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Navigating the Next Generation Science Standards: Implications and Implementation for Faculty in Writing and the Sciences

Maria Gigante
Western Michigan University

Introduction

The Next Generation Science Standards (NGSS), released in 2013, were created by educators in twenty-six states who partnered with Achieve, a nonprofit organization, to build a new framework for K-12 science education, similarly to how the Common Core State Standards (CCSS) were built to redefine Mathematics and English Language Arts. According to the introductory material of the NGSS document, their purpose is to “better prepare high school graduates for the rigors of college and careers” (“Introduction,” 2013, p. 1). Developers of the NGSS appear in videos on the main website to promote the standards and explain their overarching objectives, which include “to be competitive globally” (“Why NGSS,” 2013). By calibrating the exigence of the NGSS to a global scale, the developers attempt to create a case with which few people would want to openly disagree; who, in other words, would argue that the U.S. does not need to improve science education in order to compete globally? Likely in an attempt to sway critics and skeptics, the developers in the video concede that the shift in curriculum necessitated by the NGSS is “scary” and “risky” but emphasize the “excitement” that accompanies it.1

Proponents of the NGSS tout the new standards’ potential to create richer curricula that focuses less on fact-based knowledge and more on how knowledge is applied in context (Robelen, 2013). Critics seem to focus on the same

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1 As of February 2015, thirteen states have adopted the NGSS, which have been met with both criticism and praise in education communities (Robelen, 2013; Schrank, 2015).
content/application binary, arguing that the NGSS place too much emphasis on “skill” at the expense of content (Bruno, 2013; Gross, 2013). At least part of this assessment is prompted by one of the specific problems that the Next Generation Science Standards target: the lack of connection between the sciences and critical thinking and communication skills in the U.S. education system. To foster that connection, NGSS developers have directly linked science practices to the Common Core State Standards (CCSS) for English Language Arts (ELA); in brief, that means that science teachers are required to place more emphasis on teaching writing in their classrooms in order to comply with the new standards.² Hence, the perceived threat to science content-knowledge.

Alluding to the difficulty of transitioning into the NGSS, one of the developers in the video says, “Teachers have to be open-minded. They have to be willing to take a risk. They have to be willing to get messy.” (“Why NGSS,” 2013). Positioning the NGSS as a radical departure from the status quo is one option available to the proponents of the new system, but it is not the most persuasive option. By styling the NGSS as an overhaul of the current model of science education, the creators of the standards are not facilitating an easy transition into the new system. This rhetorical situation is not new. Consider the case of Sir Isaac Newton, who, according to rhetorician of science Alan Gross (1988), failed to persuade his contemporaries to believe his theory on optics when he positioned that theory as different from accepted models and beliefs. Nearly three decades later, Newton tried again to publish his theory, but, this time, he “substituted a rhetoric that invented an essential continuity between his work and the optical and scientific past” (Gross, 1988, p. 2). By concealing the radical change and promoting his work as a continuation of past research in physics, Newton was successful in securing adherents to his science. Likewise, proponents of the NGSS have the option to position writing as integral to science education, rather than promoting the idea that the new system entails risk-taking and messy curricular reform.

In reality, writing is integral to science, a fact that the NGSS could make transparent in order to facilitate a smoother transition into the new system. The purpose of this paper is twofold: first, to show the implications of the NGSS’s characterization of the linkage between science education and English-language

² Adding to the tension that this shift in emphasis would reasonably cause is the fact that the NGSS are explicitly not curriculum but, rather, objectives. Thus, the burden of pedagogical development is placed on science teachers who are, generally, not trained in writing pedagogy. Resources for teachers have been or are being developed by Pearson, TCI (a K-12 publishing company), and The Einstein Project. Several articles in such journals as Science Scope and Science Educator are focused on putting the NGSS into practice (see, e.g., Huff & Bybee, 2013; Lewis et al., 2014). Berkeley (2013) also has a website devoted to assisting teachers with developing curriculum that aligns with the NGSS.

