JOURNAL OF CHEMICAL EDUCATION

Commentary

pubs.acs.org/jchemeduc

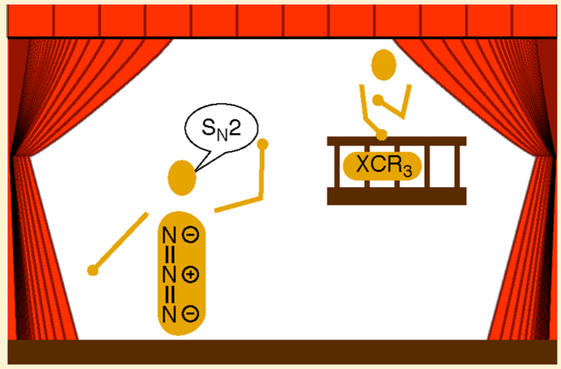
Similarities between Scientific and Dramatic Prose

Reuben Hudson*

Department of Chemistry, McGill University, Montreal, Québec H3A 2K6, Canada

Department of Chemistry, Colby College, Waterville, Maine 04901, United States

ABSTRACT: Most approaches for teaching the art of scientific writing focus overwhelmingly on the technical and less on the art itself. To tickle the imagination and creativity of educators hoping to provide a more balanced curriculum, the following discussion illustrates that the elements of dramatic structure are no more relevant to playwrights than they are to the authors of scientific manuscripts. One can appreciate this connection between scientific and dramatic prose by analyzing a manuscript as one would a play, and vice versa. By stressing these intrinsic similarities, chemical educators have a chance to foster young scientists who are as creative in their prose as they are in their research.



KEYWORDS: *First-Year Undergraduate/General, Second-Year Undergraduate, Interdisciplinary/Multidisciplinary, Analogies/Transfer, Communication/Writing*

■ INTRODUCTION

Chemical educators have long sought to improve students' technical writing skills in class,[1−6] lab,[7−11] culminating experiences,[12,13] or even across the curriculum.[8,14,15] Few attempts, however, delve beyond the purely technical aspects to treat scientific writing as an art form.[16,17] The following commentary, therefore, hopes to tickle the imagination and creative side of chemical educators to promote the *art* of scientific writing.

If a drama is the playwright's canvas, then the manuscript is the scientist's and these works are woven from the same thread. Freytag's elements of dramatic structure[18]—exposition, rising action, climax, falling action, and denouement—intimately mirror their scientific counterparts—introduction, materials and methods, results, discussion, and conclusions (Figure 1). By drawing on this connection, we may yet have a chance to foster a generation of scientists who cherish technical writing as an art form.

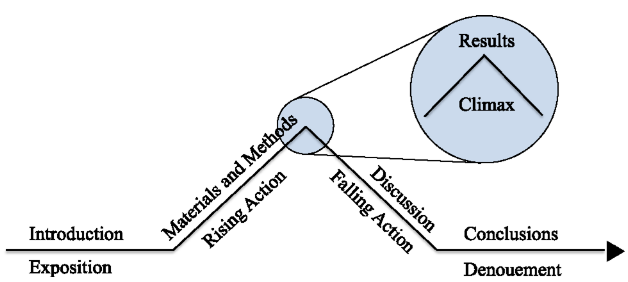


Figure 1. Components of a scientific manuscript presented over Freytag's pyramid of dramatic structure.[18]

Student-generated reports can easily betray to the reader their authors' misconception that the scientific manuscript is dry, formulaic, and inelegant. If scientific authors believe it, their reports will reflect dry, formulaic writing. As scientists, we are constrained to write within certain well-defined boundaries, but so too are playwrights constrained to the format of acts and scenes—and who would accuse them of dry, formulaic, or inelegant prose? We have a duty as educators to demonstrate the potential mobility within these boundaries for artistically disseminating our research to the greater scientific community.

■ COMPARING ARCS OF SCIENTIFIC AND DRAMATIC WRITING

Two general approaches can elucidate the connection between scientific and dramatic prose. We can either digest a particularly well-written scientific manuscript[19] as we would a play—identifying the exposition, rising action, climax, falling action, and denouement—or ask students to critique and rewrite a manuscript that does not offer these elements in a clear manner. Alternatively, we can analyze a drama[20] as we would a scientific manuscript—identifying the introduction, materials and methods, results, discussion, and conclusions. These two opposed comparisons, likely providing the most impact when preformed in tandem, only begin to demonstrate the intrinsic similarities (Table 1).

