JOURNAL OF CHEMICAL EDUCATION

Article

pubs.acs.org/jchemeduc

Integrating the Liberal Arts and Chemistry: A Series of General Chemistry Assignments To Develop Science Literacy

Diane M. Miller* and Demetra A. Chengelis Czegan

Division of Natural and Health Sciences, Seton Hill University, 1 Seton Hill Drive, Greensburg, Pennsylvania 15601, United States

Supporting Information

ABSTRACT: This paper describes assignments that have been implemented in a General Chemistry I course to promote science literacy. This course was chosen in particular because it reaches a broad audience, which includes nonscience majors. The assignment series begins with several discussions and tasks to develop information literacy, in which students find and critique sources of information and evaluate a journal article. It then culminates in an assignment that asks students to critically review a variety of information on a current issue and compose a written supported argument. This set of assignments gives our course a broader, liberal arts context, and according to student feedback, it has been successful in fostering science literacy. Adaptation for use in upper-level courses is also discussed.

KEYWORDS: *First-Year Undergraduate/General, Curriculum, Communication/Writing, Problem Solving/Decision Making, Consumer Chemistry, Enrichment/Review Materials, Nonmajor Courses, Professional Development*

While the principal goal of a General Chemistry course is the teaching of chemistry content, learning goals for students often extend beyond that. Numerous articles have been written addressing the teaching of higher-order skills, such as critical thinking[1−5] and information literacy;[6−8] however, the majority of these activities focus on the practice of higher-order skills within the boundaries of chemistry. A question still remains: are we training students to be informed citizens? In an article by A. Truman Schwartz, winner of the 2007 George C. Pimentel Award, we are called to the task of advancing science literacy.[9] This is not a new request; others have argued the case for its importance,[10−12] and the science−technology−society (STS) movement in education, which started in the 1980s, has been a proponent for the understanding of science within the context of its societal impact.

Science literacy can be viewed as the ability to critically evaluate scientific studies and apply this information to personal decisions. One only needs to look to news headlines to see that scientists are asked to weigh in on many issues, such as the safety of consumer chemicals, environmental concerns, and diet or medical advice. Moreover, it is important that we develop students who can be part of an informed public able to understand and act upon scientific findings.

Science majors are given numerous opportunities over the course of their studies to practice and develop the ability to analyze and discuss data. Yet it is also crucial that we give nonscience majors opportunities to interpret data and to formulate and evaluate arguments based on scientific data. In addition, a liberal arts context is beneficial for science; scientists are called to think beyond the laboratory and demonstrate an ability to communicate effectively with others, including broad audiences. Thus, providing students the opportunity to address a real-world issue brings relevance and meaning to the chemistry they are learning in the classroom.

A common approach to addressing the issue of science literacy in courses for nonscience majors is to use real-world issues to provide context for scientific principles. Popular textbooks, such as *Chemistry in Context*,[13] lead with applications, providing chemistry concepts as needed to make sense of the topic at hand.[14] Interdisciplinary approaches focused on a particular subject have also been used; Hemraj-Benny and Beckford developed an inquiry-based approach that used art-related topics,[15] and Hill et al. used archeology as a framework for teaching chemistry, involving students in the chemical analysis of artifacts.[16] There are also a few examples of using activities focused on real-world issues to develop science literacy in general chemistry courses: Oliver-Hoyo and Pinto shared an activity on vehicle fuel consumption and CO_2 emissions,[17] Geyer related the use of fictitious case studies on unresolved scientific issues,[18] and Gomez et al. led students in an exercise in which they analyzed real-world data connected to an environmental problem.[19]

In an effort to develop first-year students' science literacy, we have incorporated a series of assignments into our General Chemistry I course that culminates with asking students to consider information on a current, controversial topic from a variety of resources and construct a rational and supported

Received: November 21, 2015
Revised: March 6, 2016

DOI: 10.1021/acs.jchemed.5b00942
J. Chem. Educ. XXXX, XXX, XXX−XXX

argument. By focusing on this particular course, we are able to reach a broad audience: chemistry, biochemistry, biology, engineering, exercise science, and forensic science majors, as well as nonscience majors who take the course as part of the liberal arts curriculum. Additionally, by including these assignments in a course students often take during their first semester of college, we reach those students who change to a major outside of science.