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http://scholarworks.wmich.edu/wte/
arts as “risky” and complicated, and, second, to offer possibilities for incorporating writing into science curricula to comply with the NGSS, but in a way that does not require a complete overhaul of curricula. Teaching writing in the sciences does not have to be presented as a risky or messy endeavor that requires a curricular overhaul, as scholars of scientific discourse and writing pedagogy know. Rather, what is required is a shift in perspective to embrace the fact that the communicative arts are essential to the scientific enterprise. My argument is predicated on the ideas that teaching writing in the sciences contributes to what has been termed “critical science literacy” (Priest, 2013) or “Critical Understanding of Science in Public” (Perrault, 2013), and that teaching rhetoric and writing in the disciplines contributes to a more democratic society (Fahnestock, 2013).

Although the NGSS represent a step in the right direction, when viewed from the dual perspective of rhetorical studies of science and writing pedagogy, they are lacking—both in clarity and in meaningful connection to the English Language Arts criteria. To address this issue and prompt a shift in perspective from teaching writing as extraneous to science curricula to teaching writing as essential to the vitality of the scientific enterprise, I discuss the concepts of reframing rhetoric and socializing students into the scientific discourse community. It is hoped that this paper will be useful for an audience of science faculty as well as writing faculty, who can collaborate across the disciplines to ease the transition into the Next Generation Science Standards.

Presentation of Information in the Next Generation Science Standards

The benefits of teaching critical thinking and persuasive communication in science classrooms ought to be presented in a way that makes them readily apparent. However, a glance at NGSS Appendix M, displaying the “Connections to the Common Core State Standards for Literacy in Science and Technical Subjects,” makes the new standards themselves as well as their connections to English Language Arts (ELA) seem very complicated. The presentation of information in the NGSS documents, in other words, gives credence to the voices on the video—integrating science and communication appears to be a messy endeavor. The NGSS developers chose to convey the integration of communication practices into science education through a series of six tables. Each table contains one of the NGSS objectives and, below it, several references to the Common Core State Standards (CCSS) “anchors” for Reading, Writing, and Speaking & Listening (“Appendix M,” 2013, pp. 2-3). Because the CCSS anchors are reproduced in their original wording, the tables are dense with discipline-specific language (see Appendix in this document). Critics have noted the difficulty in navigating the NGSS documents (see, e.g., Bruno, 2013; Gross,
2013), but, as of now, nothing has been said explicitly about these tables linking science practices to communication practices.

Both the choice to use a series of tables, as opposed to other forms of data display and/or a written narrative, and the density of the tables due to discipline-specific language, contribute to a sense of impenetrability and authority, which would not facilitate the process of implementing the standards. Tables are among the oldest types of data visualizations, originating in the mathematical tradition and generally used to facilitate data presentation and retrieval (Brasseur, 2003; Gross & Harmon, 2013). But, although tables are often accepted as objective presentations of information, according to Barton and Barton (1993), “technical and professional visuals are not only instruments of communication or even of knowledge but also instruments of power” (p. 138). The fact that there is not one but six tables—six tables that are weighed down by discipline-specific language and concepts—would make them all the more complicated to critique. Tables provide rhetors with ethos and control, according to Brasseur (2003, p. 110), and “readers will likely be persuaded of the careful work that has gone into the study and, subsequently, they might find the entire study’s findings more acceptable because they table is a marker of the ethos of the researchers” (p.112). Therefore, the choice to use a series of tables would serve the NGSS developers’ purpose to justify a potentially unpopular decision (integrating writing into science curricula). However, these tables, in their current form, do not necessarily present what ought to be their primary message to science educators: how critical thinking and persuasive communication play an essential role in their curricula.

There are issues with the NGSS document pertaining to content as well as format. First, the scientific research process is represented through a series of six practices (each practice corresponds to a table), but these six practices are redundant and not aptly labeled. The order in which the science and engineering practices are listed is as follows: (1) Asking Questions and Defining Problems; (2) Planning and Carrying Out Investigations; (3) Analyzing and Interpreting Data; (4) Constructing Explanations and Designing Solutions; (5) Engaging in Argument from Evidence; and (6) Obtaining, Evaluating, and Communicating Information. It would be reasonable to assume that the NGSS tables list the science and engineering practices in the order in which they occur during the research process. That is the case for five of the six practices; it is the sixth one that might create confusion, especially for those who are not already familiar with the connections between communication and science practices.

