

Writing Science in Hard Times

Michael McClellan, Jefferson High School, Dawn Myelle-Watson, Jefferson High School, Brad Peters, Northern Illinois University, Debora Spears, Jefferson High School, and David Wellen, Jefferson High School

Abstract: To teach science writing effectively, scholars encourage combining writing to learn with applications of the science writing heuristic. How teachers learn to do so remains under-examined. This essay follows a cohort of ninth-grade science teachers who collaborated in a project to develop, test, and revise such a combination of writing prompts for physical science and biology in a high-poverty, urban school district. Students in the project acquired course concepts more readily. In standardized exams designed by the district, they also outperformed students enrolled in the same courses, using the same district curricula. Even special education students demonstrated better progress and retention. In addition, the exams enabled the science teachers to evaluate the curriculum and to consider how writing to learn could redress its weaknesses. Preliminary results of the project suggest that writing to learn—augmented by locally designed standardized tests—might not only transform student learning outcomes, but transform the development of secondary science curricula as well.

Background

For over a year, we have been testing the premise that writing to learn can improve student learning outcomes in ninth-grade science classes. We work in Illinois' second largest public school district. Three of us are science teachers—Dawn, Mike, and Dave—who enrolled in an on-site course, "Teaching Writing in Your Subject Area," that Deb and Brad co-facilitated. Deb is our school reading specialist, and Brad coordinates writing across the curriculum at a regional university. An Illinois state grant from Promoting Achievement through Literacy Skills (PALS) funded our course and project.

We discuss here how Dawn, Mike, and Dave implemented writing to learn, and what impact it made on physical science and biology students. First, we analyze prompts they piloted in "Teaching Writing." Then we highlight discoveries we made while Dawn, Mike, and Dave integrated writing to learn in all their classes the following semester. Next, we examine their students' performance on a district-wide exam. We conclude with comments on what principles and insights will guide us through the final semester of our project. Other teachers might find our discoveries useful, whatever their subject area.

Threats and Promises

Soon after our project began, our Board of Education cited a \$50 million shortfall as its reason to maximize class sizes, close or consolidate ten schools, and eliminate 281 teachers, administrators, and aides (Bayer,

2011). Without concessions in pensions and health-care, the Board warned it would also shut four more schools, scrap five programs, cancel new textbook orders, and cut 138 more jobs (Bayer). Slashing special education classes as well—in an 82% high-poverty district— would prevent our most vulnerable students from getting the extra help they needed (ISBE, "District summary").

Despite, or perhaps *because of* these concerns, Dawn, Mike, and Dave wanted to try writing to learn. Research from our own high school implied that all students could "produce statistically significant learning outcomes" through its implementation (Peters, 2011, p. 85). This research suggested that even our special education students would benefit, contrary to opposite claims (Rivard, 2004; Bangert-Drowns, et al., 2004, pp. 6, 53). Such data bode well for Dawn and Mike, whose physical science classes would most likely include at least 30% special education students the next fall.

We also discussed National Science Foundation claims that science students in general boosted test scores with increased writing (Peery, 2009, pp. 17-18). We looked at activities that have worked nationwide (Childers & Lowry, 2012; Hohenshell & Hand, 2006; Peery, pp. 127-151, Petersen, 2001; Keys, 1999; Chabot & Tomkiewicz, 1998):

- Free-verse descriptions of plant and animal life
- Informal reports on student-generated experiments
- Observation journals
- Interpretations of graphs and tables
- Summaries of reading assignments
- Cornell notes
- Short defenses of answers on multiple-choice tests
- RAFT assignments (role, audience, format, topic)
- Four-square reflections
- Graphic organizers
- The Science Writing Heuristic

Moreover, we saw how writing to learn could introduce our students to common science-communication practices, such as group authorship, peer reviews/ critiques, collaboration, and writing for audiences other than scientists (Zimmer 2000; Keys, 1999; Clark, 2005; Richardson, 2005; Blakeslee, 2001; Reitsma, 1999). Writing to learn could help them understand that making scientific knowledge relied on speculation, prediction, induction, deduction, argument, and controversy—often focusing on seemingly small, technical details that scientific method proved important (Hohenshell & Hand, 2006; Myers, 1990, p. 140). Writing to learn might enable our students to recognize the "sociopolitical and moral contexts" that affected science literacy, particularly at a time when conservative ideologies contested scientific findings (Soliday, 2005, p. 67). Finally, among the purposes, forms, and functions that writing could serve in science classes, we hoped it would encourage our students to reflect on what they'd learned, so Dawn, Mike, and Dave could see what they should review or re-teach (see Oltenacu, 2003, p. 82).

Testing WTL Premises: Units, Method, Curriculum

Our course followed four key National Writing Project practices:

- Plan informal writing at least twice a month
- Discuss writing strategies in the context of course content
- Do some form of redrafting
- Collect, examine, and reflect on the writing (Nagin, 2003, p. 44)

We used a rubric we'd developed specifically for writing-to-learn prompts (see Figure 1, below) because as Zimmet (2000) notes, if an activity is not evaluated in some way, "students often think it doesn't matter" (p. 105).

