I teach high school chemistry and physics at Troy Athens High School. In neither of my subjects do I teach reading or writing explicitly. There is too much content and not enough time to make it happen; in order for my students to get the material needed for finals, AP classes, and their futures scientific endeavors I have to move at a brisk pace. I am not incredibly upset by the lack of focus I place on reading and writing on a daily basis. My coworkers would most likely echo my opinion as well. One could easily argue that it may be best for our students that we do not dive into these skills frequently, as our degrees do not qualify us to do so. However, on the other hand, our department often complains that our students lack the needed reading and writing skills that accompany our scientific lessons. For example, many students struggle (or lack the effort) to read scientific texts or articles and write poorly constructed lab reports. As science teachers we typically shrug this off, and expect the students to be able to read and write effectively when walking in the door. It is this set of expectations that allows for us to gage our content, curriculum, and develop successful materials in our classes. So the question becomes, what can be done within our courses that will help students who struggle with reading? Also, how can we implement easy to use, quick, and effective processes to support these students? With these questions in mind I set out to focus on one area in particular; reading comprehension.

I chose to work with three students during my study. This was a choice that I made immediately as we are required to study three specific students when doing end of year evaluations at work. I feel, as does our administration, that if a method is successful it must show improvement for students at the top, middle, and bottom of the educational spectrum. Shawn, Maddie, and Abby fit these three categories quite nicely; all three were students of mine in physics during the year. Because I implemented similar lessons with a similar goal during the school year in chemistry, I chose these three students not only to reflect the range of our

students, but also to insure I had students who had not seen the articles yet. It also ensured that they had a general idea of the content. I was able to obtain some useful information on each student prior to the end of the year in order to guide me while the lesson was in progress. Shawn is a high level reader and was one of my strongest students. While he tends to be somewhat excitable during class, he would consistently do better on exams and labs than any other student I had. The questions he would ask were phenomenal. Maddie reads at an 11th grade reading level, which corresponds to the grade she is in. She is a very diligent and hardworking student, but she often times would struggle with the material in class, especially mathematics. Her success in science came from her asking questions and coming in for extra help. Her parents also did a great job at working with her constantly at home in order for her to be successful. Finally, Abby reads one grade level lower than her grade according to our counseling staff. She was a great student to have in class as she always helped others and participated in class activities. However she often lacked the focus and the motivation of the other two. I was told near the end of the year in a personal conversation between the two of us that she was also having troubles at home, and that her parents were divorcing. While this may have contributed to her lackluster performance in chemistry, it would not have had a great impact on her reading skills over the course of a long period of time. Together these students were perfect for studying the impacts of my lessons on students across a variety of reading and maturity levels.

The specific outline of my work with Shawn, Maddie, and Abby was pretty simple. The lessons followed a pre-test, instruction, post-test model, which is a fairly typical way to measure student growth. My goal was to provide a method of improving reading comprehension, and help them show demonstrate their improvements in two ways. The first way that they would demonstrate an improvement in the comprehension of their reading would be on a standardized

multiple choice test (hence the pre-test and post-test of the model). While it is my general belief that any type of multiple choice assessment is not the best overall way of measuring a student's complete abilities, I would argue that it is the perhaps the best method given the task at hand. The nature of a multiple choice test is that it prevents much of the ambiguity or confusion in grading that could exist with an open ended question. Multiple choice testing also mimics standardized tests such as ACT and SAT, making this a useful method. By improving their score on a multiple choice assessment by 20%, or an improvement of two correct answers out of ten possible, I would suggest that an improvement of reading comprehension has taken place. The tests were created by my coworkers and me earlier in the year. We aimed to not only include flat out regurgitation questions, but rather questions that also included some analysis. We also spent a great deal of time attempting to make the assessments fair and equal to one another. This was incredibly difficult to do since the articles lend to such different question sets.

Despite the benefits of an easy comparison across students, and the similarity to standardized tests, the multiple choice method does not completely and accurately reflect if a student is actually comprehending things better, or showing deep thinking. So, in conjunction with the improvement of 20% on the test, I also looked for an increase in visible thinking on the reading itself. For students to improve their "visual thinking" it means they increased the amount of annotation via highlighting, circling or starring, or writing questions in the margins. It is also important that students actually make these annotations meaningful, not just indicating or writing random things, but getting to the key ideas in the work. This is slightly harder to gauge.