DESCRIPTION OF ASSIGNMENTS

The First Step: Introducing Information Literacy

Most of the students in our General Chemistry I course are first-year undergraduates. With this in mind, significant scaffolding is required in order for students to be successful with the final assignment, a decision on a real-world scenario. Consequently, the series of assignments begins with an introduction to information literacy in general. Several exercises are completed over the course of two lecture periods to foster students' skills in this area. To provide practice in dealing with a controversial topic, these initial assignments focus on the use of aspartame as an artificial sweetener.[20] In addition, aspartame works well for our curriculum because the corresponding laboratory course includes a determination of aspartame in an artificial sweetener.[21]

During the first lecture period, the instructor begins class with a brainstorming session on how to look for information about aspartame. This leads to a discussion of how to best use Internet resources, such as webpages and news, and guidance on how to search the college library's databases. Students are instructed on what to look for in assessing the reliability of a source, tips for spotting poor science, and an overview of the peer review process. The handouts used to guide this discussion have been provided as references.[22,23] Students are then given an activity to complete outside of class to practice and reinforce these concepts; the exercise, which has been included in the Supporting Information, has students evaluate unreliable, reliable, and ambiguous webpages and document the reasoning behind their decisions. Instructor feedback on this assignment can help identify any students who need further practice.

Prior to the second lecture period, students are individually assigned one of two journal articles to review; a copy of the assignment is included in the Supporting Information. Both of the articles[24,25] were chosen based on length, clarity, and obvious weaknesses. The students also must find the impact factor of the journal, which provides a means for introducing the concept that not all journals carry equal weight. The lecture period begins with students sharing their findings in small groups. Each section of the General Chemistry I course typically has an enrollment of 24 to 36 students, so instructors are able to monitor group conversations and assess students' level of understanding. In a larger course, it might work well to survey groups with polling software. After giving the groups time to discuss, the instructor asks groups to report out and facilitates a class discussion to ensure that students are aware of the main points, as well as the limitations and strengths, of each article.

Students Weigh in on a Real-World Scenario

After completing the preparatory assignments, students are given one of the real-world scenarios outlined in Table 1. The scenario includes a dilemma, guidelines for the student's response, and resources that address the arguments on both sides of the issue (students are not allowed to use outside resources for this assignment). The two scenarios, along with the guidelines, are given in the Supporting Information. Students are individually asked to review and evaluate the resources, come to a decision, and create a written argument that fully supports the decision. This assignment is similar to a Council for Aid to Education (CAE) performance task, in which students are asked to compose a decision based upon the review of various resources.[26]

An overview of the provided resources is given in Table 1. The documents span a variety of types and are meant to mimic what a student's search might turn up on the issue. All of the resources are posted in PDF format on the course learning management system for students. For some resources, minor modifications have been made by the instructor; for example, a few lines were removed from a news article to avoid giving away conclusions that students are expected to reach on their own.

It might be noted that only abstracts, rather than full journal articles, are provided for the bisphenol A (BPA) scenario; two journal articles of a simpler nature are provided for the antiperspirant deodorant scenario. Our students are predominantly first-year undergraduates, and their prior experience in reading primary literature has been very limited. The second preparatory assignment is intended to develop this emerging skill, but we do not expect enough competency to warrant the inclusion of complex and/or numerous journal articles in the real-world scenario, although this would be encouraged for an upper-level course with students who have more experience reading primary literature.

ASSESSMENT AND STUDENT PERFORMANCE

Because the assignment uses a closed pool of resources, the grading is simplified for the real-world scenario. In the past, we had tried other assignments that allowed each student to choose a real-world topic; this required extra effort on the part of the instructor in order to evaluate student products. In addition, the closed pool of resources starts students off on equal ground because they are all completing the same task.

In assessing student products, we are primarily looking for a sound and supported argument to be made; a rubric has been provided in the Supporting Information. The best student work identifies the salient features of each resource, successfully evaluates the quality of information presented in each resource, and clearly states a position and supports it, while addressing concerns from both sides of the topic. Quite a few students have been successful in meeting all of these criteria. Students who were not as successful typically fell short for one or more of the following reasons: notable weaknesses were missed in some of the resources; personal biases dominated the argument; or many reasons were given in support of the student's position, but possible counterarguments were not addressed. It is encouraging that a large majority of the students are able to move beyond personal opinion and see past the "scare tactics" presented in some of the web resources. One aspect of this assignment that is particularly appealing is that there is not a correct answer. In each of the scenarios, one side of the argument is stronger, but students have successfully crafted arguments on both sides of the issues.

