10 Developing Support for Teachers and Students in Secondary Science Classrooms through Writing Criteria

Angela M. Kohnen
Missouri State University, United States

E. Wendy Saul and Nancy R. Singer
University of Missouri-St. Louis, United States

Content-area teachers are increasingly called upon to link curriculum to broad literacy standards and goals, yet they often feel unprepared to teach these skills in their discipline. This chapter reports on the implementation of a National Science Foundation-funded grant, Science Literacy Through Science Journalism (SciJourn). Through the grant, U.S. secondary teachers brought science journalism into their school curricula. To support the teachers' efforts, university researchers sought to create criteria for science journalism. This chapter describes the iterative process of creating the criteria by looking first to experts outside of schools and then to the way the resulting criteria were taken up in schools. The authors argue that generic rubrics for writing are not sufficient to support and advance student writing in the disciplines and present this effort as an alternative.

Les enseignants spécialistes d'une discipline sont régulièrement appelés à établir des liens entre leur programme d'études et les normes et objectifs de l'écrit, mais ils se sentent souvent mal formés pour enseigner ces techniques dans le cadre de leur discipline. Cet article présente la mise en œuvre d'un programme subventionné par la National Science Foundation (fondation nationale pour la recherche scientifique) pour l'enseignement de la science à travers le journalisme scientifique (SciJourn). Grâce à cette subvention, les enseignants américains du secondaire ont introduit le journalisme scientifique dans le curriculum

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des élèves. Pour soutenir l'action des enseignants, des universitaires ont entrepris d'établir des critères définissant le journalisme scientifique. Cet article examine le processus continu de l'établissement des critères depuis l'avis d'experts externes à l'établissement scolaire jusqu'à la manière dont ces critères sont appliqués dans les écoles. Les auteurs défendent l'idée que les rubriques génériques dans le domaine de l'écriture sont insuffisantes pour assurer le soutien et le développement de l'écriture des apprenants dans les domaines disciplinaires et présentent cette initiative comme une alternative possible.

Content area teachers are increasingly called upon to link curricula to broad literacy standards and goals, yet they often feel unprepared to teach literacy skills. What can we as writing researchers and teacher educators do to support their efforts? What are the impediments to bringing more reading and writing into content area classes? Would "standards" or "writing criteria" help? What should these standards/criteria look like in order to be effective? This chapter describes the iterative process of creating criteria designed to support teachers in their efforts to bring meaningful literacy into science classrooms in a large metropolitan area.

In order to sort through the many roadblocks to bringing more writing into disciplinary subjects, we need to better understand what discipline-specific literacy means to classroom-based educators and what it might look like *in situ*. When we asked the secondary science teachers with whom we work "what is science literacy?" most responded with a version of this answer: It is the ability to read and write in science class (or about science). In the United States, science teachers may equate "science literacy" with "science" plus "literacy" for a variety of factors, including the content area literacy movement and national initiatives related to reading and writing across the curriculum. Content area literacy approaches suggest that when taught a "generalizable" set of reading and writing strategies, students can apply these strategies in all content area classrooms (Hynd-Shanahan, 2013; Shanahan and Shanahan, 2012). This approach to reading and writing in the subject areas has been the topic of required coursework common in U.S. Schools of Education and gained further traction when the concept that "every teacher is a teacher of reading" was codified by the No Child Left Behind Act (U.S. Department of Education, 2002). As U.S. states revised their education standards in recent years and added writing assessments to go along with the reading assessments (e.g., the Common Core State Standards, National Governors Association, 2010), uniform school-wide writing programs and rubrics have been vaunted as a "revolutionary" approach to school turnaround (Tyre, 2012).

Among scientists and academics, however, the term “science literacy” has a long and contested history and is used in a way not to be confused with the act of understanding science through reading and writing. First popularized by Hurd (1958), the term “science literacy” has been viewed as a proxy for familiarity with of a body of scientific knowledge. This view influenced science education in the United States for decades and underpinned the National Research Council’s 1996 Science Education Standards, standards that required the teaching of specific fact-based content in order to build a scientifically literate public. However, competing definitions of science literacy exist in the research literature, as elucidated by Roberts (2007). Roberts differentiates between the science knowledge approach, calling it Vision I, and a Vision II view of science literacy that emphasizes being able to apply scientific information to real world problems. Scholars who approach science literacy from a Vision II perspective define scientifically literate people as those who can use scientific information to inform their health, consumer, technological, and civic decisions (Feinstein, 2011).

