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Activity

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# Nature or Naughty: Bringing "Deflategate" to the High School Chemistry Classroom

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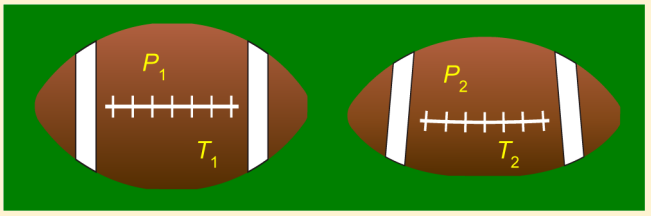
Supporting Information

**ABSTRACT:** In this activity, students work in groups, delving into a real-life sports melodrama—"Deflategate". Using their knowledge of the behavior of gases, and data collected by an independent investigative team, students draw evidence-based conclusions to the question: "Could the underinflated footballs used by the New England Patriots have been caused by environmental conditions during the game?" As this engaging and thought-provoking activity unfolds, students employ many of the science practices outlined in the National Research Council's A Framework for K−12 Science Education.




**KEYWORDS:** *High School/Introductory Chemistry, Curriculum, Collaborative/Cooperative Learning, Communication/Writing, Gases*

The 2015 National Football League (NFL) season of American football almost started without the New England Patriots four-time Super Bowl champion, Tom Brady.[1] Why, you may ask? Or maybe you know and agree or disagree with the ruling. In this activity your students delve into a real-life sports melodrama involving footballs, inflation pressures, temperatures, and perhaps mischief and rule-breaking. The activity can be completed in two 45 min classes with the written portion completed for homework.

As this engaging and thought-provoking activity unfolds, your students employ many of the science practices described in the National Research Council's *A Framework for K−12 Science Education*[2] and found in the Next Generation Science Standards (NGSS),[3] including (i) analyzing and interpreting data; (ii) using mathematics and computational thinking; (iii) constructing explanations; (iv) engaging in argument from evidence; and (v) obtaining, evaluating, and communicating information. These science practices are those used by scientists and engineers as they investigate problems and work to understand natural phenomena. These practices require both content knowledge and skills (including critical thinking, data analysis, mathematical computations, and communication) and allow scientists (and students) to make sense of phenomena. But let us begin with the back story.

## CONTEXT OF THE ACTIVITY

On January 18th, 2015, the New England Patriots squared off against the Indianapolis Colts in the AFC Championship at Gillette Stadium, Foxborough, MA. During the first half of the game, the Colts staff approached game officials with suspicions that the Patriots were using underinflated footballs. This led officials to check the pressure of the footballs being used by both teams at half-time. Using two different pressure gauges, officials found that all 11 of the Patriots' footballs were underinflated, meaning <12.5 pounds per square inch gauge pressure (psig), whereas the four footballs of the Colts they tested were within the accepted pressure range of 12.5−13.5 psig on at least one of the two pressure gauges used for the study. At that time, the referees filled the Patriots' balls to the proper pressure, and the game concluded uneventfully with a convincing win by the Patriots, 45−7.[4−6] In an effort to determine the cause of the underinflated footballs, the NFL hired an independent law firm, Paul, Weiss, Rifkind, Wharton and Garrison (PWRWG), to lead an investigation.

In this activity, data from the Wells Report (the complete investigative analyses)[4] were used to determine if the underinflated footballs of the New England Patriots could have resulted from the environmental conditions of the day. Students work in teams to determine what data they will need, and how they will analyze it. The students then perform the necessary analysis, state a claim, and present their findings (based on evidence and reasoning) to the class. The students are empowered to lead their own investigation into a topic that many have followed intently in the news. Using footballs to study gases is not a new concept in school;[7−11] what makes this activity so relevant and engaging is the use of the actual data from a highly publicized controversy.

## PROCEDURE

### Part 1: Pondering the Question and Data Needed

I began by describing the scandal to my students and then proposing the following question:





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*Tom Brady, the quarterback of the Patriots, has publicly admitted that he likes throwing a slightly underinflated football. If the Patriots filled their footballs to the minimum allowed pressure of 12.5 psig, could the lower pressure of the Patriots' footballs be a result of the environmental conditions during the game?*

Students were asked to discuss the issue with their collaborative group members (small groups of four) and make a list of all the information they would need to answer this question. After about 10 min, each group then shared their ideas with the class and a master list was compiled on the board. Students were reminded that, at this point, all ideas were to be accepted and that they would have an opportunity later to evaluate them.

