; Oakley et al., 2004). In brief, the first blog assignment required students to summarize an experiment and pose questions about methodology and content; the second assignment required students to add a more formal statement of the research hypothesis, more completely spell out the methods and results, and identify an assumption made by the authors; the third assignment required students to add explicit links between hypothesis and results and to propose a follow-up experiment rather than just a general follow-up question; the fourth assignment was identical to the third with the goal of providing additional practice in the short format before the longer individual reports.

After the students completed each set of blog assignments, 30 minutes of class time was devoted to recapping the main points of the papers in their assigned groups, followed by 30 minutes of instructor-led discussion of the main points of each paper. In addition to grading the blog assignments, the teaching assistant (TS) provided feedback to students about the quality of their writing and clarified questions that had not been answered during the small group discussions.

Final written assignment

About 2/3 the way through the semester, students in both years (2015 and 2017) chose an original, peer-reviewed research article in neuroscience. They then were required to complete a report in which they described the hypothesis, results, limitations, and proposed a follow-up experiment. The assignment was the same for both terms (see Supplementary Materials 6 and 7 for full assignment and grading rubric that were distributed to students in both terms). In order to compare across the two terms, Spring 2017 reports were submitted electronically to the instructor (DJB) and then mixed randomly with anonymized, archived submissions from Spring 2015. The combined, shuffled, anonymized set of reports was then given to the Spring 2017 teaching assistant (TS), who graded all reports from both terms together with instructions to follow the rubric that had been made available to students in both semesters to aid in preparing their reports (Supplementary Material 7). Scores were then de-anonymized by the instructor (DJB) and matched with student names and terms. Statistical comparisons were run using R-studio.

Four students were excluded from analysis in Spring 2017, and three students in Spring 2015, because they did not complete the final report.

Collecting Data about Student Perceptions via Focus Group
At the end of class time the class period before the final report was due, thirty-five students participated in a feedback session for the course run by an independent facilitator from CMU's Eberly Center for Teaching Development (Dr. Emily Weiss, see acknowledgements). The instructor and TA left for the session, and students were informed that individually identifiable responses would never be revealed to the instructor or TA.

After splitting the class into small groups, the facilitator briefly explained the focus group process (for details see Supplementary Material 8, reprinted with permission from correspondents). One person from each group wrote down the students' responses to the following two general questions: "What are the strengths of this course that are helping me learn?" and "What specific suggestions do you have for changes that could improve your learning?" Students were asked to reflect on the blog assignments and their usefulness both with respect to class exams and in preparation for the written assignment that they were finishing up.

Students were also asked to comment on the effectiveness of the blog assignments and the value of feedback from the TA both in general terms and in their preparation for the upcoming written report. Prompts used to elicit comments on the blogging assignments included: "are they interesting, valuable (comparable to other homework assignments), helpful for individual reports, etc.?" After the small group time, the facilitator asked the class as a whole for consensus on points raised by individual groups. The results of this focus group were relayed to DJB without revealing the names of the participating students.

RESULTS

Student perceptions and confidence

A few days before the final written report was due, a focus group with 35 students from the 2017 class was run by an outside facilitator from CMU's Eberly Center for Teaching Excellence, Dr. Emily Weiss, with the instructor and TA not present (see: Course Feedback, Focus Group Report, Supplementary Material 8). Students were specifically prompted to include comments on the blogging assignments (see Materials and Methods).

One hundred percent of students surveyed felt that the blog assignment helped them learn to read scientific papers effectively (Supplementary Material 8). For example, students wrote that "it helps us learn to identify what is important [in a research article]" and "[the assignments give] you hands-on experience reading papers and learning about many topics." Additionally, 25/35 (~70%) of students voiced enthusiasm for the blog assignments as a learning tool (Supplementary Material 8 and Weiss, *pers. comm.*). Students also found it valuable that the blog papers chosen related to class material and that the main points of the blog articles were recapped in class.