The sixth practice is problematic because “obtaining, evaluating, and communicating information” is not actually a single practice but rather three separate practices lumped together. In essence, the three elements contained in the sixth practice could be overarching headings for some of the other practices.
mentioned: “obtaining information” describes the second practice pertaining to investigation; “evaluating information” describes the third practice of analyzing and interpreting data; and “communicating information” describes the fifth practice of engaging in argument from evidence. For the sake of parallelism and clarity, the first practice might have a heading like, “Delineating Information,” and the fourth practice might be labeled, “Synthesizing Information.” There are thus five identifiable practices listed in the NGSS, not six: **delineating, obtaining, evaluating, synthesizing, and communicating information.** Briefly put, in order to begin researching, it is necessary to have questions in mind and define the issue at hand. At that point, a researcher can plan an experiment and investigate the issue. When data are produced from the investigation, a researcher can analyze and interpret it, then construct explanations and solutions, and, finally, develop an argument about the data.

In addition to their imprecise representation of the scientific research process, the NGSS tables do not aptly demonstrate how persuasive communication drives scientific practice. Essential communication practices from the Common Core State Standards (CCSS) are reproduced in each of the tables corresponding to the scientific research process, but, whereas some of these communication practices are repeated across the tables, others are excluded from the tables entirely. For example, the literacy practice of gathering relevant information from multiple sources to assess their credibility appears in three of the science tables. But the CCSS literacy practice of producing writing “appropriate to task, purpose, and audience” (CCSS, 2015) does not appear anywhere in the NGSS document—a huge oversight, from a rhetorical standpoint. The process of tailoring scientific discourse to a specific audience, in a particular context, and for a particular purpose is one of the most important (if not the most important) concepts for students to learn: understanding audience and purpose is essential to effective communication (see, e.g., Bazerman, 1989; Fahnestock, 2013b; Keys, 1999). Thus, the choice to exclude the writing anchor pertaining to context, purpose, and audience is problematic, especially given the overarching objective of the NGSS to prepare students for college and careers. Students need to know that science does not happen in a vacuum, that it impacts and is impacted by social forces, and that there are multiple and diverse audiences for scientific information (see, e.g., Gigante, 2014; Perrault, 2013; Priest, 2013).

The issues described here are not meant to discredit the NGSS developers or their intentions. In reality, it is of utmost importance for science curricula to integrate reading, writing, and speaking skills, as scholars in rhetoric and writing

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3 Gathering information is Writing Anchor #8 (CCSS, 2015; “Appendix M,” 2013). It appears in the tables for “Planning and Carrying out Investigations,” “Constructing Explanations and Designing Solutions,” and “Obtaining, Evaluating, and Communicating Information.”
have argued for the past thirty years (see e.g., Bazerman, 1989; Carter et al., 2007; Fahnestock, 2013b; Haas, 1994; Keys, 1999; Lerner, 2007). That said, the NGSS are certainly a step in the right direction in that they demonstrate how science practices link to best practices in communication. However, as it stands, the presentation of information in the NGSS tables opens the door to critics and skeptics of the NGSS to argue that the linkages to the English Language Arts Common Core State Standards are ill-conceived or, worse still, disposable. The NGSS does not make the best use of the available means of persuasion to demonstrate how the communicative arts fit into science education.

The question thus becomes: How can writing be positioned as integral to science education rather than as a risky importation that could disrupt science teaching and learning? In what follows, I attempt to answer this question by briefly discussing the collaboration between writing and science faculty, as well as a reframing of rhetoric and its importance in the classroom, and, lastly, a synopsis of the concept of “socialization” into a discourse community. These three steps prompt a shift in perspective from teaching writing as extraneous to science curricula to teaching writing as vital to the scientific enterprise.

**Writing in the Sciences: Practical Applications of Scholarship in Scientific Rhetoric**

Science teachers’ apprehensions about sacrificing content for writing are understandable, especially given the expectations to prepare students for standardized tests, but integrating writing into the curriculum does not have to be seen as sacrificing content at all. Re-conceptualizing what is already in place and reframing scientific practices for students can lead to more effective communication. Reading and writing are not extraneous to science; they are inextricable from it. The connections between science and writing are more transparent than the NGSS framework makes them out to be. What is required is open-mindedness on the part of educators who are pressured to make what NGSS creators are characterizing as risky changes to their curricula, but what are actually simpler shifts in how lectures and assignments are framed for students.