The student-generated lists showed that they had a background in scientific inquiry skills, basic gas laws, and the game of football. A subset of their list included the following:

- The outside temperature on that day
- Atmospheric pressure on that day
- The weather (was it raining, snowing, sunny)
- The temperature of the locker room where the balls were filled
- The initial pressure of the balls
- How were the balls used during the game (kicked, passed, not used)?
- How many times were the pressures checked?
- Were the gauges calibrated?

## Part 2: Thinking about Necessary Data Analysis

In part 2 the students were asked:

*Assume you have all the information needed to answer the questions you generated. What would be your next step? Which questions are relevant to answering the question? How would you analyze the data? What equations would you need? How would you interpret the results?*

Students were free to refine their list and narrow down the data that were truly needed to determine whether the lower ball pressure was a result of environmental conditions.

## Part 3: Data Collection and Analysis

Data from the Wells Report was given to the students (Supporting Information) to perform analyses in class. They were free to ask questions and use their notes and the textbook. They were not allowed to use the Internet so as not to be persuaded by others' analyses. Sifting through the data proved to be a challenge to many students. Too often in education we give students just the limited information they need to answer a question. This unrealistic situation does not require students to think critically about the wide variety of data that often accompany real-world problems, some of which is relevant to the problem and some of which is not. By the end it was refreshing to see that students used several different approaches to answering the question.

## Part 4: Presenting Information

Scientific findings are typically disseminated via peer-reviewed papers and presentations at conferences and seminars, so this activity took a similar, though less formal, approach. Students wrote their scientific explanation in the format of claim, evidence, and reasoning (CER), and prepared for a lively discussion on the controversy the next day. What makes this approach so powerful is that it requires students to engage in a wide range of cognitive activities. They must think about the problem, use their experience to sort through the available data, analyze the data, and in the process make some basic assumptions and inferences. They must then reflect on the validity of their approach and assemble this information into a clear, succinct, unbiased explanation format that is delivered both verbally and in writing. It is critical that we remind students that objectivity leads to a better analysis and greater credibility.

The CER format consists of a statement that answers the original question (claim), appropriate and sufficient scientific data that supports the claim (evidence), and then a justification that defends the data and support the claims using scientific principles (reasoning).[12] Guided-inquiry activities with a writing and reflection emphasis, such as this one, have a positive impact on chemistry students' critical thinking abilities.[13]

In chemistry, true understanding becomes apparent when students can articulate why a natural phenomenon is occurring at the molecular level. The reasoning portion of the CER format requires students to do just that—delve into why pressure changes with a change in temperature—not simply the fact that it does. Without this explanatory framework students are often unable to apply the same logic in a new situation.[14] The CER format plays a critical role in cultivating the critical thinking skills of students.

## Part 5: Student Groups' Presentations and Discussion

On discussion day, we divided the class into these three categories:

1. Nature group: Those who deemed nature was to blame.
2. Naughty group: Those who deemed tampering was to blame.
3. N and N group: Those who deemed the data were inconclusive.

Before the discussion we developed some ground rules as a class. The three categories were given about 10 min to organize themselves, compare their approaches, and then determine how the information was going to be presented. As the presentations ensued, the spectators listened and jotted down questions. At the conclusion of each presentation, they asked their questions and offered rebuttals and counterclaims. Then the next two groups presented in the same manner. As the discussion ended, the Naughty group seemed to think that the environmental conditions were not enough to cause the lower pressures, because the drop in pressure of the Patriots' balls was greater than could be attributed to the reported environmental conditions, whereas all the Colts' balls fell within the expected pressure drop. The Nature group thought that a combination of factors had caused the lower pressures, but did not know how to confirm this and speculated that the Colts' balls were within the allowed pressure range due to their higher initial pressures. Finally, the N and N group simply concluded they did not have the whole story and needed more information.

Students were for the most part able to keep their biases in check. And if they did not, their peers were quick to bring it to everyone's attention. After the presentations the final NFL ruling on the controversy and the subsequent appeal were discussed (Supporting Information). Students remarked that the initial reports had incomplete and often inaccurate information, thus, leading to incorrect or unsubstantiated conclusions. Using the data presented in the Wells Report alleviated the problem of unconfirmed data, presented the best overview of what transpired that day, and thereby, allowed for greater confidence in data analyses and interpretations.



