"The Chemicals Project": Connecting General Chemistry to Student's Lives†

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At gatherings of chemical educators, discussions of problems universally encountered in teaching often include the observation that students do not recognize the role of the chemistry they are studying in their everyday lives. If the discussion continues, a second problem often surfaces: chemical phobias. These two problems are aspects of a larger issue, scientific ignorance. In the absence of specific knowledge of chemistry, some persons view all chemicals as dangerous and only indirectly relevant to their lives. The Chemicals Project described here was developed to counter these problems. It is presented as part of the second semester of college-level general chemistry, helping students make connections between the chemistry they are studying and the world around them.

The issues described above have long been recognized by many science- and technology-related organizations, many of which have developed programs designed to address them. These organizations include Sigma Xi, the AAAS, the APS, and the NSF. Our own society, the ACS, has an Office of Community Activities that is "designed to enhance public awareness of the contributions chemistry makes to society and our everyday lives" (*1*). The outreach of these organizations is largely educational. Textbooks and other course materials focusing on making connections between science and life are now available at levels from lower elementary science (*2*) to college chemistry (*3*).

This *Journal* uses "Chemistry for Everyone" as one of its main headings, effectively indicating its editorial interest in these issues and its commitment to deal with them. That "Outreach", "Public Understanding", and "Consumer Chemistry" are key words for this *Journal* (*4*) is further evidence of this commitment. A search of the *JCE Online* electronic Index (*5*) shows that these three key words were listed a total of 27 times in a single six-month period from January through June 1999.

The Chemicals Project

This project grew out of assignments and course activities I have developed and used over several years. The Chemicals Project combines several of these into a semester-long systematic developmental project. The primary objective was to emphasize the connection of chemistry to students' lives. Specific student learning objectives are:

> To generate a realistic understanding of chemical properties and hazards.
>
> To generate a basic understanding of Material Safety Data Sheets and how to use them.
>
> To understand the causes and effects of chemical phobias and how to combat these.
>
> To trace a chemical substance from its production to its final use.

This project was developed in a cooperative learning format using portfolio grading. It accounts for a substantial portion of the course grade (20%), to prevent students from simply ignoring it.[1] Individual students are held accountable for their project grade through exam questions, specific assignments done individually, and group and self-evaluations.

The Chemicals Project began with a statement posted to the Chemed-L electronic discussion list a few years ago:[2]

> HELP! I just found out that I am pregnant and I am a chemistry teacher. Should I stay away from any chemicals? My doctor suggested staying away from all organic chemicals.

Students were asked to respond to this statement in class, in writing. We then looked up the definitions of the words "organic" and "chemical" using both common and chemical dictionaries. This led to a discussion of the use and misuse of terminology, and how it effects our perception of chemistry and chemicals.

The next four assignments built on this beginning. Each had several parts and covered 1–3 weeks in time. These assignments are listed in more detail in Appendix I along with details about the portfolio grading and the implementation of cooperative learning.[W] The first assignment dealt with chemical phobias and included an interview with an adult family member. The second centered on Material Safety Data Sheets (MSDSs). These were introduced and explained in class. Several exercises then asked students to find and interpret information from MSDSs. One exercise required students to prepare a report for this high school teacher advising her of the hazards of carbon tetrachloride and recommending whether she should keep a bottle of it in her stockroom.

The third assignment required students to read product labels, identify the key ingredients, and find basic toxicology information for them. In the fourth assignment students watched the railroad tracks just outside our building. Tank cars are often labeled according to their contents and represent industrially significant chemicals.[3] Students were asked to list a minimum of 8 substances carried by these cars. The class as a whole found train cars labeled for more than 40 individual chemical substances. Students then used several sources to determine what these substances were, what they are used for, and whether they are hazardous.

A final project asked each group to choose one substance from assignment 4 and to research and describe its production,

†Presented in part at the 217th American Chemical Society Meeting, March 1999, Anaheim, CA, as part of the symposium on Incorporating Risk Assessment in Chemistry Courses.