While the real-world scenario has typically been assigned to students to complete individually, it was piloted as a group assignment in the Fall 2014 semester in two sections of the course. The group work was initiated in response to many student products over the previous years that were of good, but not great quality. It appeared that individual students were

DOI: 10.1021/acs.jchemed.5b00942
J. Chem. Educ. XXXX, XXX, XXX−XXX

Table 1. Real-World Scenarios Used in a General Chemistry I Course

Scenario	Summary of Resources[a]	Student Product
An obesity prevention program is being developed at an elementary school, and the student is part of a five-member committee working to design the program. A fellow committee member suggests that 15% of the allocated money should be spent to remove canned foods due to a possible linkage between childhood obesity and bisphenol A (BPA).	*General* Information from the Wikipedia entry on BPA. *News* Articles summarizing a research study linking childhood obesity to BPA; interviews with scientists. *Primary Literature* PubMed abstracts of several articles on the following two topics: the amount of BPA in canned foods and the possible linkage of BPA to childhood obesity. *Web Resources* Blog entry about plastics; blogger's video about the research study linking childhood obesity to BPA; fact sheets on BPA by industry groups; report on BPA by a consumer group.	A written supported argument communicating the student's decision to the committee.
Students are asked to serve as a scientific writer for a women's magazine and write an article addressing an e-mail rumor that antiperspirant deodorant causes breast cancer and is unsafe to use.	*General* Copy of the e-mail rumor; pamphlet from a personal care products manufacturer on deodorant safety; breast cancer pamphlets and fact sheets from national health organizations. *News* Modified news story covering the story of a doctor whose wife died from breast cancer that is researching a link between antiperspirant deodorant and breast cancer. *Primary Literature* Two peer-reviewed research articles: one written by the doctor in the news story, and one reporting no connection between deodorant use and breast cancer. *Web Resources* Information from breastcancer.org; Web site article from a naturopathic products retailer; blog entry about deodorant safety.	An article written for the magazine that advises readers on the safety of antiperspirant deodorant and a supporting letter for the magazine editors that justifies the inclusion or exclusion of provided resources.

[a]Resources for the first scenario are listed as refs 27−41; resources for the second scenario are listed as refs 42−54.

DOI: 10.1021/acs.jchemed.5b00942
J. Chem. Educ. XXXX, XXX, XXX−XXX

grasping many, but not all, of the key concepts on their own; so, it was hypothesized that collaboration would result in stronger arguments. To implement this, students were assigned to groups of three on the antiperspirant deodorant scenario. The assignment of groups was predominantly driven by overlaps in student schedules, as it was deemed important that students be able to physically meet to work on the assignment; schedules were matched up using CATME, an online program for team management.[55] This trial went well; the quality of student products improved compared to those seen in prior years. For student populations who need additional scaffolding, the use of groups is a promising adaptation.

STUDENT FEEDBACK

Student course evaluation data on questions related to the assignment series has been encouraging. The two questions asked are as follows: *I learned to analyze a scientific article at a level specified by the instructor and to assume a position on its content in writing*, and *I can express in oral or written form a position on a political, economic, social, philosophical or ethical issue involving science*. The distribution of student responses is shown in Figure 1. The majority of students selected "strongly agree" or "agree" as responses (totaling 83% and 75% for the two respective questions). These responses are self-reported, but they are in agreement with our assessment of students' work.[56]

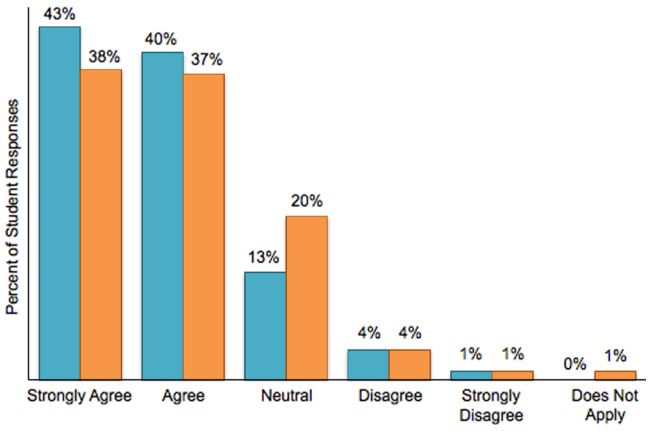

Figure 1. Distribution of student responses to the following questions on a five-level Likert scale: *I learned to analyze a scientific article at a level specified by the instructor and to assume a position on its content in writing* (blue), and *I can express in oral or written form a position on a political, economic, social, philosophical or ethical issue involving science* (orange). Out of the 279 students enrolled in 2012–2014, 192 (69%) completed the survey.