In addition to the positive aspects, students felt that the discussion time was helpful to them (Supplementary Material 8 and Weiss, *pers. comm.*), but 100% agreed that the online response and recap portions were not very

helpful. Additionally, in order to match the total amount of work with previous years, blogs were assigned to replace some of the regular homework assignments in the class. Ninety percent of students present had concerns about blog assignment logistics and wanted more homework in addition to the blog assignments (Supplementary Material 8).

Final written report comparison

Our second measure of the effectiveness of the blogs was to directly test whether students in Spring 2017 (with blog assignments) performed better on an identical final report (see Supplementary Materials 6 for report assignment and 9 for grading details used by TA and published for students) than students in Spring 2015 (the comparison group who had instructor-led discussion of research articles without blog assignments). The final assignments from both Spring 2015 and Spring 2017 were anonymized and shuffled together and graded blindly by the 2017 graduate TA. Aggregate results are broken down by report sub-sections of the assignment: 10 points for introducing the hypothesis of the research article the student chose for the report, 10 points for describing one experiment performed in the research article, 10 points for describing a second experiment performed in the research article, 10 points for describing a shortcoming in the original research article, 10 points for proposing a follow-up experiment that is independent of the student-identified shortcoming in the chosen article, for a total of 50 points for the entire report. Results are shown for Spring 2015 students ($n=66$, Table 2) and Spring 2017 students ($n=57$, Table 3).

Rubric item	Range	1st-3rd quartile	Median	Mean \pm StDev
Introduction	5.5-10	8-9.5	8.75	8.6 \pm 1.1
Expt 1	5-10	8.13-10	9	9.0 \pm 1.1
Expt 2	5-10	8.63-10	9	9.1 \pm 1.0
Shortcoming	5-10	8-10	9	8.8 \pm 1.2
Proposal	3.5-10	8-10	8.5	8.4 \pm 1.2
Total score	30-50	42.1-46.9	44.5	43.8 \pm 4.3

Table 2. Aggregate scores from Spring 2015. Range, quartiles, median, mean, and standard deviation broken down by rubric item (see Supplementary Material 7).

Rubric item	Range	1st-3rd quartile	Median	Mean \pm StDev
Introduction	4-10	8-9.5	9	8.7 \pm 1.3
Expt 1	6.5-10	8.5-10	9	9.2 \pm 0.9
Expt 2	5-10	9-10	10	9.3 \pm 0.9
Shortcoming	4-10	8-9.5	8.5	8.6 \pm 1.3
Proposal	0-10	8-9	8.5	8.2 \pm 1.6
Total score	31.5-50	41.5-47.5	44.5	44.0 \pm 4.3

Table 3. Aggregate scores from Spring 2017. Range, quartiles, median, mean, and standard deviation broken down by rubric item (see Supplementary Material 7).

There was no statistically significant difference between the total score between the two semesters ($p>0.05$). Furthermore, when breaking down students by academic year, there was no significant difference found (data not shown, $p>0.05$, 2-factor ANOVA). Additionally, neither an

ANOVA nor a Kruskal-Wallis detected a difference across the different rubric items between the two semesters in mean or median, respectively ($p>0.05$ for both tests).

DISCUSSION

Lack of difference on final assignment between semesters
Several possible explanations could account for the surprising result that the scaffolded blog assignments did not result in higher scores on individual final written reports. First, it is possible that instructional feedback on the blog assignments was insufficient to help students improve. Although we cannot rule that out, we obviously hope that it is not the case. A second, converse possibility is that the common instructional methods across the two semesters led to high overall written report performance in both semesters. Additionally, in both semesters original research articles were discussed in instructor-led class time and exams required students to learn details of specific papers chosen by the instructor. These strategies (without blogs) have been demonstrated to work elsewhere (Hoskins et al., 2011; Sato et al., 2014; Köver et al., 2014; Verkade and Lim, 2016) although there exists some room for improvement in their implementation in medium-sized, advanced undergraduate lecture courses (Willard and Brasier, 2014).