Figure 1: Rubric

CRITERIA	3-exceeds expectations	2-meets expectations	1-misses expectations
Comprehension of Task— your ability to respond informally to what a writing prompt asks	You always understand and follow instructions exactly.	You usually understand and follow instructions.	You often misunderstand or disregard instructions.
Content— your ability to convey knowledge of course content received from reading or listening	You provide highly accurate information and exceptional detail.	You provide accurate information and sufficient detail.	You provide inaccurate information and/or insufficient detail.
Strategies— your ability to apply, analyze, back up, compare, classify, critique, define, describe, evaluate, explain, exemplify, graph, hypothesize, illustrate, interpret, observe, organize, predict, question, reflect, review, show cause-effect, solve, summarize, or synthesize.	You show clear control over the strategy or strategies that the prompt requires.	You show satisfactory evidence of understanding and practicing required strategies.	You show little or no evidence of understanding required strategies.
Language use— your ability to develop a readable response and use conventions of grammar and punctuation	Your response is very articulate; errors minimal.	Your response is easy to read; errors don't prevent understanding.	Your response is hard to read/ understand; errors confuse.

Dawn, Mike, and Dave each chose one science class as a "WTL lab" where they could test the approaches that "Teaching Writing" emphasized: scaffolding writing prompts to provide students with a knowledge base; developing materials to help students write/ learn successfully; designing a clear progression of tasks that led to deeper understanding of class topics (see Wood, Bruner, & Ross, 1976; Johannessen, Kahn, & Walter, 1982).

Dawn designed the initial prompts below for her ninth-grade biology class:

- What is probability, and how does it help us to understand the laws of inheritance?
- How are the terms 'dominant,' 'recessive,' 'homozygous,' and 'heterozygous' related?
- Explain how purebred crosses and test crosses can be used to determine co-dominant traits.

Students' written results verified that her prompts linked to each other well enough. But many didn't provide adequate explanations. One student's response to the second prompt, for example, simply stated that a man had long legs, a recessive trait, while his wife had short legs, a dominant trait. Dawn designed a follow-up with more exacting instructions:

Create an original Punnett square for a monohybrid cross. Give a short background (a few sentences) describing the organism, as well as the dominant and recessive traits. Explain the expected ratios of genotypes and phenotypes for the offspring.

Students wrote better explanations, such as one who identified a homozygous aunt in her mother's family, where curly haired children had been born for generations. On the other hand, her uncle was heterozygous, with curly hair only recently occurring on his side of the family. Between genotypes CC and Cc, curly hair was the most possible phenotype—with a 100% chance (4:4) that their children would have curly hair, and no chance (0:0) of straight hair. Dawn's fourth prompt required a visual metaphor, too: a Punnett square which enabled her students, as Petersen (2001) would say, "to connect and relate the knowledge" they'd acquired so they could "make leaps of understanding" (pp. 99-100).

Accordingly, "Teaching Writing" turned into a series of workshops on designing better prompts. Mike drafted several short, preliminary prompts, including the following:

Compare each of the four states of matter, using definitions, descriptions, and examples.

We talked it over, considering the elements of good assignment design that Nagin (2003) has identified: content and scope, organization and development, audience and communication, engagement and choice (pp. 47-49). Mike consequently broke his prompt into steps. First, combining talk with writing as Rivard & Straw (2000) suggest, he led a class discussion where the students wrote up a T-chart to organize their notes on the states of matter. Then Mike had the students write and talk about their lab data. After that, they wrote and illustrated their own definitions of solids, liquids, plasma, and gas—and shared those definitions in class. Finally, as Childers and Lowry (2012) advise, Mike designed a prompt that asked students to incorporate "different audiences such as peers or parents" (p. 30; see also Gunel, Hand, & McDermott, 2009):

Your ten-year-old cousin has been learning about the four states of matter at school. He still doesn't understand the differences between them and can't remember their characteristics. Compare each of the four states of matter using definitions, descriptions, and examples so that you can teach your cousin the similarities and differences.

The students' willingness to write surprised Mike. "Hey cousin, I heard you still don't understand the differences between the four states of matter!" one began. Even special education students didn't falter. Students' letters used terms well ("think of a rock, it has mass and shape"), elaborated on properties in their descriptions ("a liquid takes the shape of its container"), and provided examples of matter that a ten-year-old could grasp (an X-box, Pepsi, air in a balloon, neon signs). A few identified space among molecules as relevant to matter, and others recommended simple lab experiments ("boil ice!"). Another letter concluded: "For more details, ask your science teacher."

Dave designed a prompt for other readers, too, summing up what his biology students had learned about features that classified animals and plants. Similar to Childers and Lowry's (2005) aim "to deepen and enrich the learning experience by making critical connections between visuals and written text," Dave's prompt required artwork:

Write a short essay for a group of biologists, describing a new organism you discovered. Explain how you went about classifying it and giving it a scientific name. You may use an existing organism or come up with a new species. Include a drawing, and don't be afraid to be creative with your organism or its story.

Students' imaginative drawings helped them attend to specific traits. One came up with an egg-laying "rog" that looked like a dog with powerful hind legs for jumping. It ate worms with its long tongue and either hopped around on land or hid under water for up to an hour. It also mooed. Another student described a poisonous flower that trapped insects with its net of cotton-candy-like petals and ate them with its thorny teeth. This prolific "plantae" could produce as many as 1,000 seedlings a week.

