Assessing Writing in Undergraduate Biology Coursework: A Review of the Literature on Practices and Criteria

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For nearly fifty years, Writing across the Curriculum (WAC) has been growing and evolving, from disparate composition-related activities run by individual instructors to coordinated efforts across institutions that involve both writing as a process of learning and discipline-specific rhetorical practices. In this time, WAC has developed a series of principles and practices that best exemplify what the successful incorporation of writing into coursework looks like, as well as who should be responsible for this writing instruction. In the "Statement of WAC Principles and Practices" (2014), endorsed by both the International Network of WAC Programs and the CCCC Executive Committee, the onus of *disciplinary*-specific writing instruction is placed on disciplinary instructors, noting that "writing in the disciplines (WID) is most effectively guided by those with experience in that discipline" (p. 1). Such a statement makes sense superficially, but begs the question: What does that experience and expertise *look* like in practice?

In 2012, Reynolds, Thaiss, Katkin, and Thompson attributed the reluctance of Science, Technology, Engineering, and Mathematics (STEM) faculty to incorporate writing into their courses to a "lack of awareness of the research on the effectiveness of [Writing-to-Learn], since most published findings are in journals not regularly read by STEM faculty and the majority of studies use methods unfamiliar to most scientists" (p. 18). This articulation highlighted a major challenge to the WAC movement—the dissemination of best practices in writing instruction and assessments that have developed out of the WAC community's rich history of research and practice. This was also a reiteration of Chris Anson's findings in 2010 and 2011, which noted the intradisciplinary nature of WAC and Composition, despite the multidisciplinary composition of the WAC community. In his archival research, Anson sought to discover the "influence of this cross-disciplinary outreach and the extent to which it made its way into the inner workings of various disciplines" in an effort to explore "how particular disciplinary communities have adopted, adapted, and repurposed scholarship on writing and writing instruction based on their own instructional ideologies" (2011, p. 7). Anson's findings, which focus on journals in a range of disciplines (arts and humanities, social science, and science) between 1967 and 2006, noted that "WAC experts continue to exert an important influence [on content-area

specialists], [e]specially in the areas of writing assessment and digital literacies" (p. 16). However, Anson points out, this study does not give a clear idea of "the way that writing is integrated into individual disciplines or clusters of disciplines (such as the hard sciences)," and that a review of "journals within such disciplinary clusters could yield richer information about how writing is related to the epistemological orientations of specific areas of inquiry" (p. 16).

Here, I take up Anson's call by asking: (1) What conversations, if any, are taking place in the biology trade journals regarding writing and writing assessment, and (2) how do these conversations align with what WAC scholars have identified as best practices? This review of the literature attempts to answer these questions: first with an explication of the themes that became visible during the reading, and then by a discussion of the roles of writing and assessment within courses explored in this literature. These are followed by a discussion of the implications such assessment practices have both for students and writing program and WAC specialists.

Methodology

Biology courses frequently serve as a gateway for undergraduates into the various science majors. Even more, introductory biology courses are often used to satisfy non-science majors' general education requirements. For these reasons, I specifically chose the discipline of biology over subjects like chemistry or physics to begin my inquiry, making a conscious assumption that these courses would be among students' first exposure to science writing.

To assess the current discussions of writing and writing assessment in undergraduate biology education, I conducted an initial search of the dominant peer-reviewed trade journals in biology-related education: *The American Biology Teacher*, *Biochemistry and Molecular Biology Education*, *Journal of College Science Teaching*, *Bioscene: Journal of College Biology Teaching*, *Journal of Research in Science Teaching*, *Research in Science Education*, *and Cultural Studies of Science Education*. These journals were selected as a starting point based solely on their readership—they are titles that are frequently referenced in my work with science faculty. (Journal scope was consciously ignored, the rationale being that I wished to see *if* and *how* writing is discussed in the journals faculty most frequently referenced reading.) Keywords used were "biology," "writing," "writing assessment," "writing feedback," and "feedback"—intentionally chosen to parse the articles that dealt specifically with writing in the biology classroom. This search was also bound by the higher education context and by time, drawing only on the published literature between 2000 and 2015. While the first three journals yielded the highest results (see Table 1 for a breakdown of publications per journal), the remaining journals resulted in three or fewer articles each.