Chapter 11 of *Best Practices in Literacy Instruction* by Gambrell and Morrow is titled "Best Practices in Informational Text Comprehension Instruction" and highlights very clearly the biggest strategies that I hoped to use during my lesson and instill in my students during this

process. “Rather than expecting students to learn solely from generic approaches to instruction or from one lesson or unit of study, we… suggest that students are more likely to learn how to comprehend complex informational text well when they experience carefully designed informational text comprehension instruction across genres, tasks, and grade levels; when their teachers seek to develop strategic readers; and when they have many scaffolded opportunities to comprehend informational text” (Duke & Martin, 249). While this may seem like too much to fit into two seemingly simple lessons, I used this sentence as my inspiration when developing the instruction used for this project. It was incredibly vital that the students, by the end of the lesson, had gained the tools to be strategic and prepared readers. If students can understand the underlying skills needed to pick information out of a scientific article they will have similar success in history or math. If students can connect content area information to the reading in my class, they will also be more successful when reading in all of the other subject areas. I also wish to provide a variety of experiences with informational texts for students to practice with, hence why during my two lessons there will be two articles used, four including the tests. Finally, it is important that I provide the correct scaffolding of the material in order to reach all levels of students, which will be aided in this case by the group and partner work the students will do.

To begin the study, the three of us met in my classroom after school on a Tuesday afternoon. Since the three of them were some of my favorite students in physics, and I had given them a basic explanation as to what we were going to be doing, they were more than happy to help. I have found that if I level with my students, and ask politely I can typically get what I need from them in terms of expectations and classroom management. We began with some conversation about what was going to happen over the next 2 afternoons; I chose to split my overall lesson into two days. The first day would be the pre-test and lesson one; the second

would be lesson two and the post-test. We then began immediately with the pre-test. The pre-test reading was an article entitled “Colors Bursting in Air” from *ChemMatters* magazine which explains the chemistry behind summer fireworks. This article aligns best with the content typically taught in chemistry, with connections to properties of metals, electrons jumping energy levels, and the electromagnetic spectrum. Students were given the materials needed to annotate the article, but were not told specifically to do so. This was done intentionally as I wanted to see what types of thinking were displayed by each before any instruction took place. They were given unlimited time in order to read the reading and make any notes they wanted to make. The students’ pre-test reading articles and a set of questions are noted as *Exhibit 1* following this analysis. After they had all finished, the pre-test question set was administered. All three students were allowed to write on the test, but were given a timed seven minutes in order to answer the ten questions presented. As stated earlier, the questions were not just created to test a student’s ability to simply pick information out of the text, but also to analyze and apply content area knowledge to the text. These analysis and application questions are the ones that students typically have difficulty with. The results were fairly expectable. Shawn, my high level student got seven out of the possible ten questions correct. I was slightly surprised the score was not higher given his level of scientific expertise that he has an individual. He was also the only student to highlight on his article without any prompting. Maddie scored five questions correctly out of ten. Her difficulty came from the time constraint during the questioning period. Finally, Abby got three out of the ten correct. She struggled quite a bit with the questions, and also took the longest to read the article. The students were fairly successful with the questions that were easy to answer from grabbing bits of information directly from the text. In contrast, all students got questions 7, 8, and 10 incorrect. These were very difficult questions, and took a great deal of

analysis to get correct. I would argue that question 8 in particular is the most challenging because of the complex diagram.