Although reading and writing are a component of both Vision I and Vision II, it is important for literacy educators and science educators alike to recognize this confusion, i.e. that “science literacy” is not necessarily or strictly about reading and writing. Still, the act of prioritizing literacy or separately teaching reading and writing skills as distinct from content (Hynd-Shanahan, 2013; Moje, 2008) can rightfully be viewed as an “‘outside-in’ approach in which generic strategies are pushed into the process of disciplinary reading and learning” (Brozo, Moorman, Meyer, & Stewart, 2013: 353) rather than being born with and from content knowledge. Such push-in efforts can be applied to Robert’s Vision I, in which literacy strategies are used to help novices recall content, or as part of Vision II in which science knowledge is applied.

But such push-in efforts, whether applied to Vision I or Vision II, can be misguided. Literacy layered upon content—for its own sake or for application—can, in fact, run counter to the very notion of what science is or does. A “fun” literacy activity, for instance, asks students to describe a date between hydrogen and oxygen atoms, an activity that is about as authentic as a writing assignment from the 1950s that asked students to describe life as a postcard going from their school to the USSR. But today’s science teachers, especially those with only minimal preparation in the teaching of writing (Totten, 2005), have great difficulty bringing authentic literacy activities into their classrooms, in part perhaps because they view teaching literacy as an extra burden rather than an essential part of teaching their subject matter (Draper, Broomhead, Jensen, Nokes, & Siebert, 2010; Moje, 2008).

In reaction, some literacy scholars have advocated a “disciplinary literacy" approach to literacy in content area classrooms. Rather than emphasizing push-in or transferable approaches to reading and writing, disciplinary literacy "emphasizes the differences among the disciplines" (Hynd-Shanahan, 2013, p. 94). Scholarship in this field has examined the literacy practices of disciplinary experts and calls for including instruction of these practices in middle and secondary schools (Shanahan & Shanahan, 2012). This approach is described as prioritizing the discipline rather than teaching literacy (Moje, 2008).

In science education, disciplinary literacy research often cites studies of the way experts read texts (e.g., Bazerman, 1985) as important frameworks for disciplinary literacy instruction. However, looking to professional scientists presents at least two problems. First, science teachers are not themselves scientists and therefore the disciplinary literacy practices of experts may be unfamiliar to them (Hynd-Shanahan, 2013). Second, most secondary students in science classes will not go on to be scientists themselves (e.g., Feinstein, 2011). Seeking to educate all students as "little scientists" (e.g., O'Neill & Polman, 2004) is both impractical and unnecessary to develop the level of scientific literacy needed to function as an adult member of society (Feinstein, 2011). Feinstein (2011) argued that science education should focus on the "usefulness" aspect of science literacy and described scientifically literate people as "competent outsiders" to science: "people who have learned to recognize the moments when science has some bearing on their needs and interests and to interact with sources of scientific expertise in ways that help them achieve their own goals" (180).

In this chapter we, too, advocate for a literacy that enables graduates to function as "competent outsiders" to science; we also believe that generic reading and writing skills—those seen in content area literacy initiatives—will not promote the development of competent outsiders. Yet disciplinary literacy approaches are also unsuitable to this goal. Instead, we argue for looking to authentic models of "competent outsiders" outside the walls of the academy. In the case described here we have turned to science journalists, professionals who engage in the authentic expert work of "competent outsiders" to science. This chapter describes how we learned from the literacy practices of science journalists and worked through an iterative process of articulating these understandings in a way that was useful to secondary science teachers.