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its safety considerations, and its typical uses or products made from it. Students were required to use the library to search for information and to include a bibliography with no fewer than four sources. The most useful sources turned out to be chemical reference books and Web sites. I had to *require* students to use the library and cite at least one journal found there. *Chemical & Engineering News* and *Science News* turned out to be the most cited print publications. Appendix II lists the types of reference materials used in the project.[W]

The final paper was produced through a process that included an outline and two drafts, and the peer-review of the first draft. Different group members researched different aspects of the project. They then developed the outline for the paper together. The actual writing was done by one student (mostly for consistency) and reviewed by the other group members. Students were referred to the campus writing center for help with the mechanics of writing.

Numerous examples were drawn from these project assignments for use in the classroom, which served to integrate this project, done largely outside of class, into the course. Several homework problems based on the project were also developed. For example, a simple Clausius–Clapeyron calculation was required to determine the concentration of vapor near a hypothetically ruptured tank car carrying dimethylphthalate on a hot summer day. The students then compared this value with the OSHA regulation for occupational exposure. These connections were an important part of the project, showing students how the chemistry they were studying could be used to help them better understand some of the issues raised by the project assignments.

Project Evaluation

The course evaluation contained two questions about The Chemicals Project specifically. One asked whether the project was a valuable part of the course. The average response was 4.62 on a 5-point scale (20 responses), 5 being "very worthwhile". The second question asked about the degree to which students had a better understanding of chemistry as a result of the project. On a scale of 1 (no change in understanding) to 5 (very much better), the average rating was 4.45.

Students' attitudes toward science and technology in general and toward chemistry and chemicals specifically were tested at the beginning (pretest) and end (posttest) of the course. Science and chemical phobias were significantly reduced but not eliminated. The perception that chemistry is "important" in their lives increased significantly, as did students' assessment of their understanding of the chemistry they see everyday. These surveys indicate that students were substantially more realistic and knowledgeable and less opinionated about science, technology, chemistry, and chemicals at the end of the course then when they started.

The final exam contained an essay question asking students to identify and discuss what they found most helpful about the class. The 20 students who took the final listed 12 different subjects; several students listed more than one. Seventy-five percent of the students cited The Chemicals Project, far more than cited any other aspect of the course. Two students indicated that their new-found understanding of MSDSs had already helped them considerably. One student wrote:

> I have recently been hired to start up a water-testing lab… I didn't know where to find information about chemical safety … until you showed us how to use MSDSs. Now, I can properly handle these chemicals.

My own perception of The Chemicals Project is that it succeeded in all its objectives. Several students became more excited about chemistry, at least in part through the project. Three have declared a major in chemistry, although it is difficult to say how much this project influenced their decision. The project stimulated greater interest and more and deeper in-class discussion when topics from it were used in class. Perhaps a more telling observation is that information about the project spread by word of mouth to the point that I was being asked about the project by students in other classes and by faculty both in and outside my department. The information that filtered back to me from these questions was universally positive. Students were finding the project interesting and spreading the word. In my opinion The Chemicals Project made the connection I was trying to make: that like it or not, chemistry is an important aspect of our modern technological society and to be truly educated, we need to know something about the chemistry around us.

[W]Supplemental Material

Supplemental material for this article is available in this issue of *JCE Online*.

Notes

1. In the first offering this project was worth 100 points out of 1000. Several students did not complete it. One told me that for 100 points the project just wasn't worth the effort.
2. This anonymous statement is used with its author's permission.
3. It is difficult to improve upon the immediacy of seeing chemical names on the sides of railroad cars outside the building, but there are other ways to approach this assignment. Consider the chemicals produced or consumed in commercial quantities in your local area, or transported through or near it by train, truck, or pipeline. Including petroleum products, fertilizers, and other agricultural chemicals, there should be at least a few likely candidates for this assignment in any geographical area.

Literature Cited

1. American Chemical Society. National Chemistry Week Web Page; *http://www.acs.org/ncw/* (accessed May 2000).
2. See for example McKean, P. B. *J. Chem. Educ.* **1999,** *76,* 916.
3. See for example *Chemistry in Context*, 3rd ed.; Stanitski, C., Ed.; McGraw-Hill: New York, 1999.
4. *JCE Online*; *http://jchemed.chem.wisc.edu/Journal/Authors/Keywords.html* (accessed May 2000)
5. *JCE Online*; *http://jchemed.chem.wisc.edu/Journal/Search/index.html* (accessed May 2000).