CHAPTER 3

NEWTON'S THIRD LAW REVISITED: ACTION REACTION PAIRS IN COLLABORATION

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In 1665 Cambridge University closed as precaution against an impending wave of plague. A recent graduate, Isaac Newton took time off from further study to begin understanding "the problem of motion, both heavenly and earth bound." In a particularly productive period of his life, he formalized the physics of moving objects while simultaneously inventing a new branch of mathematics (calculus) to explain motion. His famous Laws of Motion were first described in his classic text Principia Mathematica in 1687. With these generalized principles, it was possible to understand the workings of the universe. His 3rd Law explored how forces interact as pairs: a book rests on a table pushing down on the surface and the surface pushes back up on the book.

How do WAC partnerships relate to Newton's Third Law? The idea of action/reaction may be applied to the nature of collaborative relationships in the following way: the "action" of seeking partnerships creates "reactions" often of equal (or greater) force propelling the agents in creative directions. Hansen, Hartley, Jamsen, Levin, and Nichols-Besel describe how partnerships "are sparked by curiosity, risk taking and grass roots enthusiasm" that can lead to sustainable programs in their chapter (Chapter 8). As a science educator deeply interested in using writing to promote learning, I have pondered how educators at the secondary school level could form partnerships with postsecondary institutions to improve the thinking and writing in their classroom. Like Navarro and Chion (Chapter 4), I know the value of cultivating writing skills to advance understanding within a discipline; however, as Cox and Gimbel (Chapter 2) remind us, forging collaborative communities is not limited to college-level settings. This essay will document several partnerships among secondary school educators and individuals of post-secondary institutions all in the service of improving teaching and learning.

Given the often stifling force of isolation that occurs among many teachers, the need to reach out and connect with other professionals is vital to the growth of any educator, from novice to accomplished teacher. As a physics and biology teacher at an independent day/boarding boys' school, I have felt the need to connect with other professionals who will challenge my thinking and teaching. At its most basic level, the urge to collaborate begins with an interest in improving one's craft. In July of 2011, the National Academy of Sciences released *A Framework for the Next Generation of Science Standards* (NGSS). Science educators across the country delved into the document with great interest given the implications of its content. One of the notable features of the NGSS was the inclusion of the engineering design process as part of the core practices of science (Bazerman; Giere, Bickle, and Maudlin; Petroski). It was an element unknown to many science educators and soon became an interest of mine as I reflected on how to understand this aspect of the NGSS. I needed to learn more about the subject and how it might play a role in my classroom.

One of the leaders in science and engineering design, the National Aeronautics and Space Administration (NASA) has a distinguished history of accomplishment in space and earth science, in addition to having a vibrant interest in supporting the professional growth of science educators. Part of NASA's mission is to support the recruitment of future professionals. Knowing this, I sought to partner with NASA in some way to increase my understanding of the engineering design process and advance my content understanding.

In 2012 I applied for and was accepted to a two-week workshop sponsored by NASA called the Airborne Research Experience for Educators and Students (AREES). The purpose of the program was to provide research-based experiences for middle and secondary educators through the use of the unique environment of NASA flight platforms (aircraft carrying an elaborate array of sensors). We were placed into collaborative teams and practiced science by becoming involved in NASA earth science and flight missions. In addition, these experiences were to be translated into classroom practice through the implementation of thematic curriculum modules based on a select aircraft, instrument, and research investigation. To advance our content knowledge, we attended lectures and engaged in activities from subject matter experts relevant to aircraft and research investigations. Distinguished scientists and engineers from university faculty, NASA Flight Centers, and research institutions led the lectures. Instructional content included subject matter in natural events (e.g., earthquakes, volcanoes and hurricanes), climate, remote sensing, atmospheric chemistry, and other relevant subjects. It was an intensive and exciting two-week experience throwing us into the role of student and learner.