1. Background: The SciJourn Project

The "Science Literacy through Science Journalism (SciJourn)" program was funded by the National Science Foundation (U.S.) from 2008-2013 and involved 51 teachers and more than 10,000 teenagers in classes at 37 schools and in a science museum's youth development program. Teachers self-selected to join the program which began with a two-week summer institute in which teachers (1) wrote and revised their own science news article for publication in the grant's newsmagazine for teens under the direction of a professional science journalist and (2) created plans for implementing science journalism activities in their classes under the direction of university faculty with expertise in pedagogy. Each summer institute involved a new group of teachers (referred to as "pilot," "cadre 1," and "cadre 2"); follow-up professional development meetings during the school year included all currently participating SciJourn teachers so that by the final year of the grant representatives from all three cadres were meeting together. The program was not a scripted curriculum and was adapted by teachers in parochial (3) and public urban (11), suburban (17) and rural (6) communities teaching a range of science courses with students of varying ability levels and socioeconomic and racial backgrounds.

SciJourn began with the hypothesis that science journalists are models of scientifically literate individuals (as defined by researchers like Feinstein, 2011) and that the production and consumption of science news offered possibilities for the classroom. Yet science journalism was not taught in schools frequently, either in science classes or English/Language Arts classes (see Jarman & McClune, 2007, for an exception). Furthermore, influenced by such documents as the National Research Council's 1996 Science Education Standards, the science teachers in this program felt pressure to teach and assess a great deal of specific, often decontextualized, factual content. As the project began, we knew that helping teachers find space in the curriculum for science journalism activities would be an early challenge.

In addition, we anticipated that the secondary science teachers in this program would be intimidated by the prospect of teaching, assigning, and evaluating student writing. Our concern was based on the fact that most science teachers feel unprepared to use writing in their classes (Kiuhara, Graham, & Hawken, 2009); likewise, our own research with the SciJourn teacher population uncovered a lack of formal training in and a general discomfort with the teaching of writing (Kohnen, 2013). Because of the prevalence of content area literacy initiatives and other school-wide models of literacy instruction in U.S. schools, we first thought we might adapt one such literacy assessment tool. These tools were already designed for schools, we knew, and might be familiar to teachers. One choice we considered was the 6+1 Trait Writing model, developed by the Northwest Regional Education Laboratory (NWREL) and implemented in schools in the U.S. and abroad. The 6+1 Traits are designed to evaluate writing in any genre and any discipline and studies have found them efficacious in a variety of content areas (e.g. Isernhagen & Kozisek, 2000; Jarmer, Kozol, Nelson, & Salsberry, 2000; Kozlow & Bellamy, 2004). In the original NSF grant application, we proposed overlaying an elaborated set of scientific literacy standards for writing over the 6+1 traits scoring model (e.g. Culham, 2003; Spandel & Stiggins, 1997) because school districts were already familiar with 6+1 writing and teachers were already using these standards and rubrics. Furthermore, the marketed universal applicability of the 6+1 Traits was a selling point.

However, like Applebee (2012), Moje (2008), and others, we came to believe that trying to be universal in literacy instruction is a mistake; specificity is what matters. At the same time, we also agree with Draper et al. (2010) and Brozo et al. (2013) who caution against an "artificial literacy-content dualism" (Brozo et al., p. 353). Implementing science journalism activities into science classes, we recognized, was not exclusively (or generically) about either writing or science. Science journalism had the potential to help students become scientifically literate "competent outsiders," we believed, but only if students could engage deeply in the work and receive the formative feedback research has shown is necessary for improvement (Black & William, 1998; Crooks, 1988; Natriello, 1987). Therefore, we turned away from educational models and tools and set out to study the professional practice of science journalism as well as authentic interactions with science journalism by scientifically literate people, hoping to identify what it was about the professional practice of science journalism that was important for adolescent learners.

The remainder of this chapter will describe this research, the development of criteria for teaching and responding to student science journalism that grew out of this research, and the subsequent implementation of science writing criteria by science teachers.

2. An Iterative Process: Developing Criteria for Science Writing

In an attempt to build criteria for writing science journalism, we turned to experts whom we see representing a scientifically literate population. We consulted various stakeholder groups, including practicing scientists, science journalists, editors of science journalism, and classroom teachers. Engaging experts in reading, responding, and editing tasks, we sought to understand what science experts attended to in both professional and student science journalism texts.