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### Part 6: Review of Others' Findings and Analyses (Extension Activity)

As an extension activity, divide the class into groups, each assigned with one of the tasks listed below. After students have researched and read, begin a discussion of the initial reports on Deflategate (pre-Wells Report), the Wells and Exponent reports, and then the response to the Wells Report. This exercise allows students to explore social media and how sometimes "news" is really hearsay and speculation. It also introduces students to the world of politics in sports and the need for independent, expert investigations. These are the suggested tasks:

1. Find and read at least three articles on Deflategate dated BEFORE the Wells Report was published in May 2015.
2. Read the Executive Summary of Wells Report. (This is very long, so two groups could be assigned different parts of the report.)
3. Read the Executive Summary from Exponent (appendix of the Wells Report). (This is very long, so again two groups could be assigned different parts of the report.)
4. Find and read at least three articles on Deflategate dated AFTER the Wells Report was published in May 2015.

## CONCLUSION

Students deepen their understanding of scientific processes and content when presented with relevant and multifaceted problems that engage them. Deflategate is a contemporary problem that was highly publicized and generated a great deal of hallway discussion among high school aged boys and girls. The fact that gas laws were at the center of this high profile case was fortuitous because it allowed my students to delve into the controversy and the science of gases. They quickly realized how bias can cloud one's view of the evidence, and the importance of objectively gathering, analyzing, and interpreting data from multiple sources and perspectives. Working collaboratively gave students the freedom to test their ideas and arguments on each other, and to look at the problem from multiple viewpoints.

## ASSOCIATED CONTENT

### Supporting Information

The Supporting Information is available on the ACS Publications website at DOI: 10.1021/acs.jchemed.5b00617.

Instructor notes (PDF, DOCX)
Student worksheet 1 (PDF, (DOCX)
Student worksheet 2 (PDF, DOCX)

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### Notes

The authors declare no competing financial interest.

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## REFERENCES


(1) Battista, J. Patriots Punished by NFL for Lack of Cooperation. http://www.nfl.com/news/story/0ap3000000492259/article/tom-brady-patriots-punished-by-nfl-for-lack-of-cooperation (accessed Oct 2015).

(2) National Research Council. *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*; The National Academies Press: Washington, DC, 2012.

(3) Appendix F—Science and Engineering Practices. Next Generation Science Standards. http://www.nextgenscience.org/sites/ngss/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf (accessed Oct 2015).

(4) Wells, T. V.; Karp, B. S.; Reisner, L. L. Investigative Report Concerning Footballs Used During the AFC Championship Game on January 18, 2015. https://www.documentcloud.org/documents/2073728-ted-wells-report-deflategate.html (accessed Oct 2015).

(5) Patriots Deflation Controversy. http://sports.espn.go.com/nfl/feature/index?page=patriots-deflation-controversy-index (accessed Oct 2015).

(6) Burnett, A. J. *Deflate-Gate: Could Weather Have Played a Role in Deflated Balls?* http://www.wcsh6.com/story/weather/2015/01/20/inflate-gate-weather-roll/22065861/ (accessed Oct 2015).

(7) Bare, W.; Andrews, L.; Pickering, T. L. A Demonstration of Ideal Gas Principles Using a Football. *J. Chem. Educ.* **1999**, *76* (5), 622−624.

(8) Cantu, D. V. DeflateGate": The "Pressure" of Getting the Game Ball Right. *Technol. Eng. Teach.* **2015**, *Apr*, 12−16.

(9) Houser, J.; Johnson, D.; Siegel, P. Getting Pumped Up on the Ideal Gas Law. *Phys. Teach.* **2002**, *40* (7), 396−397 (accessed Oct 2015).

(10) Orzel, C. *Football Physics and the Science of Deflategate—Does the Ideal Gas Law Explain 11 Deflated Footballs?* http://www.popsci.com/football-physics-and-science-deflategate (accessed Oct 2015).

(11) Khan Academy. Deflate Gate. https://www.khanacademy.org/science/chemistry/gases-and-kinetic-molecular-theory/ideal-gas-laws/v/deflategate-ideal-gas-law (accessed Oct 2015).

(12) McNeill, K. L.; Krajcik, J. *Assessing Middle School Students' Content Knowledge and Scientific Reasoning through Written Explanations*. http://umaine.edu/center/files/2011/06/Krajcik-Handout-with-examples.pdf (accessed Oct 2015).

(13) Gupta, T.; Burke, K. A.; Mehta, A.; Greenbowe, T. J. Impact of Guided-Inquiry-Based Instruction with a Writing and Reflection Emphasis on Chemistry Students' Critical Thinking Abilities. *J. Chem. Educ.* **2015**, *92* (1), 32−38.

(14) Cooper, M. M. Why Ask Why? *J. Chem. Educ.* **2015**, *92* (8), 1273−1279.




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