

Chemistry, Poetry, and Artistic Illustration: An Interdisciplinary Approach to Teaching and Promoting Chemistry

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The first-year general chemistry classes are often viewed by students as stressful and demanding. Students are typically required to take notes in class, do homework to help master the class content, and take weekly quizzes, tests, and finals to measure their class understanding. The correct solutions to problems are usually standard and lack variation. Although this conventional way of learning is essential for students to gain important chemical skills, we believe that some personal and creative experiences may not only help the students enjoy chemistry but also add to their ability to learn the material.

In the past eight years, we have incorporated annual chemistry poster sessions with set themes into the general chemistry class curricula as a means of broadening students' chemistry knowledge, encouraging their creativity through artistic illustrations, improving their skills for researching and communicating information, and promoting an awareness and appreciation of chemistry on campus and in the community. For instance, the theme "Presidential Award Winning Green Chemistry Technologies" was used two years ago and the winning posters were also displayed at the city's Earth Day Festival. Several recent articles in this *Journal* also supported the view that poster sessions can be effective in teaching chemistry at the college level (1–5).

In addition to using posters to illustrate ideas, various art forms including story, drama, chemistry demonstrations, and art work have been reported as methods to enhance teaching and promote chemistry learning in particular (6–13). Root-Bernstein says sensual, aesthetic, and even artistic considerations are an important motivation for general interest in chemistry (14) as well as for scientific discoveries. Root-Bernstein said that he was attracted to chemistry because of the colorful and "magical" reactions Hubert N. Aleya used in the entire introductory chemistry course he took. Simplicity, symmetry, beauty, elegance, and emotional enjoyment are often the sources that inspire and enthrall us to engage, learn, overcome, and discover. Francis Crick (Nobel Prize in Medicine–Physiology, 1962) says that two aesthetic criteria, symmetry and simplicity, played key roles in the discovery of the DNA double helix (15). A former student of Roald Hoffmann (Nobel Prize in Chemistry, 1981) stated that she decided to become a chemist after learning about the Woodward–Hoffmann rules, which she considered to be the most beautiful insight in all of science (14). Promoting the beautiful face of chemistry and expressing it aesthetically can provide a means to enhance students' interest in chemistry and attract them to be further engaged in our subject. In an edi-

torial found in this *Journal*, Moore (16) also emphasized the importance of connecting the emotions of art forms and the objectivities of science in teaching science and chemistry.

Poetry is one of the art forms containing short pieces of creative and imaginative writing, of a personal nature and laid out in lines (17). It, however, has not been fully explored as a common way of teaching college chemistry. There is much research to support the view that writing promotes learning in addition to its role of informing. Young says language is a tool for learning (18). Walvoord writes verbalization at the more conscious levels, including writing, probably helps the writer to understand the thoughts that otherwise would remain inaccessible (19). This aspect of writing may have its best application in chemistry, where connecting the abstract ideas to concrete experiences enhances understanding. As Cooke states "when we ask our students to write, we are encouraging them to engage actively with the subject matter in our disciplines: to see patterns, connect ideas, make meaning—in other words, to learn" (20), similar to the way we guide them through in solving a chemistry problem via exploration or experimentation. In this sense, language provides us with a unique way of knowing and becomes a tool for discovering, for shaping meaning, and for reaching understanding (21). Our experiences also tell us that if students reconstruct the information received in their own words, they often comprehend and retain it better. Poetry allows human language to be used for its aesthetic qualities in addition to, or instead of, its notional and semantic content. The images and metaphors used in a poem can intensify the meaning of abstract concepts. Walders says "the condensed, tight language of a poem can turn on the light and deepen meaning as nothing else" (22). Poetry, therefore, provides students a powerful means of expressing themselves, an opportunity to combine information with their personal reactions, and a special method for exploring, reflecting, and understanding chemistry. Artistic illustration of ideas makes thinking visible through color, texture, and shapes and extends the meaning of the words. It provokes emotion, brings about creativity, promotes inquiry, and enhances learning much as poetry does. Artistic illustration of their own poetry not only adds visual appeal to the presentation, but also allows students to convey their thoughts and achieve the full meaning in a way that comes only when the two are interwoven. Combining chemistry, poetry, and artistic poster illustrations also allows the instructors to measure students' learning in an unconventional way, provides additional practices to help students become better communicators, and makes chemistry accessible

to the general public, although the initial goal is to help students learn chemistry in a creative and aesthetic way while enjoying chemistry. Additionally, presenting chemistry aesthetically using words and arts may also help enhance students' and viewers' appreciation towards chemistry.