EXTENDING BEYOND THE INTRODUCTORY COURSE

In General Chemistry II, we include a follow-up assignment in which students are asked to read and draft a summary and a one-page critique of a more challenging journal article on aspartame.[57,58] This gives the students additional practice on summarizing and evaluating the validity of a scientific resource. To allow further learning opportunities, an open class discussion is held after the assigned critique.

The real-world scenario assignment is highly adaptable and can be modified to fit other student populations as well. There are numerous topics that could be chosen to build a scenario around, and more or less scaffolding can be used, depending on the experience level of the students. At our own institution, two topics have been used in our Biochemistry course: the benefits versus risks of genetically modified organism (GMO) crops, and the controversy surrounding the use of Avastin as a chemotherapy drug for breast cancer.

CONCLUSIONS

The assignments described in this article have been a useful way to develop science literacy in our students. While this series of assignments requires dedicated class time, we feel that it addresses an important gap in science curricula. Science literacy is crucial for the general public, and more needs to be done to promote it. We would argue that this is one of the most essential skills we can impart to the nonscience majors in our courses. For those teaching at a liberal arts college or university, this series of assignments can be used to incorporate liberal arts learning objectives into the science curriculum, such as critical thinking and the ability to draft a persuasive argument. In addition, including an assignment of this nature adds relevance to the course; students appreciate and are motivated by real-world problems.

ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available on the ACS Publications website at DOI: 10.1021/acs.jchemed.5b00942.

Introductory exercises, real-world scenario assignment, and grading rubrics (PDF, DOCX)

AUTHOR INFORMATION

Corresponding Author

*E-mail: dmiller@setonhill.edu.

Notes

The authors declare no competing financial interest.

ACKNOWLEDGMENTS

We gratefully acknowledge Jephthe Ferdilus for creating the abstract graphic. We would like to thank several of our Seton Hill colleagues: John Cramer for sharing his work on the GMO scenario, Diana Hoover for reviewing this manuscript and sharing her work on the Avastin scenario, and Dennis Jerz for suggesting the addition of a letter to the magazine editor for the antiperspirant scenario. In addition, we are grateful to Christopher Chengelis for sharing his expertise in toxicology as a guest lecturer for the analysis of aspartame and BPA literature in General Chemistry II. Finally, we thank Mark Chun and the Council for Aid to Education (CAE) for providing helpful instruction and resources through a performance task workshop.

REFERENCES

(1) VanOrden, N. Critical-Thinking Writing Assignments in General Chemistry. *J. Chem. Educ.* **1987**, *64* (6), 506–507.

(2) Kogut, L. S. Critical Thinking in General Chemistry. *J. Chem. Educ.* **1996**, *73* (3), 218–221.

(3) Oliver-Hoyo, M. T. Designing a Writing Assignment to Promote the Use of Critical Thinking Skills in an Introductory Chemistry Course. *J. Chem. Educ.* **2003**, *80* (8), 899–903.