My first actual lesson with the students explored the importance of annotation when reading a scientific text. In general it proceeded incredibly smoothly. I began by passing out an article entitled "Sugar an Unusual Explosive" also from *ChemMatters.* I felt that it was rather important for me to get all of the articles from the same place to insure that they have similar reading levels and style. This article has great use of chemical formulas and symbols as well as review of combustion reactions. I began by reading the first section out-loud to the students, and had them follow along. After reading the first three paragraphs, I stopped and we discussed the reading and what was important. I pointed out the main ideas, numbers, and scientific vocabulary, and we talked about how these are typically critical to the overall structure of a scientific article. Modeling for students is a very common practice in science, and other subjects, as it provides students examples of what is expected. For the next section of text I had the students read chorally, each taking a small chunk (paragraph or two) of the reading. After each paragraph the students and I would stop and discuss the important parts to note. One example that Shawn pointed out was the importance of the three characterizations of explosions in the text. He even pointed out how that would make a good multiple choice question. Abby called to the group's attention that the chemical formula and name for sugar are presented in the beginning of the article, and this tied in with their background knowledge. We also noted a variety of other things including the presence of the combustion reactions at the bottom of the first page. For students who are reading scientific text it is vital that they notice figures outside of the text, and also for them to connect things to their studies. Many of the articles students see on standardized tests, and in readings in class are not exactly topics they have covered. No

chemistry class will explicitly cover exploding sugar, but when students are able to make the logical connections to chemical formulas, covalent compounds, and combustion reactions, it can make the reading easier and more meaningful. Following the choral reading by the students,

I allowed them to read the next section silently. When completed, we shared our individual annotations with the group. For the most part we had similar things highlighted and circled, which is a great indicator that they understood what was important within the text. Truthfully, they had more comments than I made on my own paper which was also a positive sign. Finally, we read the rest of the piece individually and participated in a think-pair-share activity. If done as a whole class, the use of a think-pair-share is a great tool to allow students to contemplate on a topic, develop ideas with a partner, and then share their thoughts in an educationally rich and safe environment. In our case it was slightly difficult to do with only three students and myself, but we made it work, and the students got a lot out of it. In particular, one of the great comments I heard from all three of the students was that they found highlighting and writing helped to organize their thoughts better. They also indicated that if this were to be done as a class, the paired activity is a great tool in order to avoid the nervousness some students feel when having to contribute ideas in front of the whole class. My modeled article, and a sample annotated article is Exhibit 2.

The second day we met I chose to focus in on more in-depth thinking skills. The tool that I chose as a method for digging deeper is one partially of my own creation called "word-phrase-question" which I based on a routine featured in the book *Making Thinking Visible: How to Promote Engagement, Understanding, and Independence for All Learners* called "sentence-phrase-word". In the text the activity is described as "a routine used for 'essence capturing' and exploring the meaning of text from a variety of personal viewpoints" (Ritchhart, p 207). While I

am not certain that I have the whimsical vocabulary to say this about the technique, I found it very useful to have students find words, phrases, and sentences in a text that stand out and explain why they feel they are important. Also, this material comes from a wealth of research across the globe as the literature points out, so I feel comfortable using it to teach. From the first time I heard of the routine I thought this would be a great tool for deepening thought it science, and that it would facilitate great class discussions. After doing "sentence-phrase-word" a few times as a whole class, I made the change of having students pick a single word they feel describes the text, not necessarily a word they found within it. I also replaced having the students identify an important sentence within the text with them developing a question that they still have about it. I found this to be even better at getting students to critically think about the literature, and it allowed them to ask questions that they still had after reading that could be further clarified by their peers or me.

I began by explaining the routine to the students, and providing them with sticky notes. Indigo sticky notes would be for words, yellow for phrases, and neon blue would be for questions. I then passed out the article "Super Fibers" for them to read and annotate. In general this article was the easiest of the four that they would see by the time the post-test was completed later in the afternoon. It follows the chemistry content of covalent bonding and carbon chemistry. I provided them with as much time as needed to read and annotate the article. Once again they finished within a reasonably similar amount of time, with Abby finishing last. After completing the reading I gave each of them a few moments to write the information on the provided sticky notes. The notes were then put on the board under their specific categories (word, phrase, and question) for discussion (see exhibit 3). The words were all different and touched partially on the impressiveness of the properties of the carbon nanotubes discussed in the reading. When the