This year, with these reasons in mind, we decided to use poetry and artistic poster illustration to help students learn, appreciate, and enjoy chemistry. In this article, we describe our successful implementation of this project through an interdisciplinary collaboration among the faculty from the Chemistry, Humanities, and English Departments at this university.

Learning To Write Good Poetry

In the spring, one of the authors, Herbert Kitson of the English Department, visited the general chemistry classes and spent about 25 minutes introducing students to what makes poems good. He suggested some limericks and explained how to write them. He also used different poems to show how poetry is more than a mere statement, to explain figures of speech, such as the simile, to demonstrate the importance of the concrete in verse as well as how poetry can be composed without a persona, or author's voice. After reading and analyzing some selected poems with students, Kitson reviewed the following essential elements for writing good poetry:

- Try to "flesh out" abstract ideas by making them as concrete and reality-oriented as possible.
- Try to get your readers to experience what you are writing about. Try to make them see, hear, feel, smell, touch, and taste your subject matter.
- Pound, a famous poet, said, "Make it new." This is good advice for poets. Try to have fresh ideas and express yourself in fresh, new ways. Avoid the trite, the hackneyed, and the overused. Avoid such expressions as "fresh as a daisy" or "clever as a fox" or "happy as a clam".
- Try to use figures of speech certainly, but try to make these figures original and new. Humor is always appreciated, and good poetry has an element of mirth and humor attached.
- Also try to be modern. Avoid archaic and "poetic" language and avoid writing in rhyme or meter. Of course, one can use rhyme and meter if one is deliberately writing in a form, such as the limerick, the sonnet, etc. However, one should not use rhyme or meter gratuitously. A funny rhyme is a blessing; a forced rhyme is a curse.
- Letting the reader figure out what the poem means is half the fun. In short, be natural. Write what you believe. Make your poem interesting. Use fresh language and respect your reader.

Learning To Artistically Illustrate Ideas on Posters

Every year, one of the authors, Cynthia Andes of the Humanities and English Department, gives a 25 minute seminar to students taking general chemistry classes on "Hints for a Successful Chemistry Poster" during a chemistry class. Using a CD ROM containing posters from previous years,

Andes shows the students the most successful and the least successful posters with regard to the themes and visuals. Although research posters and the museum posters (ones that display the information only) share many common features, and Huddle (4) has given detailed guidelines on how to prepare the former ones, comprehensive tips on how to enhance the visual appeal of the museum-type posters presented during this seminar are listed here:

- Include a large, bold, and visually interesting title.
- Do not fill the poster with too much text!
 - Use large fonts so people can read from a distance of three feet.
 - Always mount the text on a piece of colored construction paper. Layer the text on top of multiple borders.
- Use a fluorescent highlighter or create textural edges to make the message stand out.
 - Avoid hand lettering for sentences. Use "bubble letters" or text outlined with color if you must use hand lettering.
 - Use computer fonts or bold textural materials. Use foil candy wrappers as fillers, Styrofoam pieces for backing or cheap "Foamies" as 3D letters, shapes, or backing.
- Use a variety of interesting materials that reflect the poster's theme.
- Include questions for subtitles (you might hide answers under flaps so the viewer has to lift or open).
 - Include color photos with short but clear captions and indicate progression with arrows, etc. Consider overlapping these photos or combining them with black and white graphs or small photo collages.
 - Use 3D objects either found or purchased, interesting shapes for the poster or materials extending from the poster.
- Remember that a poster is a visual message. It should make the passersby want to stop and investigate the content. It should also allow the viewers to grasp the message quickly and easily within a matter of minutes.

