Turning STEM into STREAM: Writing as an Essential Component of Science Education

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Summary: Robert and Michele Root-Bernstein, the authors of Sparks of Genius: The 13 Thinking Tools of the World's Most Creative People, make the point that writing is essential for teaching the entire range of disciplines and critical to the training of innovative and successful scientists.

There is a movement afoot to turn the acronym STEM—which stands for science, technology, engineering, and mathematics—into STEAM by adding the arts. Science educators have finally begun to realize that the skills required by innovative STEM professionals include arts and crafts thinking. Visual thinking; recognizing and forming patterns; modeling; getting a "feel" for systems; and the manipulative skills learned by using tools, pens, and brushes are all demonstrably valuable for developing STEM abilities. And the National Science Foundation and the National Endowment for the Arts have gotten the message: formal meetings between the two agencies have begun in order to figure out how to fund productive research and teaching at the intersection of these sets of disciplines.

The agencies also realized that adding the arts to STEM is not enough. We also need to add the thinking skills embodied in reading and writing. STREAM may condense into STREAM!

Writing, like any other art, teaches the entire range of "tools for thinking" that are required to be creative in any discipline (Root-Bernstein and Root-Bernstein 1999). To be a lucid writer, one must observe acutely; abstract out the key information; recognize and create patterns; use analogies and metaphors to model in words some reality that takes place in another dimension; translate sensations, feelings, and hunches into clearly communicable forms; and combine all this sensual information into words that create not only understanding but also delight, remorse, anger, desire, or any other human emotion that will drive understanding into action.

Think about it: what we've just described is what a scientist or mathematician does too. And that is our point. Writing isn't just wordsmithing. It also teaches mastery of the creative process. Whether one is writing fiction or nonfiction, creative nonfiction or poetry, the process of taking inchoate facts, trends, feelings, impressions, images, and emotions and translating them into words requires mastery of all the tools for thinking required to perform any other creative activity. Moreover, since words are our primary means of communicating, anyone who has not mastered their creative use is simply underprepared for any discipline, including STEM subjects.

This is not just theory. The average science course requires a student to learn the same number of new vocabulary words he or she would learn in a foreign-language course. Take a look at a medical dictionary, a scientific dictionary, or an encyclopedia of mathematics: they are foreign languages to most of us, even though they are (supposedly) written in English. Those who have not mastered their own language, and do not understand how to parse it and manipulate it to their own ends, are in no position to master the use of a STEM language. This, in fact, is the conclusion of a recent series of articles in the journal Science (Woodford 1967, Miyake et al. 2010). Mastery of the English language, these articles concluded, is a prerequisite to scientific success and demonstrably improves performance in STEM courses.

Many scientists have reached this conclusion from their own experiences. For example, Priya Venkatesan double-majored in comparative literature and biochemistry at Dartmouth College and writes: "While conducting molecular biology research . . . I have found the parallels between literature and science all too striking. Further, I have determined that being a literary theorist could have advantages in the laboratory—not only in enhancing scientific productivity, but also in more accurately understanding scientific activity" (Venkatesan 2007; see also Rohn 2007).

Nobel laureate and physicist William D. Phillips writes similarly that "[i]n high school, I enjoyed and profited from well-taught science and math classes, but in retrospect, I can see that the classes that emphasized language and writing skills were just as important for the development of my scientific career as were science and math. I certainly feel that my high school involvement in debating competitions helped me later to give better
scientific talks, that the classes in writing style helped me to write better papers" (Phillips 2011).

Fellow laureate and chemist Roald Hoffmann has gone a step further: he has become a professional poet. He notes that "[t]he language of science is a language under stress. Words are being made to describe things that seem indescribable in words—equations, chemical structures, and so forth. Words do not, cannot, mean all that they stand for, yet they are all we have to describe experience. By being a natural language under tension, the language of science is inherently poetic. There is metaphor aplenty in science. Emotions emerge shaped as states of matter and more interestingly, matter acts out what goes on in the soul" (Hoffmann 2011). Poetry can therefore help Hoffmann understand not only what he does but also why.

Moreover, these anecdotes are confirmed by large statistical studies. For example, we've compared the avocations and hobbies of the average scientist to Nobel laureates and members of the U.S. National Academy of Sciences and the British Royal Society. Nobel laureates and members of the prestigious academies were at least twenty times as likely to have a writing avocation as the average scientist. And that's the most conservative reading of the data. The real difference may be more than one hundred times (Root-Bernstein et al. 2008)! So if you want to train innovative and successful scientists, there isn't any doubt that you want to teach them to love and cherish writing.

It is therefore with great regret that we learn that one of the premier writing programs in the country, the National Writing Project, has lost its funding. The National Writing Project teaches teachers to teach writing. What a wonderful and useful occupation! But in the rush to focus resources ever more tightly on the skills that will make Americans more innovative, might we not be undermining the very goals we espouse by failing to understand how we learn to learn? As Grant Faulkner, an editor at the National Writing Project, puts it, "Writing is thinking.... So we shouldn't sacrifice the teaching of writing" (Faulkner 2011). And certainly not for the sake of STEM subjects—that's just cutting off our nose to spite our face!

Turning STEM into STEAM will empower the sciences, but adding reading and writing skills will create the STREAM from which STEAM can be produced! We all have so much to learn from each other. Let's integrate, not set the disciplines at each others' throats.

**About the Authors** Robert and Michele Root-Bernstein, co-authors of *Sparks of Genius, The 13 Thinking Tools of the World's Most Creative People* (Houghton Mifflin, 1999) and *Honey, Mud, Maggots and Other Medical Marvels* (1997), met as doctoral students in history and history of science at Princeton University. Since then they have married their diverse and complementary interests to a wide variety of creativity studies, stimulated by Robert's *Discovering, Inventing and Solving Problems at the Frontiers of Scientific Knowledge* (1989), which he wrote as one of the first fellows awarded a "genius" grant by the MacArthur Foundation. A full professor at Michigan State University, Robert studies the evolution of physiological control systems, autoimmune diseases and scientific creativity; Michele, a writer, Kennedy Center teaching artist and adjunct faculty member at MSU, currently studies the invention of imaginary worlds from childhood to adulthood. Together they lecture, consult, lead workshops and write *Imagine That!*

**References**

Faulkner, G. 2011. "To Write or Not to Write. To Be or Not to Be." Available at [http://www.examiner.com/literature-in-oakland/to-write-or-not-to-write-to-be-or-not-to-be](http://www.examiner.com/literature-in-oakland/to-write-or-not-to-write-to-be-or-not-to-be).


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