Decades-worth of scholarship on the rhetoric of science and writing pedagogy can assist in easing the transition into the Next Generation Science Standards. My objective here is to consolidate that scholarship into a manageable set of tools for recalibrating science curricula to include more attention to critical thinking and persuasive communication. These ideas were originally conceived of for a week-long workshop for university science faculty who were interested in learning how to teach writing more effectively in their content-driven classes. An

4 There have been articles written in Science Scope and Science Educator that have attempted to put the NGSS into practice for teachers (see, e.g., Huff & Bybee, 2013; Lewis et al., 2014).
early outline of the writing workshop was presented at the Conference for College Composition and Communication in March 2015 for a special interest panel on science writing and rhetoric, and more specifically, on the “Risks and Rewards” of collaborations between writing and science faculty.

Few would disagree that there are both risks and rewards associated with the process of collaborating across the disciplines. An entire issue of the journal *POROI* (2013) has been devoted to the risks and rewards of offering rhetorical expertise to the scientific community; the pieces in this issue were a response to Leah Ceccarelli’s (2013) “To Whom Do We Speak? The Audiences for Scholarship on the Rhetoric of Science and Technology,” in which she advocates for a shift from theory to action—putting rhetorical scholarship into practice. A necessary starting point is to gain a fresh perspective on what “rhetoric” is and what the knowledge of it can do for the science classroom. Rhetorician Jeanne Fahnestock (2013a) has called rhetoric the “R word” because of its overwhelmingly negative reputation in our culture—it’s association with manipulation or vapid discourse (“mere rhetoric”). It is worth noting, first of all, rhetoric’s origins in ancient Greece as a means of evaluating people’s opinions on civic matters; in fact, knowledge of rhetoric was considered essential to becoming a responsible citizen. Rhetoric’s disappearance from curriculum during the Enlightenment and its association with eloquent (read: misleading) discourse contributes to the negative connotation that it has today, even though knowledge of rhetoric is still essential to being an informed and responsible participant in civil society (Fahnestock, 2013b). The rhetoric of science is concerned with how science is communicated for different audiences and purposes, both within the scientific community and in civil society.

Rhetorical studies of science are useful to promoting the NGSS because they are focused on making scientific discourse conventions transparent and showing how discursive choices lead to certain effects. The rationale for making conventions transparent is that it can help students view themselves as members of the discourse community, as opposed to outsiders and novices who therefore see themselves as incapable of contributing meaningfully to the field (Haas, 1994; Keys, 1999). This process of socializing students into a discourse community is defined by Patricia Duff (2010) as “students’ acquisition and production of target genres and of the tacit cultural knowledge represented by such genres” (p. 170). Science faculty can craft assignments and lessons that facilitate “meta-awareness” or “metaunderstanding” for their students (Duff, 2010; Haas, 1994; Kelly and Bazerman, 2003; Nowacek, 2009). Scholarship that is situated at the intersection of the rhetoric of science and writing pedagogy has shown that the practice of writing can lead not only to student learning in the sciences, but also to socialization into the scientific discourse community (Blakeslee, 1997; Carter et al., 2007). One of the reasons that students are not socialized into the discourse
community is that teachers and professors are often not aware of their own socialization into the discipline (Duff, 2010; Kelly & Bazerman, 2003; Lerner, 2007). Thus, the concept of socializing their own students into the discipline is not on their radars. Currently, scholarship is focused on how to socialize students, not as much on how to teach science teachers how to socialize their students, which is essentially what the NGSS ask teachers to do.

Of course, there are several roadblocks in the way of achieving this goal of socializing students into the scientific community. One of them, as Neal Lerner (2007) puts it, is that “Teaching writing well is simply hard to do, whether in first-year English or an upper-division molecular biology lab. This dilemma is compounded by the self-imposed separateness of writing studies and science education” (p. 217). There are a few steps that can be taken to assist with socializing students into the scientific discourse community and that teachers can consider when tailoring their curricula to comply with the NGSS.