Project Assignment

After the poetry and poster seminars, students were encouraged to use their imagination and creativity to brainstorm and write their own chemistry poems on the concepts and principles covered in their chemistry classes and illustrate their original work on posters artistically (they were also encouraged to write chemistry humor). Each poster was required to include a brief and clear introduction of the concept(s) involved. Students were given two months to finish the project. The project was counted as two lab grades or 3% toward a student's course grade. On the project due day, all the posters were displayed in a public area and each student made a verbal presentation in front of his or her peers. The bright colors, eye-pleasing geometrics, and glittering textures of the posters decorated the hallway and attracted various viewers on campus (Figures 1 and 2).



Figure 1. Poetry posters from general chemistry classes. The poster, "Chemistry Rocks!", is shown in the lower right corner.

Five faculty members from different disciplines helped judge this year's posters based on the following criteria:

- Clarity and effectiveness of the chemistry concept introduction.
- Creativity, originality, and craft of the chemistry concept illustration and reflection through poems or humorous writing.
- Overall impact of the display for eye-catching appeal and visual attractiveness.
- Appropriateness of the graphics for the content.

Four exemplary, six runner-up, and eight honorable mention projects were selected. All winners received prizes as well as certificates of achievement. The poems of the winning posters were published in the campus biweekly newsletter (23). The winners of the project consisted of A-, B-, and C-level students. Examples of their work are given in Figure 3.

Reflections from Students

Forty students were asked to write any comments on their experiences with this project along with comments on other chemistry-enriching activities they participated during the semester. Most of them reacted positively to this particular experience as shown in the comments in Table 1.

The students indicated that the project made chemistry fun, added variety to the class, and allowed them to be creative and unique. They stated that the project also helped

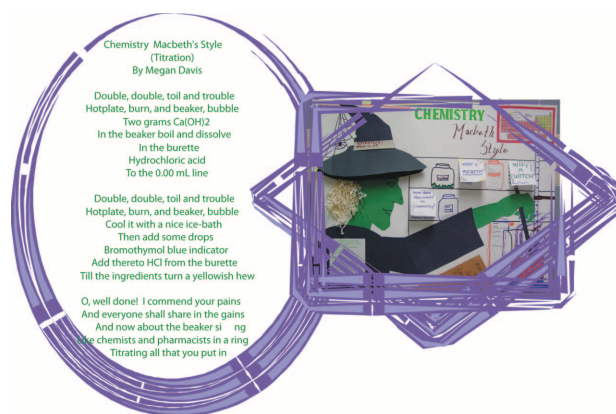


Figure 2. Sample chemistry poetry poster from a general chemistry student.

Table 1. Summary of Student Comments on the Project

Comment	Number of Comments
Made chemistry more enjoyable	29
Helped review concepts/made chemistry more understandable	19
Helped demonstrate chemistry knowledge	9
Allowed them to be creative and unique, added variety to the class	14

NOTE: Four students did not give specific feedback and three students gave negative comments.

them review chemistry, motivated them to search for additional chemistry information on the topic, and increased their chemistry understanding. One student stated, "I was a little worried about this project at the beginning, but when I got started it was actually fun. By reviewing the material, researching for additional information from the Internet, and thinking about it more deeply, I understand the chemistry I talked about much better after the project." Another student said, "I liked this project a lot! It allowed us to show our creative ability as well as demonstrate some things we learned this year in chemistry in our own ways." The students stated that the project was a fun way to demonstrate their chemistry knowledge and enjoyed reading their chemistry poems or humorous writing in groups. They were also proud of their colorful exhibit of chemistry and glad that their poetry and posters may help promote an awareness of chemistry on campus. One student said, "They (the posters) were fantastic presentation. The poems and art made me feel that chemistry is beautiful." Another student stated, "It was cool trying to help 'outsiders' understand a little more about chemistry. Glad we could help..." Four students did not specifically give feedback on this project but made general favorable comments on all the enriching activities they participated in. Three students, however, indicated that they did not like the project because either they did not like to write or they thought that they were not good at art. For these students, additional examples of good poems and artistic illustration may help motivate them to be involved in a more assertive way.