2.1. The First Draft

As part of this effort, sixteen interviews were conducted using a think-aloud protocol. Two articles were chosen for each interviewee, one in a field in which they were clearly expert and another in a science area where they were not as well versed. All articles came from Science News, a publication targeted toward a scientifically interested, but not expert public. Interviews were recorded and later transcribed. Each interview lasted at least 30 minutes and some more than an hour.

Subjects were told that we wished to better understand how readers comfortable with science think about what they read—what stops them, what makes their head nod in agreement, what makes them question what they are reading. We then asked them to read the first article aloud, the one where they were expected to be scientifically "in the know," and to stop and comment when an idea "crossed their minds." After that read-aloud was completed, the second round began, this time with the article on a topic with which they were less familiar.

Using a grounded theory approach (Glaser, 1992), we began with open coding of the transcribed interviews. In the first round of coding the read-aloud protocol, responses fell into the following categories: sources (13%), contextualization (17%), relevance to readers (11%), factual accuracy (30%), writing quality (23%), and answering the journalistic 5 "Ws" (6%). A second coder created slightly different categories: up-to-date, relevant, clear, concise, attributed, accurate, and credible.

These two groups of categories were discussed and refined by the larger SciJourn research team, a team that included former high school science teachers as well as university researchers. Newman, a co-PI on the project who had decades of experience as a science journalist and editor as well as a Ph.D. in chemistry, provided guidance to help the team understand science news writing from the perspective of a producer of science journalism. For example, everyone involved in the project (including those who participated in the interviews) thought that accurate reporting—getting the information correct—was important. However, Newman clarified how complex factual accuracy is when the topic of an article is cutting edge science and the information and implications are uncertain. Science teachers involved in the project were used to "correcting" students' factual misunderstandings, but factual accuracy in science journalism meant something different. In these ways, we attempted to deepen our definitions of the categories from an authentic perspective.

Like merchants, we took wisdom gathered from one group to get feedback from another group. The interview data with the science experts was organized and brought back to both educators and to science writers and journalists. For instance, a focus group was organized at a meeting of the American Association of the Advancement of Science (AAAS) by Julie Ann Miller, then editor of Science News and a member of our grant's advisory board, Again, we recorded and examined their feedback, looking particularly at what they viewed as important, what they saw as missing and what they thought was under- or over-emphasized.

In all of our collected data, there were a number of comments about "writing." Upon closer examination, these comments referred to different things. Sometimes the word "writing" was used to refer to ideas not being clear, e.g. "this statement could be confusing," and sometimes "writing" referred to delight in metaphor or word choice. As we drafted disciplinary criteria we purposefully omitted writing in this second sense. Our goal was to help students and their teachers attend to building competent outsiders, not necessarily graceful writers.

Based on this data, we created our first working draft of criteria for science journalism which included the following: 1) Able to effectively search for and recognize relevant, credible information sources, especially on the Internet (referred to as "search" below), 2) Articles are based on multiple, credible, attributed sources ("sources"), 3) Scientific information, discoveries and technologies are contextualized ("context"), 4) Scientific information is relevant to readers ("relevance"); 5) Information is factually accurate ("factual accuracy").

2.2. Revisions to the Criteria

The first draft of the criteria was field tested in professional development meetings with participating teachers and their students. Newman's responses to participating student writers were also analyzed to determine if the criteria captured his comments. In addition, transcripts of a series of three approximately 75-minute interviews with two experienced science journalists on the topic of science journalism were used to check the authenticity of the criteria.

Based on these data sources, several related, significant revisions were made. First, the fourth criterion, "relevance," proved to be difficult for both researchers and classroom teachers. The research team struggled with this concept—relevant to whom? For what purpose? Furthermore, "context" and "relevance" often became intertwined and several of the pilot year classroom teachers resisted the importance of "relevance to readers," instead arguing that "relevance to author" was more important in a classroom. In other words, teachers didn't care whether or not readers would find the particular story engaging as long as the writer (their student) was interested. Yet interviews with practicing science journalists and editors revealed that the ability to make science information "relevant" to readers was an essential skill for a science news writer and, if the criteria were to be "authentic" to true practice, "relevance" seemed necessary. The problem with this criterion was identified early in field testing, but a solution was not found until the related revisions were completed.