DOI: 10.1021/acs.jchemed.5b00942
J. Chem. Educ. XXXX, XXX, XXX–XXX

(4) Jacob, C. Critical Thinking in the Chemistry Classroom and Beyond. *J. Chem. Educ.* **2004**, *81* (8), 1216−1223.
(5) DeWit, D. G. Predicting Inorganic Reaction Products: A Critical Thinking Exercise in General Chemistry. *J. Chem. Educ.* **2006**, *83* (11), 1625−1628.
(6) Levine, E. Reading Your Way to Scientific Literacy: Interpreting Scientific Articles Through Small-Group Discussions. *J. Coll. Sci. Teach.* **2001**, *31* (2), 122−125.
(7) Gawalt, E. S.; Adams, B. A Chemical Information Literacy Program for First-Year Students. *J. Chem. Educ.* **2011**, *88* (4), 402−407 and references therein..
(8) Ferrer-Vinent, I. J.; Bruehl, M.; Pan, D.; Jones, G. L. Introducing Scientific Literature to Honors General Chemistry Students: Teaching Information Literacy and the Nature of Research to First-Year Chemistry Students. *J. Chem. Educ.* **2015**, *92* (4), 617−624.
(9) Schwartz, A. T. Chemistry Education, Science Literacy, and the Liberal Arts. *J. Chem. Educ.* **2007**, *84* (11), 1750−1756.
(10) Moore, J. W. Science Literacy and Science Standards. *J. Chem. Educ.* **2006**, *83* (3), 343.
(11) Miller, S.; Gregory, J. *Science in Public*; Perseus Publishing: Cambridge, MA, 1998.
(12) Hazen, R. M.; Trefil, J. *Science Matters: Achieving Scientific Literacy*; Anchor: New York, NY, 2009.
(13) Middlecamp, C. H.; Mury, M. T.; Anderson, K. L.; Bentley, A. K.; Cann, M. C.; Ellis, J. P.; Purvis-Roberts, K. L. *Chemistry in Context: Applying Chemistry to Society*, 8th ed.; McGraw-Hill Education: New York, 2015.
(14) Schwartz, A. T.; College Chemistry for Nonscientists. In *Sputnik to Smartphones: A Half-Century of Chemistry Education*; Orna, M. V., Ed.; American Chemical Society: Washington, DC, 2015; Vol. *1208*, pp 79−92.
(15) Hemraj-Benny, T.; Beckford, I. Cooperative and Inquiry-Based Learning Utilizing Art-Related Topics: Teaching Chemistry to Community College Nonscience Majors. *J. Chem. Educ.* **2014**, *91* (10), 1618−1622.
(16) Hill, A. D.; Lehman, A. H.; Parr, M. L. Using Scanning Electron Microscopy with Energy Dispersive X-ray Spetroscopy to Analyze Archaeological Materials: Introducing Scientific Concepts and Scientific Literacy to Students from All Disciplines. *J. Chem. Educ.* **2007**, *84* (5), 810−813.
(17) Pinto, G.; Oliver-Hoyo, M. T. Using the Relationship between Vehicle Fuel Consumption and CO_2 Emissions to Illustrate Chemical Principles. *J. Chem. Educ.* **2008**, *85* (2), 218−220.
(18) Geyer, A. M. Social Networking as a Platform for Role-Playing Scientific Case Studies. *J. Chem. Educ.* **2014**, *91* (3), 364−367.
(19) Gomez, S. A. S.; Faurie-Wisniewski, D.; Parsa, A.; Spitz, J.; Spitz, J. A.; Loeb, N. C.; Geiger, F. M. A General Chemistry Assignment Analyzing Environmental Contamination for the DePue, IL, National Superfund Site. *J. Chem. Educ.* **2015**, *92* (4), 638−642.
(20) Brubacher, L. Searching the Internet—Aspartame. *Chem. 13 News* **2009**, *367*, 3−5.
(21) The experiment was adapted from Fenk, C. J.; Kaufman, N.; Gerbig, D. G., Jr. A New Colorimetric Assay of Tabletop Sweeteners Using a Modified Biuret Reagent. *J. Chem. Educ.* **2007**, *84* (10), 1676−1678.
(22) A Rough Guide to Spotting Bad Science; Compound Interest [Online]. http://www.compoundchem.com/2014/04/02/a-rough-guide-to-spotting-bad-science/ (accessed Oct 2015).
(23) I Don't Know What to Believe; Sense About Science [Online]. http://www.senseaboutscience.org/resources.php/16/i-dont-know-what-to-believe (accessed Oct 2015).
(24) Siegler, J.; Howell, K.; Vince, R.; Bray, J.; Towlson, C.; Peart, D.; Mellor, D.; Atkin, S. Aspartame in Conjunction with Carbohydrate Reduces Insulin Levels During Endurance Exercise. *J. Int. Soc. Sports Nutr.* **2012**, *9* (36), 36.