A first step is to focus on reading science as a significant rhetorical practice that is an essential precursor to writing science (Haas, 1994). Reading rhetorically, according to Christina Haas in “Learning to Read Biology” (1994), involves understanding disciplinary texts as “intensely situated, rife with purpose and motive, anchored in myriad ways to the individuals and the cultures that produce them” (p. 44). In other words, students need to understand texts as written by human agents, as opposed to believing that texts are objective, factual pieces of static knowledge. This perspective goes against the traditional-idealist perspective that science is objective and has access to capital-T “truth.” Needless to say, science is not objective, and inculcating students into a traditional-idealist ideology will not give them the confidence to contribute to this human-made body of knowledge. To be able to complete the first science practice in the NGSS tables—Asking Questions and Defining Problems—students have to understand science as a body of carefully argued and agreed upon knowledge, as opposed to seeing textbooks as repositories of facts. Thomas Kuhn’s The Structure of Scientific Revolutions (1996) is often cited as being one of the first texts to demonstrate how objectivity and truth in science are constructed by illustrating that what was once accepted knowledge can be suddenly cast out in favor of a new paradigm (see e.g., Harris, 1997; Penrose and Katz, 2010). Science faculty are poised to explain to students that science is open to dispute, that textbooks and articles are written by human beings who must argue for acceptance of their ideas, and that what counts as “facts” inevitably changes.

When students learn how to read science, they are better prepared to learn how to write science, which is the next step in the process of socializing students into the discourse community. Scholars such as Keys (1999) and Carter et al. (2007) have made the point that writing can facilitate the process of becoming an insider in a discipline. There are some stipulations, however. First, students must
be given more agency in the investigative process—they should be trained in seeking out information, solving problems, and collecting authentic data (Keys, 1999). This agency in the investigative process corresponds to the second scientific practice in the NGSS tables: Planning and Carrying out Investigations. By having this agency, Keys (1999) argues, students can then write to communicate their findings to an audience, using their own data to substantiate their conclusions. Blending “content space” and “rhetorical space” enables students to “try on the ways of writing in a community,” according to Carter et al. (2007, p. 297), a concept referred to as “legitimate peripheral participation” (see, e.g., Blakeslee, 1997; Carter et al., 2007). In this model of legitimate peripheral participation, students are apprentices to instructors, who help them to develop their own authority as scientists. For legitimate peripheral participation to take place, science teachers require a vocabulary for making written conventions transparent to students.

One option for cultivating this vocabulary is to become familiar with how discourse conventions have changed in the sciences since the seventeenth century, which is when journals became an important means of communicating scientific information. The juxtaposition of historical and current practices can make the conventions of current scientific papers stand out to the extent that they can be pinpointed and articulated to students. Gross, Harmon, and Reidy’s (2002) first chapter in Communicating Science, in which they discuss the stylistic and organizational features of scientific papers and how the discourse conventions have changed over time, would be a useful reading for teachers, who can then distill relevant concepts for their students. Knowledge of conventions will assist students in grasping the third practice from the NGSS tables: Analyzing and Interpreting Data. The idea is that students are able to understand that scientific writing follows accepted and expected conventions, and that they can learn to read, analyze, interpret, and write according to them.

Preliminary activities that can be completed in class or for homework can help students negotiate scientific argumentation. For example, tracing a popularization to its source article and highlighting the differences that occur in style, organization, and argument, is one way to help students understand the genres of science communication (Penrose & Katz, 2010). Another example is to show students the differences in style and structure between literature reviews and actual research papers to teach the importance of understanding genre conventions. Still another activity example is reading several introductions to scientific papers and underlining the “moves” that writers make to establish exigence for their claims and propose an argument (Swales, 1990). The activities mentioned here, as well as the overarching step-by-step approach to facilitating socialization into the discourse community require open-mindedness about blending “content space” and “rhetorical space” (Carter et al., 2007; Keys, 1999).
Teaching students to write like scientists, according to Carter et al. (2007), necessitates a shift from traditional educational practices of transmitting knowledge in a top-down fashion to prompting students to see themselves as members of a discipline by giving them opportunities to write in the legitimate genres of that discipline. Of course, once students understand writing as a way of participating in a discourse community, teachers have to be prepared for challenges that arise with any written assignment. The next step in the process of socializing students into the discourse community, then, is teaching students how participation works. Blakeslee’s (1997) piece on learning to write scientific papers in situ discusses some of the issues that novice writers have in joining the scientific community at the graduate level—issues that students can learn to address much earlier, in secondary school classrooms. For example, she finds that students have uncertainty over what information to include, frustration with how to organize information, and (likely as a result) preoccupation with mechanics and stylistic details over higher-order issues of argumentation and organization. 