Buffer

Chemistry is a way of life, our real life
 Life is either good or bad
 And chemistry is either acidic or basic
 When life is too good, it's boring
 And when it's too bad, it's awful
 The best way of life is being in the middle
 And resisting being too good or too bad
 The safest chemistry is being neutral
 Not too acidic, nor too basic
 So the best chemistry that sustains life
 Resists too much acid or too much base
 What I talk about is buffer
 It exists in our blood stream
 Buffer
 The essential of life

Phase Changes of Water

Is
 It a
 Mystery?
 You know,
 It's everywhere
 You can see it, or
 Touch it, You're made
 Of it, and you even drink
 It. It's good, and you like
 It. But when it's bad, you
 Hate it. You think it's beautiful
 When it doesn't hurt you, and
 You're scared of it when it's
 Ugly. You know so much
 About it, but you don't
 Isn't it a mystery?

My Opposite Attract

Chemistry is all around us
 Everything is composed of atoms
 Including yourself
 But atoms don't bleed like you and I
 You're like a proton
 Having a positive charge
 It can conjure up and make me a blush
 You know opposites attract
 So I wish I was an electron
 So we could then attract
 Maybe even a neutron?
 Then we could convert for a while
 That could bring a smile
 Someday we will meet together in a
 Central atom
 There together we will neutralize
 So until that day
 Good-bye

Nuclear Fusion

Hydrogen, the first among many
 Two H become one He
 Fused together by inconceivable forces
 An exothermic reaction
 Energy escapes as heat and light
 Photons hurl across the vast divide
 To light the world

Surface Tension (Chemistry humor)

What did the stressed out molecule do in the liquid?
 It went to the middle to relieve some of the surface tension.

Chemistry-Macbeth's Style

Double, double, toil and trouble
 Hotplate, burn, and beaker, bubble
 Two grams $\text{Ca}(\text{OH})_2$
 In the beaker boil and dissolve
 In the burette
 Hydrochloric acid
 To the 0.00 mL line
 Double, double, toil and trouble
 Hotplate, burn, and beaker, bubble
 Cool it with a nice ice-bath
 Then add some drops
 Bromothymol blue indicator
 Add thereto HCl from the burette
 Till the ingredients turn a yellowish hew
 O, well done! I commend your pains
 And everyone shall share in the gains
 And now about the beaker sing
 Like chemists and pharmacies in a ring
 Titration all that you put in

Chemistry-Bonding Is All the Same to Me

Bonding, bonding, what's the difference?
 You bond, you don't, or you separate
 With all your subject up on the fence
 Confusing I sometimes believe
 With what I read and what I see
 Covalent and ionic bonds
 Sigma and Pi too
 Often the same to me, I tell you
 With single, double, and triple on my mind
 Sharing electrons, coming to mind
 With all the speculations
 Octet rule, ionic, covalent
 I didn't know where to start, what to do
 Then again it's what holds us all together
 If it weren't for bonds of these kind
 What would we be?
 Confusing yet, but needed too
 To learn difference for all these bonds
 Here come you

Figure 3. Examples of poems created by the students. *Buffer*, *Nuclear Fusion*, and *Surface Tension* were written by A-level students; *Phase Changes of Water* was written by a A/B-level student; *My Opposite Attract* and *Chemistry-Macbeth's Style* were written by B/C-level students; and *Chemistry-Bonding Is All the Same to Me* was written by a student who showed little understanding of chemistry on the exams.

Reflections from Campus Viewers

The comments from the general viewers were also encouraging. A nonchemistry faculty member said that he viewed all the posters during his breaks. He praised students' displays saying that they were colorful and inviting and allowed him to get to know chemistry that he would otherwise not come across. Students who were not in the general chemistry classes stated that the posters gave them something to view while waiting for their classes and they had fun reading the chemistry poems and humor. One campus staff member liked the posters so much that she brought many of them home to "decorate" her 10-year-old son's room as a way to stimulate her son's interest in science. The campus newsletter editor commented, "The posters made a visual statement about different chemistry aspects and projects and with the poetry you can form pictures in your mind about 'bonding' and 'my opposite attract'." The project made chemistry accessible to campus members and helped the general viewers get to know and appreciate chemistry in a fun and colorful way.