To get a clearer understanding of the landscape, I expanded my search to science journals in general, using both the PubMed Central database as well as Academic Search Premier. This provided literature from *CBE—Life Sciences Education*, *The Journal of Undergraduate Neuroscience Education*, *Advances in Physiology Education*, and *Science Education*. While the overall search did not omit conference proceedings from the corpus, it is worth noting that none came up in my broad search. Whether this is a result of keyword tags associated with such documents, database cataloging, or actual presence cannot be speculated on. Finally, in the interest of rigor, this entire search process was conducted twice to ensure no relevant articles were missed. In all, this search resulted in 59 articles related to the explicit use of writing within the undergraduate biology classroom since 2000. I intentionally did not parse the articles based on the acknowledged or known status of formal WAC programs at the respective institutions.

Table 1
Total number of articles related to writing published per journal between January 2000 and December 2015.

Journal Name	**Publications Found**
The American Biology Teacher	21
Biochemistry and Molecular Biology Education	8
Journal of College Science Teaching	13
Bioscene: Journal of College Biology Teaching	3
Journal of Research in Science Teaching	3
Research in Science Education	2
Cultural Studies of Science Education	0
CBE—Life Sciences Education	5
The Journal of Undergraduate Neuroscience Education	2
Science Education	1
Advances in Physiology Education	1
Total Publications	59

At the outset, I was interested to discover what types of genres might be privileged in this writing instruction, as well as what was privileged in the assessment of those genres (e.g., mechanics, content). I was also interested in whether this literature drew primarily from the scientific community proper or was written by (or in collaboration with) educators or writing specialists. The rationale for this latter query was that it might shed insight into the assessment choices authors made, as well as to whether non-scientist WAC professionals were publishing in these trade journals. As I read, I was led to other questions regarding the extent to which the authors discussed writing assessment in the articles, as well as to the role of writing as a gatekeeping or border crossing tool (Kleinsasser, Collins, & Nelson, 1994). In an effort to answer these questions, I tabulated data from each article related to my key questions, noting whether the authors explicitly discussed assessment, which genres were the focus of the articles, the mode of assessment (e.g., computerized, rubric), whom the authors cited in their theoretical framing (i.e., known WAC scholars), and any additional thoughts on the nature of the study—including author attitude toward writing. This tabulation served as the primary means of organizing and analyzing the material.

Findings

As was noted in Anson's research (2010, 2011), writing has earned a place of importance across the disciplines—and this is evident in the biology education literature, as well. With few exceptions, every article consulted for this review opened with a discussion of the importance of competence in scientific writing for a career in the sciences. Most approached the topic emphasizing commonly-shared values and concerns: Morgan, Fraga, and Macauley (2011), for example, asserted that "education in a scientific discipline should also develop scientific writing skills, so that students can systematically organize their knowledge and demonstrate this through clear communication" (p. 149); while Curto and Bayer (2005) invoked concerns of "communication deficits" in students at all levels of education as a need to incorporate writing (p. 11); and Mayne (2012) focused on writing as an "employability skill" (p. 234). Many, either explicitly or implicitly, invoked principle characteristic of WAC/WID: that "writing enhances students' conceptual knowledge, develops scientific literacy, familiarizes students with the expectations, conventions and reasoning skills required of scientific writing" (Hand & Prain, 2002, p. 737); increases understanding of and facility with rhetorical conventions of the discipline (Kokkala & Gessell, 2003; Corradi, 2012; Colton & Surasinghe, 2014); and has the potential to increase student engagement with learning (Armstrong, Wallace, & Chang, 2008; Mynlieff, Manogaran, Maurice, & Eddinger, 2014). Yet, despite the articulation of such ideologies, the assessment practices that might be expected to accompany them were largely absent.

