JOURNAL OF CHEMICAL EDUCATION

ARTICLE

pubs.acs.org/jchemeduc

The Kitchen Is Your Laboratory: A Research-Based Term-Paper Assignment in a Science Writing Course

Clinton D. Jones*

Department of Chemistry and Biochemistry, Mercyhurst College, Erie, Pennsylvania 16546, United States

ABSTRACT: A term-paper assignment that encompasses the full scientific method has been developed and implemented in an undergraduate science writing and communication course with no laboratory component. Students are required to develop their own hypotheses, design experiments to test their hypotheses, and collect empirical data as independent scientists in their personal laboratories—their kitchens. Motivating students to use food preparation as a chemical experiment does more than just provide them with adequate data for their term papers. Students develop a new awareness for experimental variables, acquire experimental planning and development expertise, and gain an enhanced set of independent thinking skills. This inquiry-based assignment requires students to treat edible ingredients as a chemicals and kitchen equipment as scientific instrumentation. Students are required to provide correctly formatted scientific terms for all consumables and equipment, and they are encouraged to bring experimental results into the classroom to gather statistical taste-test data. Students submit their term papers as communication-type manuscripts, formatted using the communication-style template for *The Journal of the American Chemical Society*. The details and outcomes of this assignment are described along with sample excerpts from student papers over the past few years.

KEYWORDS: Upper-Division Undergraduate, Curriculum, Interdisciplinary/Multidisciplinary, Collaborative/Cooperative Learning, Inquiry-Based/Discovery Learning, Problem Solving/Decision Making, Consumer Chemistry, Food Science, Student-Centered Learning

Learning proper technical writing and presentation skills is an important part of an undergraduate education in the sciences. Students will use these skills as professionals in science, engineering, law, and medicine. Furthermore, the process of writing engages students in active critical thinking and advances a more complete understanding of scientific principles.[1−4] A typical undergraduate education inevitably requires students to compose term papers and essays in courses outside the sciences with an emphasis on the Modern Language Association (MLA) formatting style. Courses in the core curriculum such as history, philosophy, and English teach students to propose claims and successfully support their ideas in a cohesive manner; these courses serve as a foundation for fostering critical thinking while enhancing writing skills.

Although more technical in nature, writing assignments in the sciences often require empirical data and are not always practical in every course. A majority of chemistry undergraduates gain their first experience writing full-length lab reports in quantitative analysis and organic chemistry lab courses. Students have enough expertise at that level to successfully analyze their results and support their conclusions with known scientific theories. Ideally, the students realize the important role of written communication in science through this process, which is to pattern the flow of discovery and to provide a written account to the scientific community.[5]

This *Journal* contains a number of excellent writing assignments for use in chemistry courses, including a complete bibliography of those published between 1980 and 1990.[6] Writing assignments that promote understanding of the material have been incorporated into introductory and advanced-level laboratory courses.[7−9] Some assignments have incorporated the process of peer review, enhancing a realistic scientific publishing process for students.[10,11] For lecture courses, previous articles illustrate creative approaches for writing assignments that do not require students to include their personal experimental data as in a laboratory course,[12−14] while some target traditionally difficult lecture topics.[15]

Aside from the enhanced learning experiences presented in the above references and others too numerous to mention, how do undergraduates typically learn to completely *do* science from beginning to end? That is, personally forming a hypothesis from a natural observation and proving something about that hypothesis through planned experimentation. Undergraduate students typically learn the theories within a scientific discipline during lecture courses and practice using these theories in the corequisite lab courses; these traditional methods provide the

Published: June 03, 2011

necessary fundamental background and proper, safe laboratory practices. Understandably, most laboratory experiments provide students with a rigid recipe to follow due to equipment availability and time constraints of the lab period. The resultant data are normally submitted in a report sheet at the end of the period or in a more extensive written report due at a later date. Again, there are many assignments that go beyond this average progression, only a few of which are mentioned here.[6−10] But this is how many students typically learn to *do* science as undergraduates: follow an established procedure under time constraints, observe and interpret inevitable results, and submit the predictable findings in a worksheet or written report. This scenario has worked well over many decades and does teach students to perform basic experiments, interpret, conclude, and discuss results. However, undergraduates are not required to fully encompass the scientific method as personally conceiving a hypothesis and formulating experiments to test the hypothesis are already performed for students before they enter the laboratory.