One of our most productive workshops in "Teaching Writing" was triggered by a prompt that Dave designed on scientific method. It originally read:

Describe all the parts of a good controlled experiment. Give an example. Include a control group and an experimental group. Include the dependent and independent variables.

After we brainstormed on how he could break down the prompt, Dave scaffolded steps similar to the "Science Writing Heuristic" that Hohenshell and Hand (2006) describe (266, 271). He first came up with a writing activity on defining the vocabulary of controlled experiments. Then he introduced an article explaining that Great Lakes fish used their ability to see colors to find food. Successful fishing thus required a colored lure. Students read, wrote summaries, and discussed the article. When Dave elicited scientific questions, many students wondered what colors would attract fish most?

Once students figured out an experiment to address their question, Dave brought in different-colored glow sticks and put goldfish into a large aquarium. As a control, student groups darkened the room and failed to attract the fish with inactivated glow sticks. Then they tested which color of activated glow stick would attract the most fish. Groups wrote up their results. Next, they replicated the steps of each other's lab reports, to check for similar results. After discussing what they found, most groups revised.

Dave observed, "This type of writing activity was better than writing a paper." Students practiced scientific method (see Keys, 1999, p. 118; Halliday & Martin, 1993). The experiment involved the "peer review, collaborative problem solving, or student partner revision teams" that purportedly change "passive learners into active learners" (Mullin & Childers, 1995, p. 26; Zimmet, p. 106; Webb, 1989). And each student kept a goldfish.

As "Teaching Writing" headed toward the semester's end, Mike mentioned a problem that had bothered him for years; 25% of the Prairie State Achievement Exam focused on earth science—a middle-school course. The high school curriculum did not review this area, so when students took the PSAE, they often failed. Special education students fared the worst. Mike revised the syllabus for physical science, showing how to distribute relevant earth science material across course units on matter, energy, theories and laws. He posed essential questions that he could use as prompts, enabling students to create a review folder (see Burke, 2010, pp. 1-3). We focused a workshop on this issue.

With Dawn's and Dave's input, Mike decided that at least 20% of the next academic year's work could include a review of earth science—without compromising other curricular material. As Glaze and Thaiss (1994) observe, when WAC offers discipline-specific intervention techniques—especially interventions that address what teachers value most—those teachers will take independent action (p. 18).

"Dear Mr. Alien": Further Discoveries about Writing to Learn

Following summer break, Dawn, Mike, and Dave agreed we should have pre- and post-course samples that—in addition to writing collected in student folders—could help us gauge learning outcomes (see Peters, 2011, p. 67). Below is Dawn's pre-course prompt:

Biology is the study of living things and how they interact on Earth. Answer the following questions in an essay of three paragraphs or more. How can you tell if something is living or not alive? How are living things related/ not related (hint: you can write about cells, DNA,

characteristics, etc...)? How do living things pass on their traits or how did you inherit your characteristics? How do living things interact with each other and the environment (hint: you can write about habitats, climate, food webs, etc...)?

Many students wrote short, less coherent responses that didn't answer most questions; e.g., "Living things interact in all kinds of ways, but humans use talking and animals use noises or barks." Dawn felt she'd engaged her students in "knowledge telling" rather than "knowledge transforming," perhaps asking more than what most could do (Bereiter & Scardamalia, 1987; Rivard & Straw, 2000, p. 586). Yet she also noted several students in her honors class wrote responses that indeed showed what they knew about cells ("every living thing is made up of cells, whether it is plant, human, or bug"), DNA ("my Dad has brown eyes, and that particular gene was dominant, so I have brown eyes"), or habitats ("Us humans take in the oxygen the trees give us and breathe out carbon dioxide. It's a cycle"). She saw they had "the cognitive tools and the conceptual building blocks necessary" for completing the task (Rivard & Straw, p. 587; Webb, 1989).

On the other hand, a special education student in her "regular" class asked to take the prompt home to finish working on it. The next day, the student brought back an appropriate response. Though this accommodation might have been controversial under testing conditions, it allowed him to do classwork more on par with regular students (see Stretch & Osborn, 2005, p. 4). Dawn, Mike and Dave all agreed to let special education students have this extra time if they used it well. From then on, some regularly did—as did ELL students (see Lee, Maerten-Rivera, Penfield, LeRoy, & Secada, 2008, p. 33).

Meanwhile, Dawn and Mike teamed up on physical science prompts. Mike's previous success with rhetorical situations led them to dabble in science fiction:

In physical science, we study the relationship between matter and energy. As a person, you are made of matter. You store and use energy to live your daily life. Write a letter to an alien, describing what you know about matter and energy. You should give examples in your letter as you explain what he/she can expect to see if they visit earth.

After an introductory class discussion, a few called their alien pen pal "Bob." One advised Bob that "pretty much all of the earth is matter," and matter was "made up of elements on the periodic table." As for the difference between matter and energy, another student speculated that "you guys on Mars might not have rollercoasters," but they were good examples of matter having potential energy when stopped, kinesthetic energy when in motion—and they also needed electricity, "the energy of moving electrons," to run.