Third, we cannot rule out the possibility that blogging assignments may have left some students feeling “burnt out” on writing assignments compared to Spring 2015 where there were not as many writing assignments; thus offsetting possible gains from the blog assignments. This possibility is partially supported by the fact that the mean on blog assignment 4 (5.10 ± 0.19 (SEM) out of 6 possible points) was significantly lower than the mean on blog assignment 3 (5.62 ± 0.14 (SEM) out of 6 possible points; $p<0.05$, t-test), despite them being substantively similar in difficulty (see Supplementary Materials 4). So, even though final written report grades (Tables 2 and 3) were statistically indistinguishable between semesters, blog grades dropped off at the end within the 2017 semester on its own. Although student burn-out is a realistic possibility, the fact that the majority of students wanted more homework in the course (Supplementary Material 8) makes this possibility seem unlikely.

A fourth possible explanation of this lack of difference is that the peer interactions surrounding the blog assignments left students dependent on one another for successfully reading a scientific paper and therefore did not translate into the individual written assignment, causing no improvement compared to the previous time DJB taught the course. Again, although we cannot rule this out, this seems unlikely given the extensive literature indicating that active, peer-to-peer instruction benefits learning in a range of disciplines (reviewed in Ambrose et al., 2010 and in Freeman et al., 2014).

We therefore believe a more likely explanation is that the blog assignments made students overconfident in their abilities to write about scientific articles. This confidence is indicated in the fact that 100% of students felt the blogs improved their ability to read papers (see Results). It is possible, therefore, that this confidence represented self-

efficacy that was above the students' actual abilities. In order to help students more effectively transfer what they learned from the blog assignments to the longer written format of the report, we propose, in future implementations, to modify the 4th blog assignment. As in Spring 2017, we would assign papers, but require a longer written output that is identical in structure and length to the final report, thus giving students formal practice and feedback on the longer written report format before they complete the high-stakes report on the topic of their choosing. This proposed change fits with extensive research that scaffolded instructional practice works best when it builds as closely as possible toward the final product (Ambrose et al., 2010; Sato et al., 2014; Köver et al., 2014).

High self-efficacy measures

Students were enthusiastic in their belief that the blog assignments helped them develop as capable readers of neuroscience research articles. This kind of high self-efficacy has been demonstrated to be a major determining factor in students' performance in school and ultimate career choices, especially for students from groups underrepresented in STEM fields (Maton et al., 2016; Ballen et al., 2017). Particularly of note is that high self-efficacy is predictive of future career choices in sciences (Lent et al., 1986). Additionally, self-efficacy can build motivation and thus work to enhance student learning of material (Ballen et al., 2017). Therefore, our results align with other recent work in which significant attention has been paid to pedagogical techniques that build student confidence, including previous work linking self-efficacy specifically to reading research papers and building familiarity with research methodology (Willard and Brasier, 2014; Abdullah et al., 2015; Harrison et al., 2016).

Per the students' suggestions (see Results), in future implementations, we would modify the blog assignment in future iterations. We would begin by expanding the in-class discussion to create dedicated time for all students who had read each paper meet with all the others who read the same paper. After students have checked their understanding of the paper with others who read it, they would then return to their blog group to discuss it with them (see last page of Supplementary Material 8). In addition to maximally preparing each student to discuss their assigned paper with their blog group, this would serve to remove the unpopular online "response" part of the assignment (see Results).

Overall, the assignment structure provides students a way to build their confidence in reading, discussing, and writing about scientific articles. We believe that the blog assignment is thus valuable and, with the modifications described, could serve as a useful tool for teaching students with the primary literature and helping them learn to write effective individual reports on original research articles. Our results show that students with the blog assignments do no worse than those in past years at their final written reports. Taken with the measures of self-efficacy and the added practice and preparation to read primary research, we believe that this is a valuable approach and plan to implement it again. Collectively, this leads us to conclude that the blog assignment represents a valuable and

meaningful scaffold for the students that improves their confidence and can be modified to help them achieve high final writing performance.

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