This article describes a heuristic, research-based assignment for an undergraduate writing course with no laboratory component. Students personally conceive a hypothesis, design and implement experiments, and collect data in their personal laboratories—their kitchens. All food items are treated as chemicals and appliances are treated as laboratory equipment when the students present their findings in a professionally written manuscript adhering to American Chemical Society (ACS) guidelines at the end of the term.[16] The purpose of this article is to present the assignment within the context of the course in which it is implemented and to illustrate how it fosters critical-thinking skills and independence among undergraduate students. At the essence of the assignment, undergraduate students are required to think independently while they proceed through the realistic process of conducting science from hypothesis to publication.

WRITING AND COMMUNICATION FOR SCIENTISTS

"Writing and Communication for Scientists" is a three-credit lecture course with no laboratory component. The class meets for 2 h, twice each week over the period of 10 weeks on a trimester term system. The course is required for all chemistry and biochemistry majors within the department, as they are later required to compose a senior thesis and present a formal oral seminar to the college community based on their undergraduate research. Occasionally, students majoring in biology and applied forensic science also take the course. Enrollment has averaged 15−25 students over the past three offerings. Two textbooks are required for the course: *The ACS Style Guide* and *Write Like a Chemist*.[16,17]

The pedagogical approach when designing the course was to mimic the first two years of a typical graduate program in the chemical sciences. The course begins by introducing students to finding scientific literature by going directly to a publisher's Web site or by using common search engines such as SciFinder,[18] PubMed,[19] and ScienceDirect.[20] Student-gathered articles are discussed in a "journal club" type of setting, where students begin to realize how to interpret and analyze scientific articles that cover a wide range of topics.

As the class begins to recognize the common structure and flow of scientific articles through many readings, topics such as ethics and proper figure and table formatting serve as the basis for the first assignments. Consequently, multiple manuscript readings across chemical disciplines allow students to learn about modern science and also helps some students decide which discipline of chemistry they might like to pursue. Next, students compose separate main sections of a manuscript (introduction, methods, results and discussion; IMRD) by using canned project data that accompanies the text, *Write Like a Chemist*.[17] Students begin by writing the methods (experimental) section, which is the one they will typically write first as graduate students. This approach is analogous to other assignments presented in this *Journal* where students build up to composing a full manuscript by completing focused, separate assignments.[14] Students are next required to choose a topic that interests them from the modern literature (2000−current) to present in a formal oral seminar. Because it is not fiscally reasonable to require all students to prepare a full-size poster, they gain experience by submitting an electronic version of a poster in common software such as Microsoft PowerPoint. The subject material for the poster can be the same as that chosen for their oral seminar; the important aspect is that students learn the differences in these two forms of communication. Students are required to compose an abstract for both the oral seminar and poster, as they would for any conference. Topics then turn to the process of submitting a peer-reviewed manuscript, where students learn about the different types of written works (letter, communication, invited, feature, full and review articles); they learn where and how to submit written works by comparing requirements and document templates from various journals. The process of peer review is practiced through given assignments and by using peer-review guidelines from publishers.[21] All of the content mentioned above integrates at the end of the course within the term-paper assignment discussed herein.

THE TERM-PAPER ASSIGNMENT

The motivation was to create a term-paper assignment that would offer students a realistic experience in science while providing them with their own empirical data to present in a properly formatted, scientific manuscript. A lecture course with no laboratory component initially precluded this goal. Students could have easily been given spurious experimental data, statistical data, or even results from an experiment performed in a previous lab course; however, an authentic scientific experience was desired, one that encompasses the entirety of the scientific method from beginning to end. Luckily, most students have a convenient laboratory in their place of residence—the kitchen. Students are required to treat the preparation of a food dish as a scientific experiment to collect real data. This heuristic assignment requires students to rely on learned scientific principles as they independently build and test their own hypotheses. Students are required to *do* science as they would as practicing professionals: devise a hypothesis, conceive experiments to test the hypothesis, observe the results, reformulate experiments, conclude on relevant data, and report their findings to the scientific community. The community in this case is their class of peers and the instructor.

The term paper is graded on the merits of concepts learned throughout the course such as formatting, jargon, organization, and flow. Students' critical-thinking skills are then tested as they progress through the assignment and learn to become independent in every aspect of a scientific endeavor, the first time for many students.