(25) de Matos Feijó, F.; Reis Ballard, C.; Carraro Foletto, K.; Melo Batista, B. A.; Magagnin Neves, A.; Marques Ribeiro, M. F.; Casaccia Bertoluci, M. Saccharin and Aspartame, Compared with Sucrose, Induce Greater Weight Gain in Adult Wistar Rats at Similar Total Caloric Intake Levels. *Appetite* **2013**, *60*, 203−207.
(26) Council for Aid to Education. www.cae.org (accessed Oct 2015).
(27) Bisphenol A. https://en.wikipedia.org/wiki/Bisphenol_A (accessed Oct 2015).
(28) Jaslow, R. BPA exposure linked to childhood obesity in older girls. http://www.cbsnews.com/news/bpa-exposure-linked-to-childhood-obesity-in-older-girls/ (accessed Jun 2013), CBS Broadcasting Incorporated, June 2013.
(29) Li, D.; Miao, M.; Zhou, Z.; Wu, C.; Shi, H.; Liu, X.; Wang, S.; Yuan, W. Urine Bisphenol-A Level in Relation to Obesity and Overweight in School-age Children. *PLoS One* **2013**, *8* (6), e65399.
(30) Harley, K. G.; Schall, R. A.; Chevrier, J.; Tyler, K.; Aguirre, H.; Bradman, A.; Holland, N. T.; Lustig, R. H.; Calafat, A. M.; Eskenazi, B. Prenatal and Postnatal Bisphenol A Exposure and Body Mass Index in Childhood in the CHAMACOS Cohort. *Environ. Health Perspect.* **2013**, *121* (4), 514−520.
(31) Trasande, L.; Attina, T. M.; Blustein, J. Association between Urinary Bisphenol A Concentration and Obesity Prevalence in Children and Adolescents. *JAMA* **2012**, *308* (11), 1113−1121.
(32) Noonan, G. O.; Ackerman, L. K.; Begley, T. H. Concentration of Bisphenol A in Highly Consumed Canned Foods on the U.S. Market. *J. Agric. Food Chem.* **2011**, *59* (13), 7178−7185.
(33) Carwile, J. L.; Ye, X.; Zhou, X.; Calafat, A. M.; Michels, K. B. Canned Soup Consumption and Urinary Bisphenol A: A Randomized Crossover Trial. *JAMA* **2011**, *306* (20), 2218−2220.
(34) BPA Linked to Obesity. https://www.youtube.com/watch?v=S2eSPlmPCFE (accessed Oct 2015).
(35) Environmental Working Group. Bisphenol A—Toxic Plastic Chemical in Canned Food: People Are Exposed at Harmful Levels. http://www.ewg.org/research/bisphenol/people-are-exposed-harmful-levels (accessed Oct 2015).
(36) My Plastic Free Life. BPA-Free Does Not Mean Safe: Most Plastics Leach Hormone-disrupting Chemicals. http://myplasticfreelife.com/2011/04/bpa-free-does-not-mean-safe-most-plastics-leach-hormone-disrupting-chemicals/ (accessed Oct 2015).
(37) Butterworth, T. Anti BPA Crusade Discrediting Science and Environmental Health, Says Leading, Independent Expert. http://www.forbes.com/sites/trevorbutterworth/2013/02/26/anti-bpa-crusade-discrediting-science-and-environmental-health-says-leading-independent-expert/ (accessed Oct 2015), Forbes.com LLC, Feb 2013.
(38) Polycarbonate/BPA Global Group; Bisphenol A Fact Sheet [Online]. June 2007. http://www.bisphenol-a.org/pdf/FactSheet-what.pdf (accessed Oct 2015).
(39) FactsAboutBPA.org; How Much BPA Does a Typical Person Take in through a Normal Diet? [Online]. http://factsaboutbpa.org/sites/default/files/press-releases/ACC_BPA_Infographic.pdf (accessed Oct 2015).
(40) Goetz, G. BPA in Food Packaging is Safe, Researchers Say. http://www.foodsafetynews.com/2012/04/bpa-in-packaging-is-safe-experts-say/#.ViRF4BCrSRt (accessed Oct 2015), Food Safety News, April 2012.
(41) Hamilton, J. How Much BPA Exposure is Dangerous? http://www.npr.org/2012/03/30/149668771/how-much-bpa-exposure-is-dangerous (accessed Oct 2015), NPR, March 2012.
(42) Adams, C. The Straight Dope, Does Antiperspirant Deodorant Cause Breast Cancer? http://www.straightdope.com/columns/read/2540/does-antiperspirant-cause-breast-cancer (accessed May 2011), March 2000.
(43) Lagorio, C. The Cancer-Antiperspirant Myth: Could Shaving and Antiperspirant Be Related to Breast Cancer? http://www.cbsnews.com/stories/2005/12/05/eveningnews/main1098995.shtml (accessed May 2011), CBS Broadcasting Incorporated, December 2005.
(44) Mirick, D. K.; Davis, S.; Thomas, D. B. Antiperspirant Use and the Risk of Breast Cancer. *J. Natl. Cancer Inst.* **2002**, *94* (20), 1578−1580.