While reviewing this selection of literature, two over-arching themes became apparent (Table 2). First, the use of writing within the classroom was employed either in service of content learning (what many labeled "writing-to-learn") or toward the development of rhetorical skill in scientific writing (an implied WID approach). Second, the use and assessment of writing served either as a gatekeeper, weeding students out of the biology-related majors, or as a border crossing mechanism, helping students begin to "realize the nuances in the differences in style and the implications of the distinctions between disciplines" (Kokkala & Gessell, 2003, p. 256).

Table 2
Distribution of articles by approach to the integration of writing in biology coursework, as well as to the function of that writing in the course.

	Border Crosser	Gatekeeper
Writing-to-Learn *(30)*	23	7
Writing in the Disciplines *(24)*	19	5
Incorporates both *(5)*	2	3

The corpus reviewed for this project could also be clearly divided between those who recognized a need to modify their assessment practices as a result of the inclusion of writing, and those who continued to apply traditional assessment methods in spite of the changes. Interestingly, whether instructors opted for a WTL or WID approach in incorporating writing did not affect where they fell in this binary. What did seem to have an effect, however, was their recognition of WAC scholarship in their theoretical framing. Authors who invoked such scholarship (e.g., Holstein, Steinmetz, & Miles, 2015; Mynlieff, Manogram, Maurice, & Eddinger, 2014; Otfinowski & Silva-Opps, 2015) tended to use assessment methods that were in line with what WAC scholarship has identified as best practices: development of rhetorical awareness, improvement through revision and over time, and making thinking visible ("Statement of WAC Principles," 2014). Those who either provided no theoretical framework (Curto & Bayer, 2005; Colton & Surasinghe, 2014; Collins & Calhoun, 2014; Singh & Mayer, 2014) or referenced other scientists' studies (e.g., Birol, Han, Welsh, & Fox, 2013; Clase, Gundlach, & Pelaez, 2010; Morgan, Fraga, & Macauley, 2011) tended to emphasize mechanics and structure over rhetorical elements or audience awareness. Table 3 notes whether assessment was explicitly addressed in the articles, what factors were of primary concern in that assessment, and which genres were privileged most across the corpus. Unsurprisingly, WID-focused pieces emphasized disciplinary genres, with the greatest emphasis being on research papers and proposals, as well as

laboratory notebooks. Writing-to-learn-focused pieces primarily drew on other, non-disciplinary genres, such as exploratory essays, blogs, and advertisements. One interesting distinction evident in Table 3 is that WTL articles overwhelmingly included assessment practices as part of the text, while WID articles were split almost evenly, suggesting an expectation that what constitutes "good" scientific writing is implicitly understood. What follows is a deeper discussion of these differences and how each played out in practice.

Table 3
The 59 articles reviewed were assessed on a variety of factors, including whether they explicitly addressed writing assessment, the genres that were privileged, and what factors were of primary concern in the writing assessment.

	Talks about assessment explicitly			
	Yes	No	Genres privileged	What is being assessed?
WTL	21	9	Non-disciplinary genres (e.g., letters, summaries, blogs, essays)	Content knowledge, clarity of ideas, mechanics
WID	14	10	Research papers, laboratory notebooks, proposals, posters and literature reviews.	Clarity of purpose, concepts, research design, and rhetorical conventions.
Both	5	0	Research papers, proposals, posters, and summaries.	

A Question of Terminology: Writing to Learn, Writing in the Disciplines, and Cases of Mistaken Identity

While the importance of writing was stated by all authors at the outset, there was wide variation in the language and use of terms to frame the use of writing in their classrooms. Some, such as McDermott and Kuhn (2011), explicitly referred to their practices as "Writing-to-Learn," while others, such as Corradi (2012) and Adams (2011), refer to the writing assignments more obliquely, discussing undergraduates' abilities

to "learn to write like a scientist" as the aim of assignments. What was clear in the reading, however, was that whether or not WAC terminology was invoked, there were varying degrees of proficiency in WAC/WID pedagogy and assessment, leading to the realization that there were some who truly employed WTL and WID in their courses, and others who were employing what might best be described as WTL- or WID-Lite.