Table 1. Suggestions To Guide Students in Their Thinking and Writing Process

Section	Suggestions
Introduction	Provide details concerning the origin, ethnicity, and history of the dish. Is it served for a special occasion? Is it served as a main course, hot or cold? What does it complement in a balanced meal? What are the nutritional values? What is the serving size? State the hypothesis that you tested, and state why it is important relative to the food dish. Perhaps your results would interest another scientist, the general public, or a chef? Above all, be creative and get someone interested enough to read further about your experiment.
Methods	Be technically descriptive in everything you do here. For example, one could describe the process of boiling salty water as, "I put 1 cup of water in a 4 ounce pot with 2 ounces of salt and brought it to a boil over high heat." A proper scientific way of describing this process is, "Exactly 56.7 g of sodium chloride (NaCl) and 237 mL of water (H_2O) were placed into a 3.78 L aluminum coated metal vessel (All Clad Metalcrafters, Canonsburg, PA) and heat was supplied via direct heat from a propane gas flame until the solution temperature reached 100 °C as measured with a Taylor 1470 digital thermometer."
Results	Provide figures, pictures, illustrations, and graphs to describe what your dish went though to achieve the final state. You may include a table of the variable ingredients here. If you varied the components of the experiment, show how they depend on each other with a figure. For example, the simple process of cooking carrots may be done in the microwave, on a stovetop, in the oven, or on a grill; each of these processes may lead to differing results in the appearance, cook time, and taste of the final product. Also consider: the physical size of carrot pieces (surface area), other components in the preparation (the addition of water, butter, herbs, flavoring). Think about ALL possibilities and be creative.
Discussion	This must be separate from the Results section, no combinations here. Restate your hypothesis and provide a discussion and your interpretation of whether you proved/disproved your intellectual proposition. Discuss your results while referencing pertinent figures. Example questions to consider: Why does the preparation method work? What is happening chemically on the molecular level? Why does it taste great/bad? How did you reach the conclusion of preparing the dish in the manner you used? Discuss your results in concise detail and support your hypothesis whether it worked or did not!

The assignment is introduced to the students as a way to bring everything in the course together into a properly formatted, technically detailed research article based on a set of empirical data. The students are reminded that the course does not have a laboratory component; "You probably have daily access to a laboratory where you may safely carry out experiments, your kitchen. After all, cooking is applied chemistry where it is safe to lick the spoon (in most cases...)." Students are presented with the following instructions on the first week of the 10-week term.

> Your assignment is to collect data from the preparation of an edible dish in your kitchen. Do not just make the dish once. Experiment! Determine experimental variables and vary them; this will provide objective data. For example, an experimental variable may be as simple as the time or power setting on a microwave oven. Because your kitchen is your laboratory, treat all ingredients as chemicals and all kitchen appliances as laboratory equipment when composing the article. Include vendors, makes, model numbers, and quantities, everything you would do in a scientific laboratory! You may choose to obtain subjective data by testing your results in a public opinion poll. Design a questionnaire and bring your edible results to class for taste-test opinions from your peers (hint, hint... snacks for class).

A hypothesis and proposed outline are due by the end of the second week of the course, as this requires forethought in scientific planning and structure for the project.[5] The instructor provides suggestions that are handed back to the student at the beginning of the third week.

In addition to using their kitchens and gathering public opinions to collect data, students are also allowed to use departmental instrumentation with approval from the instructor. For example, a student used a pH meter and probe to compare spaghetti sauces after varying the quantity and type of tomatoes. The main concern about data collection is not its complete reliability; rather, the focus is on getting students to think about their experimental variables as scientists and creating ways to collect their data. Depending on what they choose to explore, it would not be reasonable to expect all students to gather analytically sound data sets within the given conditions and time frame. However, each student should gather enough reasonable data to create properly formatted manuscript components such as figures, schemes, and tables.

The communication-style template for *The Journal of the American Chemical Society* (*JACS*) is provided to the students for formatting their articles with the following instructions:

> Your document must adhere to the communication-style article template for the *Journal of the American Chemical Society*. The length requirement is four maximum pages, and it must contain pertinent yet concisely detailed sentences. The article must contain at least two figures, one scheme, and one table. Only proper scientific language and ACS formatting will be accepted. Your article must include these components in the following order: title, author, abstract, introduction, methods, results, discussion (separate from the results section), and references.

The *JACS* communication template provides the appropriate length and complexity within the course. Students gain their first experience using a document template, which provides an added challenge to the assignment for some. For the first time, many students realize that it is not the length and wordiness of the term paper (article) that counts but the effectiveness of its content.