During our second week, our hosts turned the tables on us and posed the following question: How do you bring this experience back to your classroom? It was now time for us to construct a thematic curricular unit that would span grades seven to twelve and address the content and research practices we experienced the week before. We knew that we wanted our students to experience the "doing" of science and "doing" of engineering (Schwab). In addition, we needed a topic that was sufficiently broad to allow us to generate different curricular strands. We needed to create what David Perkins of Harvard's Project Zero calls "a generative topic" (Checkley; Gardner). Because the workshop took place in California and we had taken a field trip to see the San Andreas Fault, it became clear that the study of earthquakes using airborne sensors would be a rich subject. We settled upon using a Project Based Learning (PBL) approach, posing an authentic challenge with many possible solutions. The unit needed to stretch students and challenge them to expand their Zone of Proximal Development (Vygotsky). It was important to me that writing activities would become an essential part of the unit, from writing-to-learn prompts, writing for social change challenges, and formal scientific writing assignments.

The scientists and engineers from the previous week acted as resources in their areas of content and research authenticity. Interestingly, they became fascinated with how we devised our unit and what role writing would play in it. One senior engineer asked, "Why are you incorporating all of the writing assignments? Shouldn't that happen in their English classes? I'm interested because I never really learned how to write until my first real job." They repeatedly mentioned that effective writing skills were essential to the success of scientists and engineers. Another engineer mentioned, "I learned great technical skills during my time at school; however, it was not until I came to NASA that I discovered the need to communicate my ideas and write in a persuasive way." One scientist, an editor of a major scientific journal, shared with us, "I reject many manuscripts a month not because the science is poor, but because the authors lack the ability to communicate their ideas." He stressed the importance of receiving feedback on writing; "I've learned that other eyes need to read my work before I'm ready to publish. It takes a lot of work." When we interviewed them about the kinds of writing they engaged in, we discovered a wide variety of types: research summaries, grant proposals, requests for proposals, formal technical writing, email dialogues with colleagues across the country, budget requests, and staff evaluations were some of the examples they shared. We asked about how a team of scientists would request funding to use one of NASA's aircraft for research projects, much like the one we designed in our PBL unit. They provided the template collaborative teams must submit for evaluation by the Review Committee. We used a similar template for our project: students had to describe their research project, the methods they would employ, how they would "pack the plane" with instrumentation, and also include a summary of costs. The NASA team provided access to a web-based utility that would calculate actual costs in running a mission. We strived to keep the experience as authentic as possible, including how middle and high school students used writing as a tool to advance learning. As one senior scientist mentioned of the unit we created, "I wish I had such an opportunity when I was a student."

Our collaboration with NASA created an interesting and unexpected action/reaction pair. As a participant of the workshop, I was fully prepared to expand my content knowledge of aeronautics and gain deeper insights into how NASA accomplishes its mission, "To fly what others only imagine." To my surprise and delight, I learned the engineers and scientists were interested in supporting the next generation of STEM professionals through high quality educational resources. One of the major deficits in their education was a limited ability to communicate ideas effectively. The scientists and engineers embraced the idea of fostering this skill early in school, and as a result, a WACommunity was born. The senior scientist who acts as an editor for a scientific journal began offering writing workshops for younger colleagues; he was interested in supporting the growth of his staff. Two of the engineers agreed to act as peer reviewers for my students who engaged in the curricular unit. They mentioned how they enjoyed sharing their knowledge by providing feedback to emerging scientists/engineers. One interesting interaction involved a student who was responding to a writing for social action prompt; he was composing a letter to his senator regarding the recent sequestration budget cuts. He interviewed one of the NASA engineers to learn more about how the cuts were affecting the agency and composed a convincing piece using first-hand knowledge in his letter. My students said, "It went from being a 'so what' letter to an 'ah ha' kind of thing." Just as we learned more about the work of NASA personnel, the staff at Dryden Flight Center delved into the life of educators. Newton's Third Law of action/reaction was actively at work during our summer experience.