For those approaching writing from a WTL perspective, there were clear delineations between those studies that embraced the WTL pedagogy and those that did not, with perceptions of effectiveness tying closely to that pedagogy. Interestingly, across all of the WTL-focused articles, notably few assessments related to the student writing directly. For example, Armstrong, Wallace, and Chang (2008) report that although students wrote six short essays throughout their introductory biology course—which focused on course content, were peer reviewed, and turned in to the instructor—there were no grades assigned, nor did the instructor provide any feedback. In fact, "student performance in the lecture portion of the course was measured entirely by multiple-choice exams including six quizzes (16 questions each), a cumulative midterm (38 questions), and a cumulative final (70 questions)" (p. 486). Unsurprisingly, the authors report that they could determine no impact on learning from the WTL activities: "no difference was seen between the treatment and control groups on any of the performance measures examined" (p. 489). Though they explicitly invoked writing to learn as a framework for the study, the authors relied on the act of writing in near perfect isolation to perform the heuristic role, a process that was unidirectional and omitted the feedback loop to students that is so valuable in learning. This approach approximated what John Ackerman (1993) identified as the inclusion of writing under faulty premises, believing that "writing has inherent qualities, different from other modes of discourse, that produce or tap the conversational nature of academic work" (p. 351).

Similarly, Mayne (2012) utilized reflective writing in a biology course to assess student understanding of teamwork—"The analysis assessed the ability of students to reflect on the process of working as part of a team and whether they were able to reflect critically on their own performance and that of their peers" (p. 235). The course itself included abbreviated instruction on reflective writing, being "introduced and discussed within a single teaching session" along with the provision of writing guidelines that included generic prompts, such as "How were roles assigned in the group?" and "How did members of the group communicate and share feedback?" (p. 236). Though the authors note that students were "encouraged to report on their experience and thinking as well as the personal and emotional issues surrounding managing a group activity," the overall expectation was that students would be able to implicitly learn the techniques of critically assessing themselves and others through writing (p. 236). Student success in the course was based on how well they were able

to meet the instructor's generically stated expectations. Assessment of these reflections was based on whether components were presented as "factual or descriptive," with the latter being considered truly reflective (p. 235).

Contrast these approaches with Quitadamo and Kurtz's (2006) use of writing to prompt prior knowledge in students before laboratory work, synthesize knowledge after laboratory work, and communicate knowledge in collaboration with peers. In this mixed-method study, which included a traditionally taught control group, students "were given weekly thought questions before beginning laboratory to help them frame their efforts" (p. 145). After working on group laboratory assignments, students were then asked to work together to "draft a collective response to the weekly thought question," giving them individually an opportunity to reflect on what was learned during the prescribed activity, as well as a chance to "argue individual viewpoints as they worked toward group agreement" (p. 145). These writing assignments, which were designed in collaboration with writing faculty to elicit critical thinking, composed 25% of the students' final grade (only the group essay was formally graded) and were assessed with the use of a rubric that privileged clarity of ideas, coherency, detail, and understanding of the theories in question over mechanics. Quitadamo & Kurtz's interest in this approach was not the assessment of the writing proper, but rather "whether writing could measurably influence critical thinking performance in general education biology" (p. 149). This measurement focused on the use of the California Critical Thinking Skills Test (CCTST), implemented pre- and post-course, and showed marked differences between students in the writing-intensive course and the control group who were taught with the traditional "lab notebook" approach. The results, analyzed statistically, showed that critical thinking by students in the writing group generally improved nine times more than the non-writing group, and specifically were "15 times greater for analysis and 8 times greater for inference skills" (p. 148). Importantly, factors such as age, gender, class standing, and race/ethnicity appeared not to have any effect on these gains.

In a different approach, McDermott and Kuhn (2011) use WTL activities that integrate writing to an authentic audience outside of the instructor. In their study (the practices of which are consistent with WTL theory and integration), students are given two assignments: the first, a reflection on their out-of-class learning experiences regarding a biology topic of their choice, written to a fourth-grade audience; the second, a reflection letter on their participation in a student-led presentation, written to their advisor. In both instances, the students submitted their written work to the audience directly—the fourth-grade students attended class once to give feedback on the materials, and the advisors received the letter and completed a feedback form. Each of these assignments were graded, with an emphasis on grammar and spelling, accuracy of science concepts, audience consideration, and development of ideas (p.