Students are required to provide the common major sections (IMRD) of a full-length research article, although they are using a less-lengthy, communication-style template. Learned experiences from incremental writing assignments earlier in the course, as previously discussed, provide the necessary skills to compose each section within the full article. Although a significant number of scientific journals combine the results and discussion sections, they are separate in this assignment for the purpose of grading. It is more obvious to see that each student can distinguish the

Table 2. Example Titles from Student Manuscripts

Student Manuscript Title	Food Dish Description
Empirical Mix of Aromatic Compounds to Produce the Optimum Palate of a Sauce Containing an *Apis Mellifera* Produced Polysaccharide Mixture	Preparing barbeque sauce with honey from a certain bee species and variable herbs and spices
Denaturing Surface Muscle Proteins to Create a Waterproof Barrier	Braising chicken breasts using various oils and temperatures to retain a moist interior
Variation of the Amount and Type of Capsaicin Products to Achieve Known Scoville Ratings	Preparing chili with different amounts and types of hot peppers to reach a desired hotness in taste
Investigating the Role of Sodium Chloride During the Hydration of Starch in a High Temperature Aqueous Environment	Boiling pasta in water with various amounts of table salt to determine total cooking time and taste
Human Perceptions Toward Branded and Generic Mixtures Containing Theobromine	Comparison of taste test results from name brand and generic brownie mixes

difference in presenting the results without bias and discussing the results within the context of his or her scientific interpretation. Suggestions are given for each section to help guide students in their thinking process (Table 1).

A well-polished draft of the term paper is due on the eighth week of class for peer review. The instructor could make the process more realistic as an editor by collecting all the papers and later disseminating them to differing students. However, the students feel more comfortable getting advice from two peers of their own choosing thereby creating a more productive environment. Students critique each other's works over a two-day period (the weekend) using the current reviewers' document for Wiley–Blackwell journals[21] and a copy of the instructor's grading rubric. This affords students an opportunity to reference publishing practices in journals outside of the ACS. A cohesive written summary, as one would provide in an actual peer review, is due to the student author and instructor for grading. Handwritten comments on the article itself are also encouraged, although the instructor does not view these.

SAMPLE EXCERPTS

Students are encouraged to be creative and develop an interesting scientific title for their term papers. Some examples are shown in Table 2 along with the food dish students describe in their term papers. Students are also required to treat all kitchen equipment as they would laboratory equipment, which means listing adequate details so that experienced persons can repeat the work and obtain comparable results.[16] For example, a particular student describes his preparation of cheese biscuits in this uncorrected excerpt from his methods section:

> Biscuit mix (Bisquick, General Mills Sales, Inc., Minneapolis, MN) (starch), vitamin D milk (Giant Eagle), natural shredded fat free mozzarella (NFM), finely shredded low-moisture part-skim mozzarella (FSM), natural shredded mild cheddar (Cd), and finely shredded mild cheddar (FSCd) all purchased from Giant Eagle (7200 Peach St., Erie, Pa). All cheeses Kraft brand (Kraft Foods North America Division of Kraft Foods Global, Inc., Glenview, IL). A shiny, aluminum medium cookie sheet (38.7 cm × 26.0 cm × 1.9 cm) was purchased from Giant Eagle (Wilton: Perfect Results, Wilton Industries Inc., Woodridge, IL).

At least two figures are required in the term paper. The example in Figure 1 illustrates that student authors are able to find scientifically relevant variables in simple food dishes to create publishable figures. In this particular case, the student was investigating the viscosity of a fruit smoothie after varying the volume of milk in the recipe. The student devised a homemade apparatus that consisted of books, a protractor, and a plastic cutting board. The following is an excerpt from her methods section that describes the procedure:

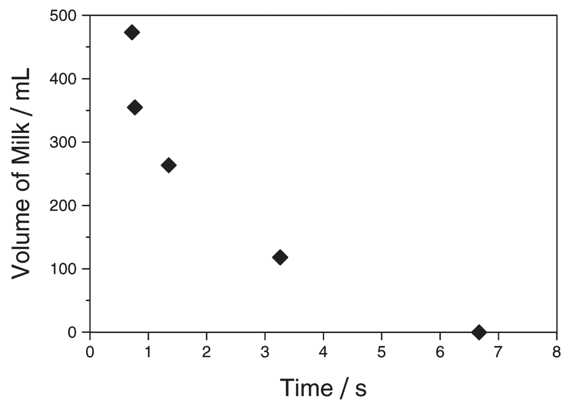

Figure 1. A figure from a student's term paper. The student used a time metric to assess the viscosity of a banana smoothie by varying the volume of milk added to the mixture.