Mike's results led Dawn and David to create a scenario where Marty the Martian visited Earth on a biological mission. He brought back a car as a dominant life form. Judges accused him of bad science. After discussion, students received this prompt:

You have just brainstormed ways to prosecute or defend Marty the Martian. Choose one side and create an opening argument for Marty's trial. Be creative in your description of how you plan to 'prove' Marty right or wrong, applying all of the characteristics of living things to cars.

As Keys (1999) suggests, such prompts require students to produce evidence, warrants, claims, logical argument, and alternative explanations (p. 122). Many asked Marty if cars showed homeostasis or reacted to their environment. Did cars not only produce energy and waste, but also breathe, show cellular organization, reproduce? Did cars grow, get injured, heal, get old, and die—or just rust? As many researchers recommend, this activity introduced students to scientific inquiry and reasoning (see Erdurian & Jiménez-Aleixandre, 2007).

Meanwhile, in physical science, even when teaching terms and definitions, Mike and Dawn asked students to write for an audience. The prompt below illustrates:

You just went shopping for peanut butter, salt, orange juice, distilled water, a gold bracelet, and a tank of helium gas for your cousin's birthday balloons. The cashier, a retired science teacher, teases you, saying you must identify each item as an element, compound, or mixture in order to take them home. Can you do it? In a paragraph, identify each item and explain how you know what it is.

Class discussion preceded students making a definition T-chart; then they "translated." One even adopted a dictionary/ check-out line style—"distilled water: compound; it has two elements." Although some researchers suggest that such an exercise may only involve recitation, Dawn and Mike found contrary evidence (McCann, Johannessen, Kahn, & Flanagan, 2006, p. 2). The rhetorical act of explaining provided students with a heuristic that put a lexicon to use.

Mike also discovered the value of regularly establishing a lexicon in later work.

Near midterm, he did a week of earth science review, as he'd planned. To save time, he told students just to take notes. He primarily used lecture/ discussion, putting key terms and definitions on the white board as he asked students questions about the Big Bang theory, formation of planets, continental drift, atmospheric layers, and sources of energy. When he finished this review week, he assigned the following open-ended prompt:

Use your notes and your knowledge to describe what you know about the earth and its atmosphere. Simply describe the make-up of the earth and the gasses that surround it. Do not refer to living things.

Because students' notes consisted of terms and definitions, a few wrote disjointed lists. One or two provided perfunctory responses—"We live off gasses." But the majority created either an analysis; e.g., "Earth's atmosphere is made up of 5 layers and earth itself has 3 main layers..."; or a narrative, e.g., "First, the big bang happened... Then basic elements formed... Next the continents formed... Then the troposphere made life possible...." The analyses emphasized what students said they knew, while narratives attempted scientific history. In each, sequencing of information followed a logical development. Students could reformulate their earth science lexicon into the analytical and narrative formats of write-to-learn exercises they previously composed, where, as Keys (1999) recommends, *explanation* was the chief communicative aim (p. 127).

Dawn's biology students replicated similar results for this prompt on DNA:

Explain 'DNA replication.' Use the following terms to describe the three major steps in DNA replication: nucleotides, base pairing, template, complimentary strands, DNA helicase, DNA polymerase, replication fork, adenine, guanine, cytosine, thymine, phosphate, & deoxyribose.

Like many classmates, one student defined replication as "a process where the DNA in an organism is duplicated." Then, moving into a biological narrative, she described how the enzyme "helicase unwinds the double helix," and then "polymerase unzips or seperates [sic] the DNA molecule into two strands." Finally, she and others elaborated on how each strand "serves as a template to produce new strands... following the rules of base pairing, where guanine and cytosine" were paired up as well as "thymine and adenine." It seemed that the lexical prompt had given Dawn's students "an important discursive tool for organizing and consolidating the rudimentary ideas" of DNA replication "into knowledge that [was] more coherent and well-structured" and retained (Rivard & Straw, 2000, p. 586).

Taken together, this semester's findings and the last's help us anticipate steps for the semester to come. We will compare future prompts with those that have produced good student writing up to now and make revisions. We will design more open-ended prompts, to encourage students to synthesize and elaborate on

their grasp of content. And we will make sure that students learn how to use the lexicon of each unit so that they can explain and deploy that lexicon in analytical and narrative writing for a variety of audiences.

But can we say yet that writing to learn has improved learning outcomes? Mike believes he's seen more improvement than any year before. Conclusions to his students' lab reports are more substantial, for example. Class discussions suggest that his students retain more content by writing about it, as well. Dawn and Dave report similar evidence. Recently, serendipity has perhaps provided us with a more salient measure.