A second problem with the original draft of the criteria had to do with the awkwardness of the wording, a direct result of the complicated nature of the criteria's purpose. The criteria were conceptualized as being about more than simply what appeared on the page of a student's final draft, although the final draft was envisioned as a piece of data for determining a student's scientific literacy. The awkwardness of original draft of our criteria was due, in part, to the fact that it included characteristics of a person (e.g., "search") as well as characteristics of an article (e.g., "context," "factual accuracy"). This led to challenges for teachers implementing the criteria. One challenge was that teachers seemed to feel free to reject certain criteria as unimportant to their classroom goals, and project leaders, without language for explicating the relationship between the article itself and scientific literacy, struggled to convince teachers not to do so. This was most apparent for the criterion "relevance," although it also came up for "context." Notably, both of these criteria (particularly "relevance") may have been seen by the teachers as being more about audience than science.

Returning to the grant's overall purpose, project leaders sought to define more clearly the project's aim. What, according to SciJourn, was "scientific literacy"? The answer, first articulated by Newman, was this: the skills and habits of mind necessary to navigate science-related issues and concerns 15 years after high school graduation (see Polman, Newman, Saul, & Farrar, 2011 for more information). Viewing scientific literacy through this lens, project leaders returned to the criteria and made the following revisions (see Table 10.1).

Table 10.1. Qualities of a Scientifically Literate Person compared to Qualities of a Science News Article

A scientifically literate person is able to . . .	**A high-quality science news article . . .**
. . . identify personal and civic concerns that benefit from scientific and technological understanding.	. . . has most or all of these elements: is local, narrow, timely, and presents a unique angle.
. . . effectively search for and recognize relevant, credible information.	. . . uses information from relevant, credible sources including the internet and interviews.
. . . digest, present and properly attribute information from multiple, credible sources.	. . . is based on multiple, credible, attributed sources from a variety of stakeholders.

A scientifically literate person is able to . . .	**A high-quality science news article . . .**
. . . contextualize technologies and discoveries, differentiating between those that are widely accepted and emergent; attending to the nature, limits and risks of a discovery; and integrating information into broader policy and lifestyle choices.	. . . contextualizes information by telling why it is important as well as which ideas are accepted and which are preliminary.
. . . fact check both big ideas and scientific details.	. . . is factually accurate and forefronts important information.
Note: Reprinted from "The Authenticity Spectrum: The Case of a Science Journalism Writing Project," by A. M. Kohnen, 2013, *English Journal, 102,* p. 29. Copyright 2013 by the National Council of Teachers of English.	

The result was a two-column table, with the left column listing skills that are necessary to function as a scientifically literate adult in a future we cannot yet imagine. The right column then correlates these particular skills with characteristics of a science journalism article. This revision clarified the relationship between the person and the writing, while also inherently making the case that all of the criterion are about science literacy and are, consequently, the science teachers' domain.

"Relevance," the most challenging of the initial criterion, underwent the most significant revision. Early analyses of comments by teachers and Newman pointed to the importance of article topic choice for students, an issue not cleanly captured in the first draft of the criteria. Many teachers initially believed they could assign science news stories based on their existing curriculum and limited student topic choice to a few curricular concepts; however, almost all teachers involved eventually concluded that student choice was one of the most important aspects of the assignment. In professional development meetings, teachers explained how students came to discover meaningful topics for their articles and invest themselves in the work of researching and writing, an investment they may not have made with a teacher-assigned topic. The importance of student choice may have also led to the pilot teachers' revision of "relevance" from audience-focused to writer-focused. (It should be noted that pilot teachers, who were, by definition, the first teachers to work through the program, appeared to feel much more license to revise various aspects of the project than did teachers in later cadres). In his comments on student drafts, Newman, too, focused on article topic. An analysis of Newman's comments on student writing from the pilot year of the program found that he regularly wrote encouraging comments to students based almost exclusively on article topic, regardless of the length or technical quality of the written article.