> Each sample was then placed into labeled (one through five) English system beakers (2.4 cm full), having a base diameter of 5.0 cm, and refrigerated for 10 minutes. The samples were retrieved one at a time, and tested for their viscosities on a polymer ramp, approximately 17.5 cm long, set up at 45 degrees on a flat surface. The angle of the ramp was established by utilizing a protractor and adding more supports (textbooks) to heighten the top of the ramp until the proper angle was achieved. The viscosity test consisted of pouring the samples, at approximately the same rate, down the ramp and timing from when each hit the ramp's surface to when each reached the level surface at the bottom of the ramp.

Results of scientific critical thinking are also evident in the students' manuscripts, as shown in this unedited excerpt.

> When trying to find what part of the pepper makes the sauce most spicy, the results show that the crushed seeds are the spiciest based on public opinion. The only sauce that showed a change in pH in the second experiment was the

dx.doi.org/10.1021/ed1011184 | J. Chem. Educ. 2011, 88, 1062–1068

Table 3. Grading Rubric for the Assignment

Component	Points	Criteria
Required Content (10%)	10	All sections, figures, table(s), scheme(s) are included and placed in logical order within the text.
	6−9	One or more of the required components is missing or illogically ordered within the text.
	1−5	Two or more of the required components are missing or illogically ordered within the text
Formatting (20%)	15−20	Nearly all text is properly formatted according to the ACS Style Guide and instructions included in the ACS template
	9−14	More than two mistakes in formatting that deviates from the terms above
	1−8	Several formatting errors and little effort shown in adherence to the ACS guidelines
Grammar and Structure (35%)	25−35	Nearly all sentences are grammatically correct and in proper English. Each section is written concisely yet provides pertinent scientific and technical details. The entire article flows together.
	11−24	More than a few grammatical mistakes. Extraneous information is included in multiple instances. The article lacks flow among sentences and between sections.
	1−10	Several grammatical mistakes. Little effort is shown to be concise and provide a logical flow between sentences and sections.
Scientific Merit (35%)	25−35	An original hypothesis is stated and tested. Critical thinking and experimental planning are obvious. The author's scientific claims and details are supported with sound reasoning.
	11−24	An original hypothesis is stated and tested. Critical thinking and experimental planning are lacking. There are minimal scientific claims, some of which lack proper support.
	1−10	Little effort is made to provide a testable hypothesis. Little thought and experimental planning are obvious. Very few, if any, scientific claims are made and supported.

> sauce with crushed seeds. This could be because the seeds have some sort of compound inside that affect the pH. The other sauces showed a very similar pH that leads to the idea that there is some compound inside the seeds which is released upon crushing that has an effect on pH. Other than this possibility, there seems to be no relationship between pH and spiciness and it can be assumed that the binding of the capsaicin to the receptor in the mouth is the sole cause of the burning sensation in the mouth.

One option that is encouraged from each student is in-class testing to gather statistics. Of course, this provides snacks for class as well! Student authors are asked to note all the ingredients in their dish to avoid potential allergic reactions from their peers, and students are not required to participate. One example is buffalo chicken dip made with various quantities of the same hot sauce. The student's hypothesis was that more hot sauce did not necessarily make the dish hotter in taste. She did not reveal the difference in the three dishes and asked that each student fill out a questionnaire on taste. Although some students did not enjoy having their mouth set on fire before noon, she was able to gather enough data and prove her original hypothesis incorrect. Another in-class test provided students with hot chocolate produced with varying milk types, such as whole, 2%, skim, and soy. Ironically, another student provided the class with various brownie selections the same day. The latter student varied name brands and generic brands of the same brownie flavor in her data set. The entire class was surprised when one generic brand won the best taste! Another student author hypothesized that he could achieve the same Scoville unit of hotness in his chili by varying the quantity and type of hot peppers used during cooking. He was able to prove that several jalapeno peppers would provide the same heat taste as a single habanero chili pepper. The student asked five taste testers to rate hotness levels of prepared samples on a scale of 1 to 5. After collecting three separate ratings on the same samples, he correlated the results with taste tests of items having known Scoville ratings, such as commercially available hot sauces using the same individuals.