Seeing is Believing

During the summer, district science teachers got together to design quarterly tests. Administrators had called for instruments that would reflect more accurately what district curricula taught, which might also help students improve on the PSAE. The first-quarter biology test focused 35 multiple-choice questions on these performance indicators:

- Read, interpret, and construct tables, graphs, and diagrams
- Determine meaning of key terms and phrases as used in specific scientific or technical contexts
- Determine central ideas of a text while understanding basic terminology (Computer generated report on biology 1st quarter, October 24, 2011)

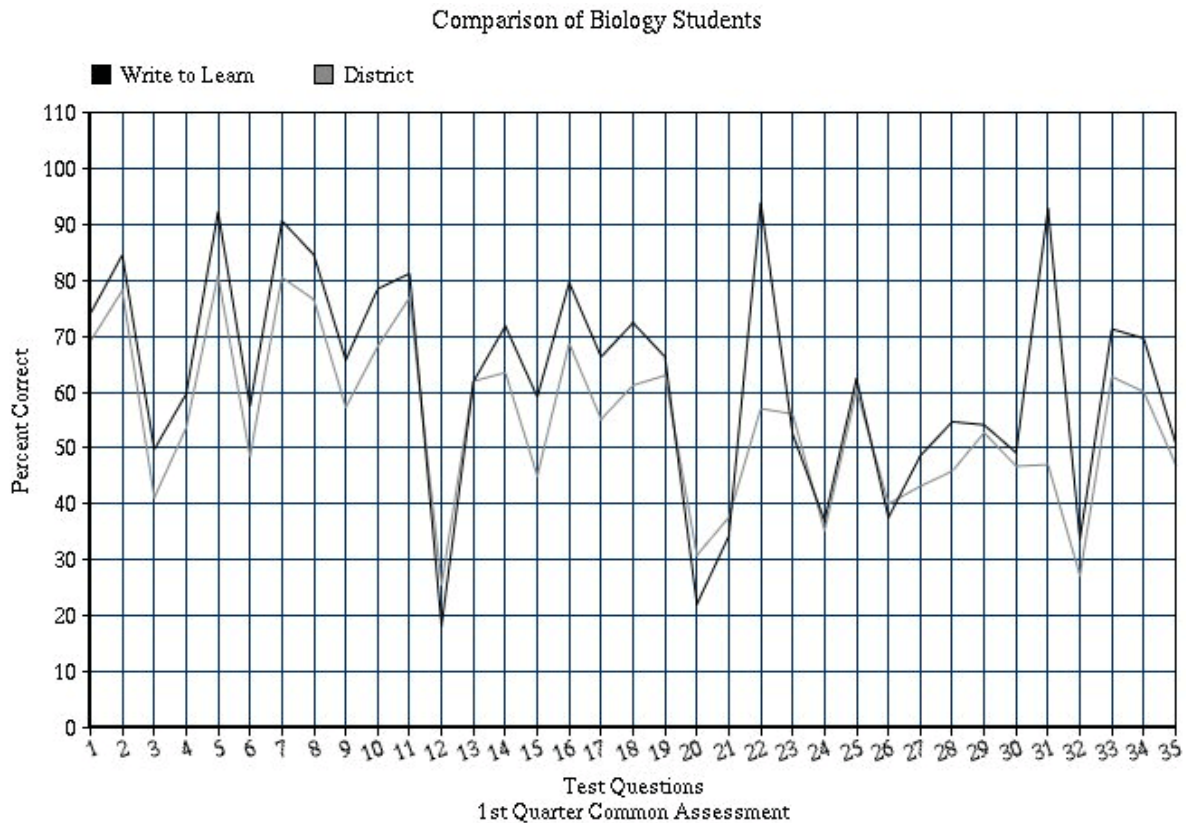
1,550 students took the test. The numbers of those who had and had not engaged in writing-to-learn tasks appear in Table 1 below, along with point and percentage averages.

Table 1: Comparison of Biology Test Scores, 1st Quarter

	Number of Questions	Number of Students	Avg. Points Scored	Total Points Possible	Avg. Percent Score
Biology students who did writing to learn	35	181	21.77	35	62.20%
Other biology students	35	1369	19.28	35	54.99%

Biology students who wrote to learn outperformed the rest of the district on 83% of the questions. Students who didn't write to learn "shadowed under" those questions by an average of 9 points (see Graph 1, below). Questions alternated sharply in difficulty.

Graph 1: Comparison of Biology Students



When a two-sample t-test compared the writing-to-learn students with the rest of the ninth-grade biology students, we found that $t(68) = 1.72$, $p < .05$, suggesting less than a 5% probability that higher scores among writing-to-learn students were coincidental. Calculating *effect size* r , however, resulted in .2—a small effect—indicating that while the numbers showed real promise, we still needed to celebrate cautiously.

First-quarter scores in physical science demonstrated similar promise, as well as similar caution. The 30 test questions clustered around four performance indicators:

- Apply appropriate principles of lab safety
- Compare/ contrast physical and chemical properties of substances
- Describe different forms of energy flows, transformations, and sources
- Solve simple story problems with one variable (computer generated report on physical science 1st quarter common assessment, October 24, 2011)

Dawn's physical science students scored similar to others in the district. But her students' write-to-learn responses had convinced her to slow down and re-teach some material, so her 45 students did poorly on material they hadn't covered. We adjusted them out of the total number of 772 examinees. At the same time, Mike saw his 129 students surpass district scores in 80% of the test questions (see Table 2, below).