When the criteria were revised, then, it was important to capture what mattered about article topics in a way that both aligned with a characteristic of science literacy and also validated the teachers' desire to have "relevance to student" acknowledged. As Newman and others shared the "15 years after high school graduation" definition of science literacy with NSF evaluators, the grant's advisory board, and classroom teachers, the concept resonated. Working with the previous draft of the standards, the project team realized that for any of these standards to matter, students first had to recognize that there was science in their hobbies and in their civic, health, and consumer concerns. As Feinstein (2011) argued, "the pursuit of science literacy is not *incidentally* but *fundamentally* about identifying relevance: learning to see how science is or could be significant to the things you care about most" (180, italics in original). Adults 15 years after high school graduation may have the skills necessary to find information online and to assess credibility, but if they do not recognize that many of their everyday choices and problems could benefit from scientific information or understandings, they won't bother to even look for that information. All of the other standards were only meaningful after the first one had been met.

For a student science journalist, identifying an issue that could benefit from scientific or technological understanding translated into choosing a good article topic. Conversations with Newman about characteristics of good article topics led to the following list: local, narrow, timely, unique angle. Each successful article topic fit at least two of these. This list helped teachers and students identify topics that were personally meaningful and in this sense "relevant": a "local" story might be about a relative with a health condition or a change in the school's lunch menu; a "timely" story might be about choosing the best gaming system for a Christmas gift; stories with "unique angles" included many of the "personally relevant" articles teachers were so passionate about letting their students pursue (including articles about why tennis ball cans "pop" when opened or if cement will ever harden in a cement mixer). From a writing standpoint, "narrow" was perhaps the most important characteristic; all published articles dealt with "narrow" topics. Keeping topics "narrow" meant steering students away from issues like climate change and towards topics like the impact of a local drought (see Appendix for definitions and editorial comments on each of the criteria).

3. Teacher Development

We set out to create these criteria in order to identify what was important about science journalism for teachers in classrooms focused on scientific literacy. Our next task was to work with teachers to develop shared understandings of what these criteria meant, how they might look in student writing, how they could be taught, and how they could be assessed. We also sought to measure whether teachers changed the way they responded to student science journalism after being involved in our program.

3.1. Teachers as Writers

Based on pre-test data, we knew that science teachers felt unprepared to teach or respond to writing and tended to focus on grammar and factual errors in their feedback to students. The kinds of writing they assigned often asked for isolated factual information so that writing could be assessed like an objective test (Kohnen, 2013). We knew that implementing science journalism activities in order to improve student science literacy would be a new use of writing for most teachers, quite different from using writing as a tool to assess factual recall. Teachers would need support in order to make this kind of change.

In the initial two-week professional development summer institute teachers were required to write themselves, with the second and third cadres writing to the criteria. Teachers chose "do-able" science topics,[1] conducted research online and via email, phone, and in-person interviews, and drafted short science news articles (~500 words) written for a teenage audience. Their writing process included instruction and explicit feedback from Newman, an experience many teachers cited as pivotal to their own understanding and classroom implementation. Barbara, a biology teacher in the pilot year of program, called writing "the best thing for the teachers that go through the training to do." As someone who considered herself a "good" writer of academic papers, Barbara said she needed to write a science news article to really understand the genre. Similarly, Mary, a chemistry teacher in cadre 1, thought of herself as a competent writer and was surprised by Newman's feedback and her own difficulty meeting the criteria; she brought this experience directly back to her classroom, even showing her students her own writing with Newman's comments. Other science teachers regularly struggled with writing and were unsurprised by Newman's editing; however, they valued the criteria and saw these as different from what they had learned about reading and writing standards in the past. Jason referred to the explication of the criteria (which was first done indirectly by Newman through Read-Aloud/Think-Alouds of science articles) as a "profound" experience, one that changed his own reading of science content. The Read-Aloud/Think-Aloud emerged as an essential step for teachers introducing the criteria in their own classrooms; students responded enthusiastically to hearing interesting science news read aloud to them, and teachers, through their own thinking comments, were able to direct student attention to the essential features of science writing.