■ EVALUATION

The term-paper assignment accounts for ~25% of the total course grade; it is due on the last week of class and is separate from the final exam. The term paper is worth 100 points, and the grading rubric used is shown in Table 3.

■ DISCUSSION

The outcomes from this term-paper assignment are fairly consistent among students. As expected, they learn how to develop an experiment on their own to test a hypothesis that they personally conceived. This instills confidence in their abilities as independent scientists and will certainly carry on into their futures. Furthermore, this is applicable across all disciplines of science, not just chemistry. Learning which data to include in the written report helps students stay focused on their hypotheses and allows them to realize which extraneous information to eliminate from their data sets. The process of writing requires students to think about the science they are conducting and requires them to provide support to the claims they make on paper. Above all, this assignment allows undergraduate students to participate in the entire publishing process within a short time period. Finally, students are allowed to view food preparation in a new way and may realize real-world applications of the scientific principles they have learned in foundational science courses, while occasionally gaining insight into nutritional information to live a healthier lifestyle.

Students are challenged by the assignment in various ways. Most have the initial problem of developing a testable hypothesis. Often they attempt to create an impossible task or make things more difficult than necessary. The instructor guides students to a reasonable hypothesis by helping the students realize the experimental variables that are involved with their initial interest. Once variables are identified, some students are challenged by how to vary them. For example, a particular student was interested in working with rice pudding; she had cooked it many times but did not know what to vary. After realizing that the *quantities* and *types* of rice, milk, and flavoring additives act as *chemicals* would in a laboratory reaction, she was well on her way. In fact, she was able to prove that unwashed rice provided a thicker product because of the additional starch; here, the variable and result went beyond her initial hypothesis, which was to prove that short grain rice provided a more consistent product.

Beyond the developed hypotheses and data collection is the realization of which information to include in the final manuscript. The assignment requires each student to include at least two figures, one scheme, and one table to test their learned skills in the course. It is important to assess their knowledge of how to effectively use each type of component when presenting their data. Students are encouraged to devise each component early in their project, as this helps them decide which details are the most important. This plan also mirrors how some scientific authors write manuscripts, by choosing pertinent figures and writing *around* them.

Finally, challenges are encountered with the manuscript requirements. Several students pose the infamous question, "How long does my term paper need to be?" Because the communication-style template from the ACS requires a maximum of four pages, the answer is simple. However, some students then concern themselves with length requirements for individual sections. They are given the advice that all sections should be as long as they need to be to provide scientific details and maintain conciseness. Some students are challenged when working with the document template. The most common problem involves learning how to apply the preformatted word styles that are included in the template. A portion of one lecture session is dedicated to this process near the end of the term to alleviate such concerns.

In addition to all of the positive aspects regarding the assignment, there are hurdles to overcome as well. Some students possess an adamant dislike for cooking. In this case, they are tasked with proposing an alternative assignment that will allow them to safely carry out experiments without the need for a scientific laboratory. This is permissible, because these students are capable of gaining the same scientific experience. One example is a study on the effect of using differing bleach products on human hair. The student tested several commercially available hair-coloring products that lighten hair on herself and her friends as a function of time and exposure to the sun. She was able to include microscopic pictures of her results and correlated ethnicity with the effects of the products.

STUDENT EVALUATION

Personal comments from students that completed the assignment reveal that they discover more than just the initial outcomes intended from the instructor. Students understand the importance of beginning the project early in the term, and they seem to appreciate using their experience from the incremental writing assignments given earlier in the course. Students say that "the process and purpose of writing a term paper actually meant something with my own data" and they like "being able to research a topic that was interesting to me" and learning "which type of data to collect" to prove their points. They also realize that some experiments do not work as planned, which prompts them to realize that either the experiment design was flawed or they have discovered something that they did not intend at the onset. One of the most important comments from a student was "This assignment made me think for myself as a scientist for the first time."