Grappling with these concerns will ultimately lead to students being able to accomplish the fourth scientific practice listed in the NGSS tables: Constructing Explanations and Designing Solutions. Like Carter et al. (2007), Blakeslee argues for an apprentice-like relationship between instructor and students, as opposed to a relationship in which the instructor possesses the information about how to write, yet does not show students how to do it. Blakeslee’s guidelines are to be explicit with feedback about how to make an argument; to tell students not to focus on style or mechanics until the very end of the drafting process; and to provide students with agency and authority in the writing process, as opposed to making them feel like novices or outsiders.

Written assignments can be reconceived as real-world applications of knowledge, not classroom exercises that students might perceive as leading to nowhere. For example, something as simple as changing the prompts on assignment sheets to address students directly could make a difference in how students view themselves in relationship to their task, especially by using active construction and direct address. Giving students an actual audience is another important element for situating the project in the larger discourse community—for example, are they writing for other science students, or are they explaining their project to an uninitiated audience, like their parents? Making this distinction will allow students to engage with the fifth step from the NGSS tables—Engaging in Argument from Evidence—which depends upon knowledge of the intended audience. Lastly, providing background information on how the project is set up and why it is set up in that way—in other words, explaining how the project aligns with accepted practices in the scientific discourse community—might also help students to see the project as having real-world applications instead of seeing it as an insular school activity. Teachers can familiarize themselves with John
Swales’s (1990) “Create a Research Space” model, in which he explains how scientists make rhetorical moves to create exigence for their research in introductions to scientific papers. This model would provide instructors with a vocabulary for making language and argumentation practices transparent to their students, which, again, is a necessary step toward students’ achieving success in writing (e.g., Kelly & Bazerman, 2003).

There are many possibilities for instruction that go unmentioned here, and, ideally, writing and science faculty members would collaborate to explore these possibilities. In sum, the characterization of the Next Generation Science Standards by its proponents suggests that writing is extrinsic to science and risky to incorporate into science education. More awareness of the centrality of writing in the sciences in primary and secondary education can perhaps alleviate some of these perceived risks.

**Conclusion: “Broader Impacts”**

To borrow a term from the National Science Foundation’s criteria for grant applications that has caught on in the past few years, the “broader impacts” of the Next Generation Science Standards are addressed in the brief videos on the NGSS homepage: these standards will purportedly prepare students for college and beyond with the ultimate goal of making the U.S. more competitive globally (“Why NGSS,” 2013). Preparing students for college and careers is an objective that might meet universal approval, but what exactly is it that science teachers have to do to facilitate that preparedness? “Taking a risk” and “getting messy” do not translate into pedagogical terms (see, e.g., Gross, 2013), nor do they present writing and communication as essential to scientific practice. Presenting writing as extraneous to science does not benefit proponents of the NGSS, it does not benefit students, it does not benefit the scientific community, and it does not benefit society.

Focusing on the connections with the English Language Arts Common Core State Standards, I have attempted to synthesize rhetoric and writing scholarship that has already considered the challenges of negotiating “content space” and “rhetorical space” in the science classroom. In familiarizing themselves with key claims from this body of work, those who are tasked with acclimating to the NGSS might find a new perspective on what their roles are in the process of preparing students for college and careers. But there really is more to the NGSS than even their developers are letting on. The exigence—or “broader impacts”—for teaching students how to communicate in the sciences is not just about preparing for the workforce or competing globally; it is about creating a more democratic society.

In the *Journal of General Education*, Jeanne Fahnestock (2013b) argues that the communicative arts are essential to cooperation on a cultural scale, and
that “persuasion is a necessary component of a successful polity” (p. 14). In an application of that argument to the sciences specifically, Sarah Perrault (2013) claims that scientists’ abilities and willingness to communicate their research outside of the scientific community is essential to moving “past the myth that science is a realm apart and understanding how it is embedded—drawing from, influenced by, and accountable to—civil society” (p. 81). Nonspecialist audiences need to be able to evaluate scientific information in order to contribute to civil society (Perrault, 2013; Priest, 2013). Students who are taught how to evaluate scientific processes, as well as participate in them, and who go on to become scientists, might be better positioned to describe methods, evidence, and interpretations of scientific discourse to audiences beyond the scientific community (Gigante, 2014). Students who do not go on to become scientists, but who are taught to view science as a body of knowledge constructed through communicative practices might be better positioned to evaluate scientific discourse and contribute to policy decisions. Teaching the communicative arts in the science curriculum would then be a step in the direction of making science visible to citizens, as opposed to claiming that science is an objective and airtight process that leads to “Truth.” Teaching the communicative arts in the science curriculum would assist in what Perrault (2013) describes as a shift in emphasis from “Science” to “science in society.”