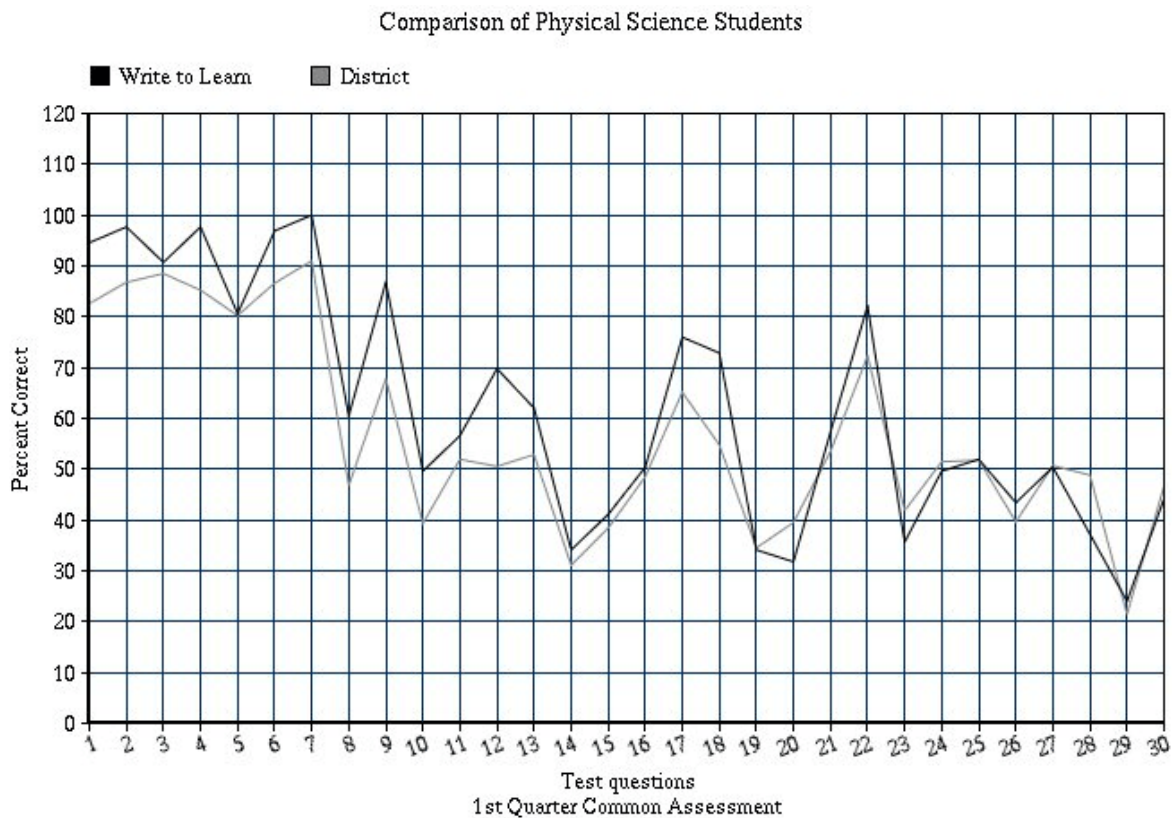
Table 2: Comparison of PHYSICAL SCIENCE Test Scores, 1st Quarter

	Number of Questions	Number of Students	Avg. Points Scored	Total Points Possible	Avg. Percent Score
Physical science students who did writing to learn	30	129	18.6	30	61.99%
Other physical science students	30	598	17	30	56.72%

When we did a two-sample *t*-test to compare Mike's students with the rest of the ninth-grade physical science students, calculations yielded no significance—so it is still too soon to say writing-to-learn was the key variable.

Yet once more, graphic representation gives a clearer perspective of student performance (Graph 2, below). Students who didn't write to learn "shadowed under" the questions, whereas write-to-learn students performed better by an average of 6 points.

Graph 2: Comparison of Physical Science Students



The alternation between harder and easier questions was a bit less pronounced, but the downward progression of scores was much steeper. As questions on lab safety or physical/ chemical properties of substances gave way to questions on energy issues or story problems, scores shrank—implying that writing-

to-learn prompts should also focus more on the latter. And another thought: could tests such as the ones that science teachers developed for the district be used in lieu of national standardized tests? Although the district test also needs to be developed further, it was rigorous, and we have realized that standardized tests—if *district-designed*—may have real potential as learning tools.

How our Findings Will Guide Us

This essay leaves off *in media res*, hovering between hypothesis and proofs. However, we feel compelled to discuss findings that seem noteworthy. Dawn articulates our primary conviction, in a recent email to other science teachers in our school:

Mike, Dave, and I have been working on writing prompts to increase writing (and thereby learning) in freshmen science classes. We are still in the early stages of creating effective prompts and using the rubric, but we are finding that having students write about what they are learning on a regular basis does have a positive effect on learning. This type of writing is not an 'extra' thing to do, but rather a written reinforcement of what you are already teaching in your classes. Mike, Dave, and I have found the writing prompts to be a useful formative assessment—a snapshot of learning/understanding—which benefits us as well as the students.

In fact, writing to learn, so stipulated, may even suffice as the foundation of a secondary writing-across-the-curriculum program (Peters, 2011, p. 78; Anderson et al., 2009).