To formalize comments, all students during the most recent course offering were asked the question "What did you gain from the term paper assignment?" on their final exam. As was the intent of a comprehensive term paper, several comments noted how all of the concepts learned in the course were "all combined in the term paper assignment" and "it was the most unique term paper I've ever written." Students realized that "it showed me how scientific writing differs from everyday writing that can be seen in newspapers and magazines" and that "scientific writing is much more detail oriented than writing in [English] and history class." Within the context of this article and the pedagogical purpose of the assignment, several students commented on what the assignment did for them as scientists. Students wrote, "The assignment gave me a chance to experience the skills and process of completing something on my own and format things in a proper scientific journal." Another wrote, "It gave me a sense of pride in finished work. There is a copy on my fridge because it looks so professionally formatted." Related to experimental planning and design, "It made me THINK about what I was doing and going to do for the first time like a real chemist. I gained foresight to know what data to collect before doing experiments so I don't take too much useless data, or even worse too little data." A few students commented similarly when they stated, "I learned that not every experiment works and I had to go back and think about things and figure out why it went wrong" and "The hardest thing was figuring out the best way to show my results." In regards to the peer-review process and use of the template, students wrote, "I realized to appreciate how hard it is to come up with an idea and prove it. I also appreciate real scientific articles more now" and "I have a better understanding of the entire publishing process now."

CONCLUSION

It is possible to provide undergraduate students with the full experience of the scientific method and the process of publishing results in a peer-reviewed journal within a lecture course without a laboratory. Students use their kitchens as safe laboratories, where they develop a testable hypothesis and gather data through the preparation of a food dish. They present their results in a properly formatted manuscript and gain pertinent experience using a document template currently used by the ACS. The overall results show that students gain confidence in their scientific abilities and gain experiences that may follow them to the next level in their education.

AUTHOR INFORMATION

Corresponding Author

*E-mail: cjones@mercyhurst.edu.

ACKNOWLEDGMENT

C.D.J. would like to thank student Eve Klajbor for the creation and use of her data for Figure 1. C.D.J. would also like to thank students Eve Klajbor, Justin Kohnen, and Andrew Rusnak for the use of written excerpts from their term papers.

REFERENCES

(1) Kovac, J.; Sherwood, D. W. *J. Chem. Educ.* **1999**, *76*, 1399–1403.
(2) Parrill, A. L. *J. Chem. Educ.* **2000**, *77*, 1303–1305.
(3) Paulson, D. R. *J. Chem. Educ.* **2001**, *78*, 1047–1049.
(4) Oliver-Hoyo, M. T. *J. Chem. Educ.* **2003**, *80*, 899–903.
(5) Whitesides, G. M. *Adv. Mater.* **2004**, *16*, 1375–1377.
(6) Shires, N. P. *J. Chem. Educ.* **1991**, *68*, 494–495.
(7) Cacciatore, K. L.; Sevian, H. *J. Chem. Educ.* **2006**, *83*, 1039–1041.
(8) Renaud, J.; Squier, C.; Larsen, S. C. *J. Chem. Educ.* **2006**, *83*, 1029–1031.
(9) Tilstra, L. *J. Chem. Educ.* **2001**, *78*, 762–764.
(10) Gragson, D. E.; Hagen, J. P. *J. Chem. Educ.* **2010**, *87*, 62–65.
(11) Berry, D. E.; Fawkes, K. L. *J. Chem. Educ.* **2010**, *87*, 57–61.
(12) Tah, C. *J. Chem. Educ.* **2007**, *84*, 639–642.
(13) Shibley, I. A., Jr.; Milakofsky, L. M.; Nicotera, C. L. *J. Chem. Educ.* **2001**, *78*, 50–52.
(14) Lillig, J. W. *J. Chem. Educ.* **2008**, *85*, 1392–1394.
(15) Rudd, J. A., II; Greenbowe, T. J.; Hand, B. M. *J. Chem. Educ.* **2007**, *84*, 2007–2011.
(16) *The ACS Style Guide: Effective Communication of Scientific Information*, 3rd ed; Coghill, A. M., Garson, L. R., Eds.; American Chemical Society and Oxford University Press: Washington, DC, 2006.
(17) Robinson, M. S., Stoller, F. L., Costanza-Robinson, M. S., Jones, J. K. *Write Like a Chemist: A Guide and Resource*; Oxford University Press: New York, NY, 2006.
(18) SciFinder for Academics. https://scifinder.cas.org (accessed May 2011).
(19) PubMed Home. http://www.ncbi.nlm.nih.gov/pubmed (accessed May 2011).
(20) ScienceDirect Home. http://www.sciencedirect.com (accessed May 2011).
(21) Advanced Materials, For Referees. http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1521-4095/homepage/2089_forreferees_2008.pdf (accessed May 2011).