Another collaborative experience resulting in unanticipated beneficial outcomes involves how Volunteer Professional Organizations (VPO) can support the growth and learning of secondary and postsecondary educators. For example, many such VPO's exist for educators: the National Council of Teachers of English (NCTE); the National Council of Teachers of Mathematics (NCTM), and the National Science Teachers Association (NSTA). NSTA is the largest organization dedicated to supporting the teaching and learning of science in the country. It offers many professional opportunities to its members: Professional Development Institutes, regional and national conferences and a dynamic e-professional development portal known as the Learning Center (http://learningcenter.nsta.org/).

Teachers may also volunteer to serve on committees with various purposes. I was appointed to one such committee, the Children's Book Council Review Panel, whose purpose is to evaluate all new science trade books for a particular year. With over 150 books published any given year, the committee's task is to select twenty to thirty exemplary texts that meet committee standards for excellence. Rubrics include criteria such as the accuracy of the science described, age appropriateness of topics, and the variety of cultures represented in the books. In particular, research indicated that few children of color see themselves portrayed as "scientific," so the committee has been interested in identifying texts that speak to that audience in compelling ways. After I had volunteered for this committee, I learned how to evaluate the reading level of a book and how important the interplay between written text and effective visuals can be when explaining complex scientific phenomena. One member of our committee, a professor of education and a reading specialist, challenged us "to do more than just review the books." She wanted us to use them and create assessments to strengthen students' cognitive development. Long before the Common Core's emphasis on using non-fiction texts to advance learning, our committee settled upon using these books to support literacy and language development along with promoting science understanding. Science teachers at all levels benefit from the reviews and use them to spur learning within the discipline.

One early collaboration that resulted from my work on the review panel centered on the annotated bibliography we created for the Outstanding Trade Books in Science. The short synopsis, along with a brief commentary of what made the book exemplary, was an excellent exercise in concise writing. Hansen et al. describe how curiosity can spark a vital collaboration (Chapter 8). I was talking with a colleague who mentioned how he was looking for a way to use writing in his classroom. I suggested we use the trade books in some way. The director of our writing center (who was my team teaching partner) suggested we review science books and write our own summaries in the style of the committee. After reading a book, the sixth graders drafted summaries and then met with our twelfth-grade students, who were trained about how to offer supportive feedback to young writers. The sixth-grade students began to master the art of revising their work to more effectively communicate their ideas. We assembled their final drafts into an annotated bibliography, which the middle school librarian used as a resource for all students. Twelfth-grade students acted as peer tutors to the sixth graders, and the librarian and writing center director assisted in compiling the final bibliographies. The bibliographies expanded in size and purpose, morphing into what Margaretha Ebbers refers to as a text set (41). These collections of different genres of books (fiction, non-fiction, biographies, field guides, and reference materials) present scientific information in different ways.

Collections of these text sets can be used to support inquiry-based instruction in science by supporting students as they pose questions, design investigations, and confirm and expand the knowledge they have learned through direct investigations. In their book *Inquiring Scientist, Inquiring Readers: Using Nonfiction to Promote Science Literacy*, Jessica Fries-Gaith and Terry Shiverdecker bring this concept to fruition; they weave together best practices for science and literacy instruction in a way that makes sense for the classroom. What began as a simple act of working on a review panel created an equal and opposite reaction rich with collaboration that spawned a host of writing, thinking and learning among young learners. I shared the assignment with the chair of our committee, and she used it as the inspiration for a unit with her university pre-service science teachers. It has become a favorite of her students, because they learn science content while reading the books, and they explore how to use the books with writing assignments in their classrooms. The "reaction" of my committee service lives on in the work of these pre-service teachers.

The previous examples demonstrate how action/reaction pairs between collaborators advance the professional growth of educators in oblique ways. Can the act of writing itself spark direct growth for educators? In other words, can we apply the principles of the writing process to advance the development of educators? And what role does collaboration play in the development process? I explored those questions as I embarked on the long and arduous process of seeking National Board Certification. Modeled after the bar examination that is used to determine if a candidate is qualified to practice law in a given state, the National Board for Professional Teaching Standards (NBPTS) seeks to identify what a teacher should know and be able to do as an accomplished teacher. The originators of NBPTS, a group of outstanding postsecondary educators across disciplines, has identified five core propositions related to what a teacher should know and be able to do:

1. Teachers are committed to students and their learning.
2. Teachers know the subjects they teach and how to teach those subjects to students.
3. Teachers are responsible for managing and monitoring student learning.
4. Teachers think systematically about their practice and learn from experience.
5. Teachers are members of learning communities.