Appendix

The fifth of six tables from The Next Generation Science Standards Appendix M, “Connections to the Common Core State Standards for Literacy in Science and Technical Subjects,” appears below. The scientific practice represented by this table is “Engaging in Argument from Evidence.” This table is representative of the other five, which can be found on the NGSS website (“Appendix M,” 2013).
## Science and Engineering Practice: Engaging in Argument from Evidence

The study of science and engineering should produce a sense of the process of argument necessary for advancing and defending a new idea or an explanation of a phenomenon and the norms for conducting such arguments. In that spirit, students should argue for the explanations they construct, defend their interpretations of the associated data, and advocate for the designs they propose. (NRC Framework, 2012, p. 73)

<table>
<thead>
<tr>
<th>Supporting CCSS Literacy Anchor Standards and Relevant Portions of the Corresponding Standards for Science and Technical Subjects</th>
<th>Connection to Science and Engineering Practice</th>
</tr>
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</table>
| **CCR Reading Anchor #6**: Assess how point of view or purpose shapes the content and style of a text.  
- RST.6-8.6: “Analyze the author’s purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.”  
- RST.9-10.6: “Analyze the author’s purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.”  
- RST.11-12.6: “Analyze the author’s purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.” | The central motivations of scientists and engineers is to put forth what they believe is the best explanation for a natural phenomenon or design solution, and to verify that representation through well-wrought arguments. Understanding the point of view of scientists and engineers and how that point of view shapes the content of the explanation is what Reading Standard 6 asks students to attend to. |
| **CCR Reading Anchor #8**: Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and suficiency of the evidence.  
- RST.6-8.8: “Distinguish among facts, reasoned judgment based on research findings, and speculation…”  
- RST.9-10.8: “Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem.”  
- RST.11-12.8: “Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.” | Formulating the best explanation or solution to a problem or phenomenon stems from advancing an argument whose premises are rational and supported with evidence. Reading Standard 8 emphasizes evaluating the validity of arguments and whether the evidence offered backs up the claim logically. |
| **CCR Reading Anchor #9**: Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.  
- RST.6-8.9: “Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.”  
- RST.9-10.9: “Compare and contrasting findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.” | Implicit in the practice of identifying the best explanation or design solution is comparing and contrasting competing proposals. Reading Standard 9 identifies the importance of comparing different sources in the process of creating a coherent understanding of a phenomenon, concept, or design solution. |
| **CCR Writing Anchor #1**: Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.  
- W.6-8.1: “Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources…”  
- W.9-10.1: “…Develop claim(s) and counterclaim(s) fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaim(s) in a discipline-appropriate form and in a manner that anticipates the audience’s knowledge level and concerns…”  
- W.11-12.1: “…Develop claim(s) and counterclaim(s) fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaim(s) in a discipline-appropriate form that anticipates the audience’s knowledge level, concerns, values, and possible biases…” | Central to the process of engaging in scientific thought or engineering practices is the notion that what will emerge is backed up by rigorous argument. Writing Standard 1 places argumentation at the heart of the CCSS for science and technology subjects; stressing the importance of logical reasoning, relevant evidence, and credible sources. |
| **CCR Speaking & Listening Anchor #1**: Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others’ ideas and expressing their own clearly and persuasively.  
- SL.6-8.1: “…Pose questions that connect the ideas of several speakers and respond to others’ questions and comments with relevant evidence, observations, and ideas. Acknowledge new information expressed by others, and, when warranted, qualify or justify one’s own views in light of the evidence presented.”  
- SL.9-10.1: “…Articulately incorporate others into the discussion, and clarify, verify, or challenge ideas and conclusions. Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify one’s own views and understanding and make new connections in light of the evidence and reasoning presented.”  
- SL.11-12.1: “…Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue, resolve contradictions when possible, and determine what additional information or research is required to deepen the investigation or complete the task.” | Reasoning and argument require critical listening and collaborative skills in order to identify the best explanation for a natural phenomenon or the best solution to a design problem. Speaking and Listening Standard 1 speaks directly to the importance of comparing and evaluating competing ideas through argument to cooperatively and collaboratively identify the best explanation or solution. |

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**About the Author**

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