43). The authors report that the practices were effective in promoting student learning. In an end-of-semester survey, "90% of the students perceived their learning to be beneficially impacted" (p. 44).[1]

For those studies approaching the inclusion of writing closer to a Writing in the Disciplines line, there were similar differences in how the assessment was approached. Singh and Mayer (2014) advocated for a blueprint approach to teaching students how to write research articles, emphasizing the use of templates and sentence stem-prompts to write, as well as computer tools. For these authors, writing scientific articles well meant an understanding of organization and mechanics, with an ability to "detect inconsistencies, inappropriate text structures, unclear messages, wordy text parts, and errors" (p. 410). This slant reinforced a misconception familiar to the WAC/WID community that science writing is about inputting facts antiseptically, privileging accuracy and mechanics above all else. Morgan, Fraga, and Macauley (2011) likewise emphasized mechanics as a significant assessment measure, with genre knowledge of the laboratory report earning almost equal weight. Like many of the studies that I categorize here as gatekeepers, the instructors provided little to no instruction in the rhetorical conventions of the laboratory report, the moves scientists typically employ, or the language appropriate to the situation. The study employed an "all or nothing grading system" where students were required to implicitly learn how to write an effective report and meet the course's B+ grade threshold in order to succeed in the introductory biology course (p. 151). Here, the same misguided premise that many of the WTL studies followed occurred—believing "that the process and attributes of writing will *inevitably* lead to learning" (Ackerman, 1993, p. 352).

In a separate study, Kokkala and Gessell (2003) designed a collaborative learning community between courses in biology and courses in English, where the English students evaluated and edited the biology students' scientific writing. In this study, the English students were instructed on rhetorical considerations for writing in science and purposes for genres. Biology students wrote in discipline-specific genres (a literature review and a scientific article), and received feedback and grades from both the English students (on grammar, logic, and rhetorical awareness) and the biology faculty member (on content accuracy). While this model relied heavily on biology students implicitly understanding the rhetorical situation based on the English students' feedback, the authors report increased awareness of rhetorical situation and scientific writing conventions.

Similarly, Yule, Wolf, and Young (2010) approach the integration of writing in the biology classroom as an opportunity to both improve student writing skills and increase engagement and understanding of the course content. Providing a blueprint

1. Another curious observation of the literature was a trend in measuring student perceptions of their learning as a result of the writing activities' inclusion in the course, as well as the chosen pedagogical approaches to teaching that writing.

approach like Singh and Mayer (2014), rather than focusing on mechanics the authors instead emphasize that the main priority in assessing student writing is about responding to the content and not proofreading, noting "whatever else your feedback does, start by taking care that it does no harm" (p. 17). The authors' blueprint approach also emphasizes that instructors explicitly distinguish for students between formal and informal writing, highlighting appropriate responses for different rhetorical situations; the inclusion of clear grading rubrics to make grading "less mysterious and the writing process more productive," where grammar and punctuation receive no more than 10 out of 100 points; utilizing a textbook such as *Short Research Paper Revision Exercises Using Strunk and White*, which allows an instructor to quickly note a page number next to problematic passages in papers, leaving the student to make progress independently; and providing samples for all writing assignments, including those on exams, to act as models (pp. 17–20). In this way, Yule, Wolf, and Young make clear that the incorporation of writing into biology coursework is not additive, but integrative. By using writing as an assessment measure of content knowledge and rhetorical awareness appropriate to the discipline, the authors note that instructors create "a learning environment within which students write about, read about, and discuss course content [that] will make them more literate, [and] will also help them learn biology" (p. 20).