The assessment process requires candidates to complete two major components: a portfolio of classroom practice, including samples of student work and video recordings of instruction, and a content knowledge assessment administered at a testing center. At the core of the process is writing: writing about practice; writing about assessment; writing about student growth and personal growth; and reflecting on how to improve as a professional. I was deeply engaged in the writing process while examining my work as an educator: prewriting (inventing approaches and aspects of learning to review); carefully responding to the prompts with supporting evidence; outlining my ideas with a narrative structure; proofreading; seeking outside feedback; and rewriting and revising my drafts. I was engaged in this iterative loop for a year as I put my practice "under the microscope" of review and self-reflection. The action of writing created an equal and opposite force that transformed how I think about teaching and learning: I no longer just "blazed through" a class, a unit, a semester; the writing process caused me to continuously question and reflect on what made my actions effective. Ultimately, I was successful in obtaining certification due largely to applying the writing process to my work. I joined a group sponsored by the national board to act as mentors to aspiring candidates. I found that mentoring a colleague was as valuable as going through the process itself.

Mary Sandowski, a biology teacher from Seattle, and I attended a dynamic Professional Development workshop that took place at the Olympic Park Institute outside the Olympic National Park in Washington. We were learning about the ecology of old growth forests of the Pacific Northwest. While crawling over the massive remains of fallen spruce, Mary mentioned that she was interested in attempting National Board Certification. I encouraged her to start the process and offered to be a mentor as she moved through the long journey of completing its requirements. Over the course of a year, we began a dialog that was highly rewarding to both of us: she would forward drafts of reflective writing about various submissions and I would offer feedback to her ideas. An interesting pattern emerged in our dialog: she would make claims about "student understanding being advanced" and I would respond "where's the evidence?" Before long, Mary realized she needed to offer support for any claims; more importantly, she began to question why she was doing certain actions with her students and how that supported their learning. The "magic" of self-reflection was beginning to take hold of Mary: "I never realized how slowing down to reflect on my work in writing would act as the catalyst for change. We are so focused on moving forward, that we forget to look back." Mary was grasping what Navarro and Chion mention in their chapter, that covering a syllabus does not guarantee deep learning (Chapter 4). Writing becomes the vehicle that "slows us down" and invites discourse about our practice as educators. I suggested she might try a writing-to-learn activity to begin a unit and track student comprehension by using a portfolio system. She instituted the idea, and it became a valuable assessment "artifact" for her certification process. Mary revised her essays multiple times, demonstrating clearer insight into the work of her students and her role in supporting their growth with each version. My "action" with Mary caused an equal "reaction" in my own practice: was I practicing what I preached when it came to using writing in my classroom? My dialog with Mary forced me to re-evaluate how I use writing and prompted me to take new directions in how I use this tool with my students. I created an assignment having students delve into scientific literature and write concise summaries of that literature. It is an assignment that continues to pay dividends with learning today; students mention in summative assessments that the research summaries forced them to become more effective communicators. The writing process as practiced by student and educator alike became the vehicle for professional and personal growth, and this insight sprang from my collaboration with the National Board for Professional Teaching Standards.

Over 350 years ago, Newton created a framework for understanding how actions of "unlike bodies may interact to move in understandable ways" (Westfall 105). He most likely never imagined his Laws of Motion might extend to collaborative "action/reaction" pairs; nonetheless the genius of his ideas lies in their applicability to other fields. My own collaborations have challenged me to move outside my classroom and interact with "unlike bodies," with educators in different fields and at other academic levels. By taking the risk of moving outside of the familiar, I have been rewarded with profound professional growth. Whether it is forming partnerships through the National Writing Project, IWCA, WAC, or working closely with a colleague to support writing, thinking and learning, these partnerships are crucial hallmarks of professional practice.

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