■ COMPARING PLOT ELEMENTS OF DRAMATIC AND SCIENTIFIC WRITING

In addition, a more meaningful comparison would be to critique the merits of various plot elements, be they dramatic or

Published: February 11, 2015

Table 1. Comparing the Components of Scientific and Dramatic Writing

Written Component	*Romeo and Juliet*[20]	S_N2 at a 3° Carbon[19]
Prologue/Abstract (one or two sentences about each section of the following works)	"Two households, both alike in dignity, In fair Verona, where we lay our scene, From ancient grudge break to new mutiny, Where civil blood makes civil hands unclean. From forth the fatal loins of these two foes A pair of star-cross'd lovers take their life..."	A 3-fold tertiary oxonium salt was synthesized. It was unsuccessfully subject to solvolysis conditions though proved reactive toward the azide anion. The S_N1 pathway was excluded, suggesting a bimolecular pathway previously thought impossible.
Act I/Exposition/Introduction	Two powerful families in Verona, Italy (Montagues and Capulets) perpetually fight. Romeo, unlike the rest of the Montague family, is a lover and he soon falls in love with Juliet, a Capulet.	S_N2 reactions do not occur at 3° carbon centers. S_N1 reactions are easy with 3° oxonium salts. The authors introduce a molecule to challenge these assumptions.
Act II/Rising Action/Materials and Methods	With a series of secret messages between Romeo, Friar Laurence, Nurse, and Juliet, the two lovers arrange to be married by Friar Laurence.	The oxonium salt was subjected to (1) refluxing ethanol, (2) reaction with nucleophiles in both protic and aprotic solvents, and (3) different nucleophile concentrations, all followed by NMR.
Act III/Climax/Results	Despite Romeo's protests, Tybalt kills his cousin, Mercutio—for which Romeo then kills Tybalt. As punishment, Romeo is exiled. Juliet's father tells her she is to marry Paris. She sneaks to Friar Laurence instead.	Solvolysis failed. Reaction with azide was faster in aprotic solvents. NMR studies suggested second-order reaction kinetics.
Act IV/Falling Action/Discussion	To help her stay true to her husband by avoiding marrying Paris, Friar Laurence gives Juliet a potion to appear dead for 2 days.	The experimental evidence suggests that no discrete carbocation intermediate exists and an S_N2 mechanism prevails.
Act V/Denouement/Conclusion	Romeo finds Juliet "dead", and kills himself. Juliet then wakes up and finds Romeo truly dead, so she kills herself. Friar Laurence then tells the truth and the families end their feud.	S_N2 reactions are possible at some 3° carbon centers despite the excessive steric bulk. This is the first example of exclusive S_N2 at a 3° carbon center.

scientific, and have the students indicate their use in the other art form, scientific or dramatic. Consider the rule of Chekhov's gun. Russian playwright Anton Chekhov famously put forward that, "If in the first act you have hung a pistol on the wall, then in the following one it should be fired. Otherwise, don't put it there."[21] In the context of a play, this could be interpreted in two ways. First, do not include extraneous details that may distract the reader. Second, the author should foreshadow major events.

These two interpretations go hand in hand with two rules of thumb for scientific writing. First, do not include irrelevant background information, because it will only draw the reader along the tangential thought process of the meandering author. Second, the scientific author should foreshadow the conclusions, so that by the time the conclusions are formally presented, the reader has already formulated them "independently", and may then think, "These authors are smart, they think just like me."

■ LESSONS FROM MISSTEPS IN DRAMATIC AND SCIENTIFIC WRITING

Contrasting manuscripts that observe literary rules, like Chekhov's gun, with those that break literary faux pas, like *deus ex machina*, can further expound the similarities between the scientific and the technical—not only providing valuable *do*s but also providing equally valuable *don't*s. Greek tragedian Euripides has been roundly criticized[22] for his use of the *deus ex machina* (the unexpected resolution of a problem by the introduction of an inextricable character, event, etc.). The scientific equivalent of a *deus ex machina* would be drawing a conclusion with little basis in the results obtained, which is a pitfall of poor science. The scientific literature is riddled with examples of the use and reliance on *deus ex machina;* comparing any one of these examples to the work of Euripides can instill an understanding of the plot elements to avoid in scientific writing.

■ CONCLUSION

As chemical educators, we have an opportunity—or rather, a duty—to engender students' artistic dispositions in scientific prose, after all, the world's great scientists have often been the world's great artists and philosophers (Aristotle, Plato, Da Vinci). By comparing the technical to the dramatic, we can work toward maintaining this tradition of art and science influencing each other.

■ AUTHOR INFORMATION

Corresponding Author

*E-mail: reuben.hudson@mail.mcgill.ca.

Notes

The authors declare no competing financial interest.

■ ACKNOWLEDGMENTS

I would like to thank Professors Audrey Moores, C. J. Li, David Harpp, Youla Tsantrizos, and Ariel Fenster for their guidance, as well as NSERC, FQRNT, and the Center for Green Chemistry and Catalysis for financial support.