Reflections from Instructors

The students' poetry posters touched upon a wide range of chemical topics and demonstrated good chemistry understanding. The displays showed that most of the students listened to the directives because many posters were witty, clever, and eye-catching. They showed fresh use of language and avoided the didactic. The chemical themes of the posters were also exemplified in the shapes and visuals used by students, which encouraged the viewers to become more involved with the subject itself. The posters went a long way in assimilating difficult chemical concepts to such an extent that they can simplify the understanding of them for the layman. For instance, the author of "Surface Tension" clearly illustrated the characteristics of surface molecules: surface molecules, experiencing an unbalanced net downward force, possess more energy compared to the interior molecules, thus are less stable and tend to move into the bulk and not stay on the surface. The author's concise presentation not only reflected his solid understanding of the concept but also humorously implied his life "experiences": it is easier to stay in the middle among the crowd than remain on top. In the poem, "Buffer", the author ingeniously utilized his life "philosophy", one should strive for balance and moderation in life, to elucidate what a buffer is, its importance and its properties. A good poem touches the reader's heart. This is exactly what "My Opposite Attract" does. The author used the words or phrases such as "bleed", "make me blush", and "bring a smile" at right moments that made the readers feel the author's emotion and resonate with his passion. The poem turned on readers' imagination, took them inside an atom, and illuminated the changes taking place inside the atom as well as the forces between the subatomic particles including electrons, protons, and neutrons in such an impressive, fresh, emotional, and powerful way. The author of the poster, "Chemistry Rocks!", (see the lower right corner poster in Figure 1) used the shape of a flask and the textures and colors of paints to signify the experimental nature of chemistry and the colors and "magic" associated with these experiments. The "Chemistry-Macbeth's

Style" described an experiment (24) involving an acid-base titration using bromothymol blue as the indicator. The end point of the titration was signaled by a color change of the indicator from blue to yellow. The procedure also required the preparation of saturated calcium hydroxide solutions at room temperature and an elevated temperature, respectively. The poem was delightful, and the arty illustration attracted passerby attention, reflected the experimental theme, and added charm, enchantment, and mystery to chemistry (see Figure 2). These posters interestingly revealed how students perceive and comprehend chemistry based on their personal experiences and the styles they choose to illustrate that comprehension. Such diversified and personalized reflections of chemistry understanding through creative poetry and art expression are usually lacking in the traditional methods of learning assessment. The fact that the best poems and art works were not necessarily created by the A-level students but actually often by B- or C-level students is interesting. The poem "Chemistry-Bonding is All the Same to Me" was created by a student who usually showed little chemistry understanding on quizzes or tests. The poem, however, surprisingly demonstrated the student's insight of bonding including how the simple octet rule is used to explain the ionic and covalent bonds and how the sharing of electrons results in the single, double, and triple bonds. All of this demonstrated how poetry may reveal students' chemistry learning and understanding that may not be shown in any of their conventional class work. The project, allowing them additional practices on their written, visual, and verbal communication skills, helped the students become better communicators while they enjoyed chemistry creatively. From 1996–1997 to 2005–2006, the class enrollments have doubled for both the first- and second semester general chemistry classes. This increase might be indicative of the students' increased desire in learning chemistry and improved attitude towards chemistry. The positive reactions from the students and campus viewers on the chemistry poster projects including this year's chemistry, poetry, and artistic illustration poster project only supported this encouraging change.

Conclusion

The poetry writing, poster illustration, and group presentation were perceived by most of the students as effective at helping them learn and express chemistry in a fun and creative way. Students applied chemistry to their poetry and art work and related chemistry to their personal experiences and feelings in a way that was witty and clever. The poster display was eye-catching and the content and format reflected a good understanding of chemistry. The artistic expression of chemistry provided an additional way of accessing the students' learning, which may supplement the traditional methods. The fine art work, coupled with the poetry, helped chemistry come alive on campus, providing an aesthetic presentation of material that engaged the general viewer. The project demonstrated that a collaborative effort among science and arts faculty can not only maximize the use of the university's expertise, but also bring out a student learning outcome that none of the single disciplines is capable of generating.

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