Calibrated Peer Review

I would be remiss if I did not mention the presence of Calibrated Peer Review™ (CPR) as a teaching and assessment tool in a few (4) of the articles reviewed (Robinson, 2001; Clase, Gundlach, & Pelaez, 2010; Birol, Han, Welsh & Fox, 2013; Mynlieff, Manogaran, Maurice, & Eddinger, 2014). CPR, a web-based writing and peer review program designed and operated by UCLA, claims to reduce the workload of instructors who assign writing as part of their course (Calibrated, 2016, n.p.). Rather than read and grade each piece of writing, the instructor (or system) provides examples of strong, average, and weak writing for the assignment. After students submit their own completed writing assignment, they are then asked to assess the three samples. This allows the system to determine the review-quality of the student—to calibrate how closely the student's assessment aligns with the instructor's (or system's). Once students are aligned, they are then given anonymous writing submissions from their peers. Students are also able to see other (anonymous) peer reviews of the same work to gain a sense of how they compared. Through this program, the creator's argue, "the pedagogy of 'writing-across-the-curriculum' [is melded] with the process of academic peer review," and "students not only learn their discipline by writing, they also learn and practice critical thinking by evaluating calibration submissions and

authentic submissions from their peers. Throughout each part of an assignment they gain a deeper understanding of the topic" (Calibrated, 2016, n.p.).

In my review of these four articles, all authors looked favorably on the use of CPR both for easing assessment, as well as assisting students in the development of their writing. Interestingly, the use of CPR was relegated solely to WTL activities and largely focused on content retention rather than rhetorical conventions. Of the four articles, only one (Birol, Han, Welsh & Fox, 2013) noted explicit classroom instruction regarding what constitutes quality writing. The rest implied that the use of CPR was additive, to increase the use of writing in the classroom without modifying instructional practices.

Gatekeeping versus Border Crossing

In their 1994 article "Writing in the Disciplines: Teacher as Gatekeeper and as Border Crosser," Kleinsasser, Collins, and Nelson highlight that instructors who integrate writing into disciplinary coursework assume (consciously or not) either a gatekeeping or border crossing role (p. 118). Gatekeepers see the assignment of writing activities as a modification to their original coursework, but "do not necessarily alter their conventional academic mission" (p. 118). As a result, writing tends to operate in a vacuum, with an assumption that the simple assignment of writing activities will "help students pass the tests which will let them through disciplinary gates" (p. 118). Border crossers, on the other hand, fall more in line with the agenda of the WAC movement, inviting a radical approach and reassessment of the use and assessment of writing in the disciplinary classroom. Border crossers "value student writing as a contribution to knowledge as well as a test of knowledge," using writing as a means of enculturating students into disciplinary discourses (i.e. crossing disciplinary borders) (p. 118).

In this review, just over a quarter the articles examined (26%) describe gatekeeping practices (practices that required students to suss out the instructors' expectations for the writing assignment), implicitly understand the rhetorical conventions of the genre in question, and then successfully compose in a way that meets both requirements. Pedagogically, such gatekeeping approaches are unfair to students, particularly those traditionally marginalized by academia, and are not accurate or valid assessments of student ability or knowledge. Yet, they persist.

This persistence might be related to the issue raised by Reynolds, Thaiss, Katkin, and Thompson (2012) in my introduction: that access to best practices in writing assignment and assessment for both WTL and WID are largely invisible to disciplinary instructors. In fact, in the review of this literature, it was interesting to discover that of the 59 articles reviewed, 40 of them (68%) were written solely by faculty in science, 16 (27%) were written by scientists in collaboration with either education or composition specialists, and 3 (5%) were written solely by education specialists.

Out of the 59 articles, as well, only 14 (24%) of them made any explicit reference to WAC scholarship in the article text, and only 6 (10%) of those did so in a comprehensive manner. Curiously, 20 of the articles (33%) did cite writing handbooks in their references, though many gave them no more attention than an in-text parenthetical citation. Instead, the authors relied on past WTL and WID studies conducted by other scientists (many referencing early works that were part of this review's corpus). Interestingly, those who did reference WAC and composition scholars by and large relied heavily on the work of Bean (2011), Pechenik (2006), and Klein (1999), with Bereiter and Scardamalia (1987) making notable appearances.