Science teachers reacted to the writing process and the developing criteria in a positive way, recognizing these criteria as at once familiar, representing concepts they had been trying to emphasize in their classes for years, and different from any writing assignment or criteria that they had ever used. Because of the connection between science journalism and scientific literacy, many science teachers embraced the idea of "15 years out" scientific literacy and saw the writing assignment as important, even essential. In interviews, teachers expressed the opinion that, unlike the school-wide initiatives they had experienced in the past, the science journalism project complemented and supported science teaching rather than only being about generic writing or reading skills.

3.2. Teachers as Responders

In addition to writing themselves, the teachers were also provided with a variety of tools to help them change their approach to assessment and feedback. In professional development meetings, teachers examined and discussed the writing of students involved in the project. Student exemplars, annotated using Microsoft Word's comment boxes to note each of the criteria in use, were provided both in handouts and online in a teacher resource website. Teachers practiced responding to sample student articles (written by participating students) using a tool developed by long-time teacher Laura Pearce called the SAFI (Science Article Filtering Instrument), which required that the teachers respond only to the criteria and return the writing to the student if it did not pass through the SAFI "filter." (SAFI asks questions like: are there two or more credible sources?; is the story plagiarized?; and is the information accurate?; see Saul, Kohnen, Newman, & Pearce, 2012 and teach4scijourn.org for the SAFI and other classroom resources).

Teachers also practiced "calibrating" their responses to student writing (a process that was inspired by Chapman & Russell, 2005). Teachers were provided with anchor papers that Newman identified as "low," "medium," and "high" based on the criteria. Using the criteria, teachers worked in small groups to try to "calibrate" their own assessment of the student writing to Newman's benchmarks. For this activity, we deliberately selected some "low" and "medium" anchor papers that demonstrated higher mastery of grammar or organization yet included incorrect or misleading information, little context, or few named sources. Teachers worked to train themselves to see past the conventions and look first for the content.

3.3. Teachers as Apprentices

In addition to formal tools, the teachers also benefited from working under the guidance of Newman, who provided editing to their students. Teachers read Newman's comments and compared them to their own way of responding to student work; some asked Newman for clarifying feedback when they were uncertain. In this way, the teachers became "legitimate peripheral participants" (Lave & Wenger, 1991) in the community of practice of science news editing, learning through apprenticeship.

Teachers found several features of Newman's editing notable. First, Newman spent more time on papers he considered closer to publication (which was based on the criteria) and commented less on papers with fundamental flaws. This differed from teacher tendencies in two ways. As noted earlier, teachers had to redefine what made a paper "good," moving from an analysis based on conventions and superficial facts to a judgment based on the criteria. Additionally, they regularly reported spending more time on papers that had errors related to poor conventions and misstated facts rather than on papers that were of higher quality. Newman's tendency, which was reified in the SAFI, was to return papers with what from a science perspective would be viewed as fundamental problems (i.e., plagiarism, topics that were too big, or a complete misunderstanding of the science) to the author for revision. It was his tendency to comment extensively on papers that showed potential and to comment less on papers that needed to be begun again. Copyediting was almost exclusively reserved for papers with publication potential; papers with fundamental content errors received few copyedits (Kohnen, 2012). Although Newman's goal as publisher of a newsmagazine differed from the teachers', several teachers learned from and even adapted Newman's approach of returning work to students who had not met the criteria with only criteria-based comments (and to return plagiarized articles virtually unedited). As a result, the revision process moved from the teacher's responsibility to the students'.

Teachers also saw Newman's editing as more direct and specific than their own feedback. Brian, a chemistry teacher in an urban school, called Newman's edits "actionable" and described Newman's feedback as a model to imitate. Many teachers knew that they previously tended to focus excessively on grammar and conventions in their feedback and saw in Newman an alternative. Brian described a term paper he assigned in chemistry:

> I purely graded it for grammar, that's the only thing. I mean I had a rubric and the rubric was assessing ideas, but my marks that I was making on papers were mostly grammatical and then the students would see how they did on the papers by looking at the circles on the rubric that I had given so, in retrospect, learning nothing from the process except for that their chemistry teacher's really into grammar.