Just as important, even special education students can benefit, if prompts present a concrete purpose and clear instructions. Reading, authentic discussion, and interactive activities must also be included (Rivard, 2004; McCann et al., 2006, pp. 2-3). In a school district severely challenged by students in poverty, this is good news. Students *want* to succeed. They have not yet learned to despair.

Therefore, professional development opportunities must give teachers the chance to design and test writing-to-learn activities. Such opportunities transform teachers into action researchers who can not only analyze and compare writing samples they collect, but also, they can reflect upon and improve their teaching practices. Then they can share their research-based methods with other teachers.

But these opportunities must include some form of support, such as collaboration between secondary-school teachers and post-secondary consultants (Blummer & Childers, 2010, p. 97). This arrangement provides the best, authentic feedback on classroom performance as well. Moreover, because the "departmentally divided social worlds of secondary educators strongly limits teacher interaction," it may be best to create contexts where teachers in the same department can collaborate (Bazerman et al., 2005, p. 43).

Finally, and most surprising, in school districts where poverty creates a highly mobile student population, standardized exams which accurately reflect the district's own curriculum—and are designed by the teachers who actually teach that curriculum—may serve as the most useful instrument to gauge the effect of writing to learn upon student learning outcomes. Faculty could also benefit from piloting such tests and refining them. Scores from statewide standardized tests never return in time for teachers to adjust classroom practices or to re-teach concepts that students struggle with. But a district-designed test administered in quarters throughout the academic year promises to be an appropriate means of getting timely feedback so that teachers can use writing to learn to intervene in areas where students need help most. Maybe this kind of district-designed standardized testing could even replace the high-cost, high-stakes national tests that have held public education hostage for so long.

We look forward to reading the collected writing that our students complete for the rest of the year. That collected writing, we surmise, will document our own learning outcomes as much as our students'.

"If we continue to use writing in this way," Mike says, "Maybe we can end up *understanding* our students instead of failing them."

We believe he's right.

References

- Anderson, Paul, Anson, Chris, Gonyea, Bob, & Paine, Chuck (July 17, 2009). "A national study of writing's contributions to learning in college: Major findings and practical implications for all writing programs." Council of writing program administrators summer conference, Minneapolis, MN.
- Bangert-Drowns, Robert, Hurley, Marlene, & Wilkinson, Barbara (2004). The effects of school-based writing-to-learn interventions on academic achievement: A meta-analysis. *Review of Educational Research*, 74, 29-58.
- Bayer, Cathy (2011, March 3). Administration's proposed cuts. *Rockford Register Star* Retrieved from <http://www.rrostar.com/carousel/x1174964897/Rockford-School-Board-still-has-3-1-million-more-in-cuts-to-make>
- Bazerman, Charles, Little, Joseph, Bethel, Lisa, Chavkin, Teri, Fouquette, Danielle, & Garufis, Janet (2005). *Reference guide to writing across the curriculum*. West Lafayette, IN: Parlor Press & Boulder, CO: WAC Clearinghouse (<https://wac.colostate.edu>).
- Bereiter, Carl, & Scardamalia, Marlene (1987). *The psychology of written composition*. Hillsdale, NJ: Erlbaum.
- Blakeslee, Ann M. (2001). *Interacting with audiences: Social influences on the production of scientific writing*. Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.
- Blumner, Jacob, & Childers, Pamela (2010). Building better bridges: What makes high school-college WAC collaborations work? *The WAC Journal*, 22, 91-101. Retrieved from <https://wac.colostate.edu/journal/vol22/blumner.pdf>
- Burke, Jim (2010). *What's the big idea? Question-driven units to motivate reading, writing, and thinking*. Portsmouth, NH: Heinemann.
- Chabot, Chris, & Tomkiewicz, Warren (1998). Writing in the natural science department. *Writing Across the Curriculum*, 9, 52-59.
- Childers, Pamela, & Lowry, Michael (2012). STEMing the tide: Writing to Learn in Science. In Lesia C. Lennex & Kimberely F. Nettleton (Eds.), *Cases on inquiry through instructional technology in math and science* (pp. 21-37). Hershey, PA: Information Science Reference, IGI Global.
- Childers, Pamela, & Lowry, Michael (2005). Connecting visuals to written text and written text to visuals in science. *Across the Disciplines*, 3. Retrieved from https://wac.colostate.edu/atd/visual/childers_lowry.cfm
- Clark, Deborah J. (2005). The use of peer evaluations to foster critical analysis of writing in biology. In M.T. Segall & R.A. Smart (Eds.), *Direct from the disciplines: Writing across the curriculum* (pp. 28-43). Portsmouth, NH: Boynton/Cook Heinemann.
- Erdurian, Sibel, & Jiménez-Aleixandre, Maria P. (Eds.) (2007). *Argumentation in science education: Perspectives from classroom-based research*. New York, NY: Springer.
- Glaze, Bernadette, & Thaiss, Christopher (1994). Resistance as inspiration in a language and learning program. In Pamela Farrell-Childers, Anne Ruggles Gere & Arthur Young (Eds.), *Programs and practices: Writing across the secondary school curriculum* (pp. 9-19). Boynton/Cook, Heinemann, Portsmouth, NH.
- Gunel, Murat, Hand, Brian, & McDermott, Mark A. (2009). Writing for different audiences: Effects on high school students' conceptual understanding of biology. *Learning and Instruction*, 19, 354-367.
- Halliday, Michael A. K., & Martin, James R. (1993). *Writing science: Literacy and discursive power*. Pittsburgh, PA: University of Pittsburgh Press.
- Hohenshell, Liesl, & Hand, Brian (2006). Writing-to-learn strategies in secondary school cell biology: A mixed method study. *International Journal of Science Education*, 28(2-3), 261-289.
- Illinois State Board of Education (2011). "Data analysis & progress reporting: Fall enrollment counts," 2010-2011 District summary & School summary. Retrieved from http://www.isbe.state.il.us/research/htmls/fall_housing.htm