DOI: 10.1021/acs.jchemed.5b00942
J. Chem. Educ. XXXX, XXX, XXX−XXX

(45) McGrath, K. G. An Earlier Age of Breast Cancer Diagnosis Related to More Frequent Use of Antiperspirants/Deodorants and Underarm Shaving. *Eur. J. Cancer Prev.* **2003**, *12* (6), 479−485.
(46) American Cancer Society. Breast Cancer Overview, 2010. http://www.cancer.org/acs/groups/cid/documents/webcontent/003037-pdf.pdf (accessed May 2011).
(47) Breastcancer.org. Breast Cancer Risk Factors, 2010. http://www.breastcancer.org/risk/factors (accessed May 2011).
(48) Breastcancer.org. Corporate Sponsors, 2010. http://www.breastcancer.org/about_us/supporters/corporate-sponsors (accessed May 2011).
(49) Batliwalla, S. Antiperspirant and Breast Cancer: Is There a Link? http://www.divinecaroline.com/22175/83451-antiperspirant-breast-cancer-link (accessed May 2011), Meredith Corporation, published September 2009, updated September 2010.
(50) The pamphlet that is used no longer has a working URL. Comparable information could be obtained from the following reference: Unilever. Antiperspirant and Breast Cancer. http://www.deodorantinfo.com/en/antiperspirants-breast-cancer/ (accessed March 2016).
(51) The article that is used no longer has a working URL. Comparable information could be obtained from the following reference: Group, E. Why You Should Use Aluminum-Free Deodorant. http://www.globalhealingcenter.com/natural-health/why-you-should-use-aluminum-free-deodorant/ (accessed March 2016).
(52) National Cancer Institute. Antiperspirants/Deodorants and Breast Cancer: Questions and Answers Fact Sheet. National Institutes of Health. http://www.cancer.gov/about-cancer/causes-prevention/risk/myths/antiperspirants-fact-sheet (accessed May 2011), reviewed Jan 4, 2008.
(53) National Cancer Institute. Reproductive History and Breast Cancer Risk Fact Sheet, National Institutes of Health. http://www.cancer.gov/about-cancer/causes-prevention/risk/hormones/reproductive-history-fact-sheet (accessed May 2011), reviewed May 10, 2011.
(54) Lanfranchi, A.; Brind, J. *Breast Cancer Risks and Prevention* [Online], 4th Ed., Breast Cancer Prevention Institute: Poughkeepsie, NY, 2007; pp 1−22. http://www.bcpinstitute.org/PDF/BreastCancerRisksPrevention_4ed.pdf (accessed October 2014).
(55) CATME: Smarter Teamwork. http://info.catme.org/ (accessed March 2016).
(56) We do not have data for student responses to these questions prior to the inclusion of this series of assignments in the course; the assignments have been done longer then these questions have been present on the student evaluation form.
(57) Soffritti, M.; Belpoggi, F.; Tibaldi, E.; Degli Esposti, D.; Lauriola, M. Life-Span Exposure to Low Doses of Aspartame Beginning during Prenatal Life Increases Cancer Effects in Rats. *Environ. Health Perspect.* **2007**, *115* (9), 1293−1297.
(58) Collison, K. S.; Makhoul, N. J.; Zaidi, M. Z.; Saleh, S. M.; Andres, B.; Inglis, A.; Al-Rabiah, R.; Al-Mohanna, F. A. Gender Dimorphism in Aspartame-Induced Impairment of Spatial Cognition and Insulin Sensitivity. *PLoS One* **2012**, *7* (4), 31570.

DOI: 10.1021/acs.jchemed.5b00942
J. Chem. Educ. XXXX, XXX, XXX−XXX