After attending professional development, Brian described himself as working with students to develop content and ideas. In a late-September meeting, he told the group, "We've already had two writing assignments that are probably higher in quality in my opinion now than that one writing assignment we had before," a fact he attributed to the training and the criteria. Likewise, Yvonne, a biology teacher, described using the SAFI: "this helps me to not want to correct grammar," a tendency she had in the past.

3.4. Signs of Growth

As teachers grew to understand the criteria, they were able to apply these understandings to student writing. Pre-test data showed that teachers had few ways of responding to student writing other than copyediting or providing comments that offered global praise. In a study comparing six pilot teachers' responses to sample student papers prior to their involvement in the program to their responses at the end of the first year, all pilot teachers provided more kinds of content feedback (rather than only marking factual inaccuracies) in the post-test; specifically, all teachers addressed sources of information and the need for multiple, credible perspectives in the post-test while only one teacher made a single comment about sources on the pre-test. On pre-test papers, all teachers provided non-specific complimentary comments; only two did so on the post-test, perhaps because they had more knowledge and confidence to bring to their end-of-the-year responses and therefore could make more targeted edits. Finally, copyediting comments decreased on the post-test for all teachers who had assigned student writing during the year (one pilot teacher assigned no writing and increased his copyediting pre- to post-test).

Teachers responding to sample papers only provided hypothetical data; therefore, a second study was undertaken, this time the analysis focused on the written feedback Mary provided to her junior honors chemistry students. Here, too, we saw teacher growth. Prior to project training, 51% of the feedback Mary gave on sample papers was related exclusively to conventions or form; 35% of her comments addressed factual information, primarily in isolation. After professional development, 61% of Mary's feedback to her students addressed content issues, including concerns about factual accuracy, topic relevance, and sources of information; only 24% of her comments had to do exclusively with writing conventions or form.

4. Conclusions

Our research indicates that it makes sense to look beyond the walls of the academy to create criteria for teaching and assessing student writing, especially in a specific content area where there are experts working. To look only within the school environment, focusing particularly on test scores rather than real world experience, is at once less authentic and at the same time less convincing to teachers. This research is of particular importance in the United States as individual states implement the Common Core State Standards. The standards, currently adopted in a majority of U.S. states, call for increased writing in all subject areas in primary/secondary school. We argue that simply asking content area teachers to require more writing in their classes will not necessarily get students to the critical thinking and writing we hope will elevate their content understanding and skills.

Likewise, we cannot rely on generic writing rubrics, hoping that they will address content-specific concerns. We, along with researchers like Applebee (2012), worry that school districts may see the CCSS as a call to institute a uniform program of writing assignments, standards, and rubrics across departments. Our research takes the opposite approach, arguing that specificity matters. "More writing" without attention to discipline-specific conventions and criteria (in the case of this research, criteria designed to improve science literacy) may not improve student learning and may inadvertently confuse and overburden content area teachers.

Our research also suggests that when looking beyond the schoolhouse gates for models of excellent writing, it is useful to consider "competent outsiders" rather than insiders, e.g. scientists themselves, as exemplars. Since these competent outsiders are tasked with explaining and finding application for the ideas laid open through content-based understandings, their work makes sense to both students who seek to become content experts themselves and those whose lives will be importantly, but peripherally, touched by knowing content.

Finally, we strongly believe that it is through an iterative process of working with various stakeholders, in this case writers, editors, literacy specialists and teachers, that useful standards or criteria will be developed. As we have learned though our work in this project, what finally has lasting impact in the classroom is what makes sense to educators. They, like all of us concerned with schooling, want to be teaching that which enables students to look back years after graduation and find it both meaningful and useful.

Note

1. Also interesting, most teachers selected a topic for their own writing based on personal interests or ideas about what their students might be interested in. Very few teachers attempted to write an article based on their curriculum.

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