- Johannessen, Larry R., Kahn, Elizabeth A., & Walter, Carolyn C. (1982). *Designing and sequencing prewriting activities*. Urbana, IL: National Council of Teachers of English.
- Keys, Carolyn (1999). Revitalizing instruction in scientific genres: Connecting knowledge production with writing-to-learn in science. *Science Education*, 8(2), 115-130.
- Lee, Okhee, Maerten-Rivera, Jaime, Penfield, Randall, LeRoy, Kathryn, & Secada, Walter G. (2008). Science achievement of English language learners in urban elementary schools: Results of a first-year professional development intervention. *Journal of Research in Science Teaching*, 45, 31-52.
- McCann, Thomas M., Johannessen, Larry R., Kahn, Elizabeth, & Flanagan, Joseph M. (2006). *Talking in class: Using discussion to enhance teaching and learning*. Urbana, IL: National Council of Teachers of English.
- Myers, Greg (1990). *Writing biology: Texts in the social construction of scientific knowledge*. University of Wisconsin Press: Madison.
- Mullin, Joan A., & Childers, Pamela B. (1995). The natural connection: The WAC program and the high school writing center. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, 69(1), 24-26.
- Nagin, Carl (2003). *Because writing matters: Improving student writing in our schools*. San Francisco: Jossey-Bass.
- Oltenu, Elizabeth (2003). Writing animals. In J. Monroe (Ed.), *Local knowledges, local practices: Writing in the disciplines at Cornell* (pp. 75-82). Pittsburgh, PA: University of Pittsburgh Press.
- Peery, Angela (2009). *Writing matters in every classroom*. Englewood, CO: Lead+Learn Press.
- Peters, Bradley (2011). Lessons about writing to learn from a university-high school partnership. *Writing Program Administration: Journal of the Council of Writing Program Administrators*, 34(2), 59-88.
- Petersen, Meg (2001). The atomic weight of metaphor: Writing poetry across the curriculum. *Writing Across the Curriculum*, 12, 97-100.
- Richardson, Dennis J. (2005). Protracted peer-reviewed writing assignments in biology: Confessions of an apostate cynic of writing across the curriculum. In Mary T. Segal & Robert A. Smart (Eds.), *Direct from the disciplines: Writing across the curriculum* (pp. 44-56). Portsmouth, NH: Boynton/Cook Heinemann.
- Rietsma, Len (1999). Innovative writing assignments in the natural sciences. *Writing Across the Curriculum*, 10, 57-63.
- Rivard, Leonard P. (2004). Are language-based activities in science effective for all students, including low achievers? *Science Education*, 88, 420-442.
- Rivard, Leonard P., & Straw, Stanley B. (2000). The effect of talk and writing on learning science: An exploratory study. *Science Education*, 84, 566-593.
- Soliday, Mary (2005). Mapping classroom genres in a science in society course. In Anne Herrington & Charles Moran (Eds.), *Genre across the curriculum* (pp. 65-82). Logan, UT: Utah State University Press.
- Stretch, LoriAnn S., & Osborn, Jason W. (2005). Extended time test accommodation: Directions for future research and practice. *Practical Assessment, Research, & Evaluation*, 10, 1-8.
- Webb, Noreen M. (1989). Peer interaction and learning in small groups. *International Journal of Educational Research*, 13, 21-39.
- Wood, David, Bruner, Jerome, & Ross, Gail (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry*, 17, 89-100.
- Zimmet, Nancy (2000). Engaging the disaffected: Collaborative writing across the curriculum projects. *English Journal*, 90, 102-106.

Contact Information

Michael McClellan
Jefferson High School
Rockford, IL
Email: c/o maria.mcclellan@nl.edu

Dawn Myelle-Watson
Jefferson High School

Rockford, IL
Email: dawn.myelle-watson@rps205.com

Brad Peters
Northern Illinois University
DeKalb, IL
Email: bpeters@niu.edu

Debora Spears
Jefferson High School
Rockford, IL
Email: debora.spears@rps205.com

David Wellen
Jefferson High School
Rockford, IL
Email: dave.wellen@rps205.com

Complete APA Citation

McClellan, Michael, Myelle-Watson, Dawn, Peters, Brad, Spears, Debora, & Wellen, David. (2012, December 8). Writing science in hard times. [Special issue on Writing Across the Secondary School Curriculum] *Across the Disciplines*, 9(3). Retrieved from <https://wac.colostate.edu/docs/atd/k12/mcclellanetal.pdf>