words are different, but have a common theme it provides a great backdrop for deep conversation. Between the four of us we had a fairly lengthy discussion about the impressive properties and application of the tubes, and what it actually meant to be a "nanotube". I found it surprising that three out of the four of us had selected the same phrase from the text in reference to the carbon nanotubes, "they're the Holy Grail of fibers" which stood out to me, Shawn, and Abby. When I asked why this phrase was so important to everyone, Shawn astutely pointed out that the entire text revolved around the properties of the nanotubes that seemed almost superhuman in capacity. Due to the diction within the text the three of us agreed that the phrase we indicated exemplified these properties nicely. Finally we discussed the questions. We discussed mine first, mostly to get it out of the way. Despite my desire to model the approach, I felt that it would be best to focus in on the student's work. One question I particularly liked, from Abby, asked how a cable could stretch into space with people riding on it. Questions that can't be easily answered are typically my favorite, and it lead to a fruitful discussion about how the cable could work. Shawn also raised a question about the expense of working with the nanotubes.

When the discussion had subsided I passed out the post-test, an article about bleaching hair entitled "Hair Today, Bleached Tomorrow". As indicated cleverly by the title the reading is about the chemistry behind the bleaching of different shades of hair. Students followed the same protocol when it came to taking the test as before. Once again I provided little or no instruction primarily to see if the skills taught would be seen without any prompting. They were allowed unlimited reading time, and then were given seven minutes to answer ten questions. This time all three finished in a more comfortable manner within the seven minutes which was a good indicator that I had been at least somewhat successful with my lessons.

When analyzing the multiple choice scores there was an improvement in all three of the students. Shawn, my high performing student received a nine correct out of ten, an improvement of two questions or 20%. This met my goal. Maddie received eight correct out of ten which was a growth of three questions or 30%, exceeding my goal. This made me particularly happy because she represents my middle demographic of student. If I can reach this population of students this strongly, I feel I will be incredibly successful implementing this on a larger scale. Abby, my lowest level student received a six out of ten, also an improvement of 30% or three questions. This also made me incredibly happy as well. All three students felt that the reading and the corresponding questions were easier to manage. This could be partially due to the nature of the articles or questions; however, I will attribute most of this commentary to an improvement of understanding fostered by my lessons. A slightly more difficult question set could be used next time to see if it makes a substantial difference. There were no questions that all of the students got incorrect during the post-test, including the more difficult analysis and application questions. My second goal, for the students to show more visible thinking, was also rather successful as indicated in exhibit 4. All three students annotated the article with varying success, mostly sticking to highlighting and underlining, however Maddie also included some notes in her margins which I thought was great. One could argue that these notes could have been the reason that her score improved so drastically, but that would be mostly speculation without further analysis.

If this lesson were applied to the full class setting I feel that it would be successful and could be easily implemented by any science teacher. Despite the fact that many of us are not English certified or experienced, we have the best skills when it comes to understanding and comprehending scientific texts. It needs to be our priority to develop these abilities in our

students. I would argue that the modeling and scaffolding present in the first lesson is the most crucial to the students' becoming more proficient readers and analyzers on the post-test. Many of the facets of the article that my students noted and highlighted were also things that I would indicate as being important as well. Also the think-pair-share activity during the reading would be easier to accomplish with a larger set (an entire class) of students. The second lesson plan would also be great, if not better with the class as a whole. If this were to be done with a larger group, there could be small groups that could meet (perhaps 5-6 people) that share with each other before meeting with the entire class. While I am not certain that this lesson had as much of a direct impact on the numerical scores, in the long run practices like this will help students build the skills needed for deeper thinking. The ability for students to read, comprehend, and think deeply can be transferred and extrapolated across content areas in other classes and disciplines.

Chapter 11 of *Best Practices in Literary Instruction* ends with a warm gesture of luck from the authors; "We wish readers of this volume success in this difficult but rewarding endeavor" (Duke & Martin, p. 263). In all truthfulness it is very hard to help students with reading comprehension of any technical piece, especially those that are based in science. However, as the quote also indicates the practice of helping students in this area is incredibly rewarding. Although I did not formally use these methods during the year to help my students, they are great for getting them to be proficient readers and thinkers. They are also methods easy enough for any science teacher to use. When students become more proficient at reading comprehension they can be more successful in later classes, college, on standardized tests, and in life. This is what is important to me as an educator, and I hope that my colleagues in science will follow suit.

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