Discussion and Conclusion

The discussion of writing and its assessment in current biology education literature exists in a realm largely detached from the conversations in WAC literature, suggesting that gaps still persist between the two that require active attention. These gaps could stem from issues of communication across the disciplines—an issue raised by Susan McLeod (1989) when she wrote:

> [A]s we move toward WAC as a permanent fixture in higher education, [we need] to define our terms more carefully for our administrative colleagues, so that they understand that the term does not mean a program that is merely additive . . . but one that is closely tied with thinking and learning, one that will bring about changes in teaching as well as in student writing. (p. 86)

However, these gaps might also be directly related to epistemology, as Anson (2011) queried. In this piece I have been examining how writing—a topic that in the last thirty years has largely been examined qualitatively through a social-constructivist lens—is presented and assessed by those working in a discipline traditionally considered positivist/post-positivist and relying on empirical data that can be analyzed quantitatively. These differing epistemologies have important implications methodologically on instruction and assessment and suggest an important area of focus for further action.

Most, if not all, of the articles in this review that I designated as gate-keepers approached the use of writing in their courses as additive, without any articulated understanding of why pedagogically they might incorporate writing, as opposed to continuing along a traditional and conventional path. As a result, they saw the assessment of writing to be a frustrating process that often resulted in either no feedback, or in one-word responses, such as "Good" or "Be careful" (Gioka, 2009). A concern closely aligned with this was the under-preparedness of instructors to *explicitly teach* the rhetorical conventions of the disciplinary genres they were assigning (Gioka, 2009; Armstrong, Wallace, & Chang, 2008; Morgan, Fraga, & Macauley, 2011; Colton

& Surasinghe, 2014). Reynolds, Thaiss, Katkin, and Thompson (2012) have noted that among the integration of WTL practices in STEM disciplines, "[t]wo major deterrents to progress are the lack of a community of science faculty committed to undertaking and applying the necessary pedagogical research, and the absence of a conceptual framework to systematically guide study designs and integrate findings" (p. 17). The findings of this review suggest that this claim may be accurate, and is an area that should be of great concern to WAC scholars and practitioners—primarily because it presents great opportunity to bridge epistemological divides.

The underlying assumption throughout this discussion has been that the "progress" noted by Reynolds, Thaiss, Katkin, and Thompson (2012) is one of increased writing-inclusion throughout disciplinary coursework, which could be perceived as intrusive to disciplinary faculty unfamiliar with WAC practices, or who have differing views on what types of data are considered valid. If WAC is to truly be agentive in driving curricular change, then it follows that finding a respectful common ground for discussion and understanding is critical. Despite being composed of multidisciplinary scholars, WAC still remains intradisciplinary—existing in a realm of its own and rarely crossing disciplinary divides. One curative to this issue might simply be the active attempt by WAC scholars to publish in the disciplinary literature, to develop a presence and ethos and build familiarity with WAC principles and practices that is not intimidating to disciplinary scholars. Given the limited occurrence of writing-focused publications in science education trade journals, it is disconcerting to find a significant presence of articles employing what WAC professionals have long known to be ineffective pedagogical practices.

What is striking about these findings, however, is that they are not necessarily representative of what so many of us actively working in WAC programs and research know anecdotally to *also* be true—that innovative approaches to writing and assessment *are* taking place, and that many science faculty are not only on board, but active participants in the push toward including writing in their coursework. The work of Quitadamo and Kurtz (2007) discussed earlier is such an exemplar. Rather than speculate on why these practices are not reflected in the science education literature (though, questions of tenure review and what qualifies as contributing to the biology field immediately come to mind), I'd like to end on a call to action for the WAC community. We know that there are communication and epistemological challenges crossing disciplinary divides that still need addressing. However, we also know that buy-in on both sides of the aisle exists. How can we ensure that those who are unlikely to read WAC- and WID-related journals are being exposed to research and insights that more accurately reflect the potential of WAC/WID programs? Even more, how can we as experts in disciplinary writing and writing as a heuristic convey our usefulness to those in content areas? How do we persuade individuals and institutions of

the value of WAC when they are otherwise uninterested, unaware, or do not have the financial resources or time to incorporate new pedagogies?

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