■ REFERENCES

(1) Robinson, M. S.; Stoller, F. L.; Horn, B.; Grabe, W. Teaching and Applying Chemistry-Specific Writing Skills Using a Simple, Adaptable Exercise. *J. Chem. Educ.* **2009**, *86* (1), 45−49.

(2) Paulson, D. R. Writing for Chemists: Satisfying the CSU Upper-Division Writing Requirement. *J. Chem. Educ.* **2001**, *78* (8), 1047–1049.
(3) Rossi, F. M. Writing in an Advanced Undergraduate Chemistry Course: An Assignment Exploring the Development of Scientific Ideas. *J. Chem. Educ.* **1997**, *74* (4), 395–396.
(4) Whelan, R. J.; Zare, R. N. Teaching Effective Communication in a Writing-Intensive Analytical Chemistry Course. *J. Chem. Educ.* **2003**, *80* (8), 904–906.
(5) Van Ryswyk, H. Writing-Intensive Multimedia Projects in the Instrumental Methods Course. *J. Chem. Educ.* **2005**, *82* (1), 70–72.
(6) Robinson, M. S.; Stoller, F. L.; Jones, J. K. Using the ACS Journals Search To Validate Assumptions about Writing in Chemistry and Improve Chemistry Writing Instruction. *J. Chem. Educ.* **2008**, *85* (5), 650–654.
(7) Olmsted, J. Teaching Varied Technical Writing Styles in the Upper-Division Laboratory. *J. Chem. Educ.* **1984**, *61* (9), 798–800.
(8) Rosenthal, L. C. Writing across the Curriculum: Chemistry Lab Reports. *J. Chem. Educ.* **1987**, *64* (12), 996–998.
(9) Squier, C.; Renaud, J.; Larsen, S. C. Integration of a Communicating Science Module into an Advanced Chemistry Laboratory Course. *J. Chem. Educ.* **2006**, *83* (7), 1029–1031.
(10) Burke, K. A.; Greenbowe, T. J.; Hand, B. M. Implementing the Science Writing Heuristic in the Chemistry Laboratory. *J. Chem. Educ.* **2006**, *83* (7), 1032–1038.
(11) Gragson, D. E.; Hagen, J. P. Developing Technical Writing Skills in the Physical Chemistry Laboratory: A Progressive Approach Employing Peer Review. *J. Chem. Educ.* **2010**, *87* (1), 62–65.
(12) Schepmann, H. G.; Hughes, L. A. Chemical Research Writing: A Preparatory Course for Student Capstone Research. *J. Chem. Educ.* **2006**, *83* (7), 1024–1028.
(13) Bressette, A. R.; Breton, G. W. Using Writing To Enhance the Undergraduate Research Experience. *J. Chem. Educ.* **2001**, *78* (12), 1626–1627.
(14) Kovac, J.; Sherwood, D. W. *Writing across the Chemistry Curriculum: An Instructor's Handbook*; Prentice Hall: New York, 2001.
(15) Gordon, N. R.; Newton, T. A.; Rhodes, G.; Ricci, J. S.; Stebbins, R. G.; Tracy, H. J. Writing and Computing across the USM Chemistry Curriculum. *J. Chem. Educ.* **2001**, *78* (1), 53–55.
(16) Ebel, H. F.; Bliefert, C.; Russey, W. E. *The Art of Scientific Writing: From Student Reports to Professional Publications in Chemistry and Related Fields*; Wiley-VCH: New York, 2004.
(17) Beall, H. *A Short Guide to Writing about Chemistry*, 2nd ed.; Longman: New York, 2000.
(18) Freytag, G. *Die Technik des Dramas*; Verlag von S. Hirzel: Leipzig, 1863. https://books.google.com/books?id=zKwCAAAAYAAJ&dq=Die+Technik+des+Dramas&source=gbs_navlinks_s (accessed Feb 2015).
(19) Qiu, Y.; Liu, Y.; Yang, K.; Hong, W.; Li, Z.; Wang, Z.; Yao, Z.; Jiang, S. New Ligands That Promote Cross-Coupling Reactions between Aryl Halides and Unactivated Arenes. *Org. Lett.* **2011**, *13* (14), 3556–3559.
(20) Shakespeare, W. *Romeo and Juliet*, first quarto; John Danter: London, 1597. http://www.folgerdigitaltexts.org/?Chapter=5&play=Rom&loc=p7 (accessed Feb 2015).
(21) Callow, P. *Chekhov, The Hidden Ground: A Biography*; Ivan R. Dee: New York, 1998.
(22) Nietzsche, F. *The Birth of Tragedy from the Spirit of Music (Die Geburt der Tragödie aus dem Geiste der Musik)*; Verlag von E. W. Fritzsch: Leipzig, 1872.

DOI: 10.1021/ed500091a
J. Chem. Educ. 2015, 92, 781–783