Chemistry and the Environment: A General Education Course to Interest Unenthusiastic Students

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Abstract

Chemistry and the Environment was a general education course that effectively captured the interest of unenthusiastic students. Topics like dinosaur extinction, nuclear chemistry, environmental implications of agricultural cloning, and acid rain integrate well with typical introductory chemistry subject material. Class participation and retention of material were improved by the use of humor and drama. Sensitivity toward preconceptions and religious beliefs of students also helped decrease their hostility toward chemistry. Efforts to make chemistry seem less intimidating also improved student attitudes. Student evaluations indicated that by the end of the semester the students generally felt successful and had favorable attitudes toward studying chemistry.

Body

Chemistry and the Environment was a general education course developed around the theme of environmental chemistry. The greatest challenge in any general education course is to engage unenthusiastic students. These students may enter general education chemistry courses with concerns about maintaining their grade point averages, and usually they just want to pass the absolute minimum number of math and science courses required for graduation. At the beginning of the course students who signed up for Chemistry and the Environment were quite open about their preferences for more “environment” and less chemistry. This problem was largely due to their perception that global warming, the ozone hole, energy efficiency, gasohol and recycling do not have anything to do with chemistry. Negative attitudes were also generated by beliefs that chemistry is the cause of water and air pollution. As the students realized that chemistry offers explanations and even solutions to real

problems they became much more interested in the subject. Most subjects in chemistry can be illustrated by related environmental issues so environmental chemistry provides an effective theme for the introduction of appropriate basic concepts in chemistry.

Chemistry and the Environment was developed in 1996 at a small private university where many students were conditionally admitted because they showed substantial academic promise despite inconsistent high school grades or a history of test anxiety. In addition to engaging their interest, it was essential to bolster their self confidence and allow them to discover their own abilities. About half of the students who took this course were pre-service teachers who were majoring in elementary education. Many students only took the chemistry course because the biology section during that period was filled. Creating a more favorable attitude among these students toward chemistry was a major goal of the chemistry department. After the chemistry department and chemistry positions were eliminated, portions of this material were used at another school for a Chemistry in Context course. That material was effective in an evening course for nontraditional students and with a traditional daytime student population.

During the fall semester, when Chemistry and the Environment was first offered, the chemistry topics were usually covered before the environmental applications were introduced. This corresponded to the organization of the textbook, *Chemistry An Environmental Perspective* by Phyllis Buell and James Girard (2). The most popular parts of the course were the environmental applications of the chemistry. Even the students slouching in the back row were more likely to sit up straight and pay attention when the topic was frogs with extra legs or acid rain melting the faces off statues. The following semester the environmental topics were used to introduce the chemistry. The resulting lecture schedule is the one described in detail in this paper.

Setting the Tone

The first lecture started with a discussion of theories and hypotheses about why dinosaurs became extinct. This is one of the topics covered at the end of a chapter on a tinted page. It includes a Far Side cartoon of one dinosaur lighting a cigarette for another with the caption, “The real reason dinosaurs became extinct.” A variety of hypotheses from other sources (1, 7, 8) are summarized in Figure I. Students were invited to think of ways to prove or disprove various hypotheses. Then class also voted on whether several of the more popular hypotheses were likely to explain why we did not have to worry about a *T. rex* peering in the window. The back row was quite enamored with the hypothesis about constipation deaths due to eating flowers. They were extremely disappointed to hear that remains of flowering plants are found in sediments which could also contain dinosaur remains. The cigarette “theory” from the cartoon got a big humor vote.

Figure I. Hypotheses About Why the Dinosaurs Died Out

Reversals of the Earth's magnetic field killed them

A huge asteroid hit the earth and/or volcanoes or other events caused
    Changes in air or water chemistry
    Climate changes/sea level changes

Rat or mouse-type creatures ate all their eggs
Epidemics occurred due to joining of previously separated land masses
    (Dinosaur pox?)

Overpopulation caused stress which caused thin eggshells

They slipped vertebral disks because they got too big
Decreasing brain size caused stupidity

A great increase in flowering plants poisoned them
    (Or made them die of constipation)
Excessive oxygen produced by plants

Space aliens killed them off (Little green men?)

Toward the end of the first lecture a second end-of-the-chapter topic was covered, "The Eruption of Krakatoa." The students wanted to know if this had anything to do with dinosaur extinction. Some of them were still discussing extinction theories in the hallway after class and several stayed after class to ask more questions. The next lecture included the textbook section on the scientific method as a review of the terms used in the dinosaur discussion. The students were able to define the textbook terms in their own words and to give examples to illustrate the definitions. During the fourth lecture they were able to give examples of the relationship between chemistry and other fields like biology and geology based on examples from the dinosaur lecture. On the first exam the students were able to successfully list three theories about why the dinosaurs became extinct, and some voluntarily responded with opinions or essays.

Students who have experienced serious academic failure in high school or on standardized exams tend to lack the self confidence necessary to participate in class. It is essential to reassure them that there will be no penalties for giving incorrect answers in class. Since they were repeatedly told that nobody knows exactly why the dinosaurs died out, they felt free to vote on favorite theories and contribute to the discussion. They were also promised that only written work would be graded. Even shy students were willing to vote on the probability of cigarette-induced dinosaur

extinction when they felt safely anonymous in the middle of the class. Since nothing terrible happened when they raised their hands, they progressed to answering and even asking questions during subsequent classes. This discussion also addressed the common perception among the students that “science knows everything.” A comment that nobody knows the colors any of the dinosaurs was met with initial disbelief and then delight. At another university nontraditional students and students with excellent academic records also enjoyed the dinosaur discussion in a Chemistry in Context course. An abbreviated version has been effective in general chemistry and nursing chemistry as well.

Since the first lecture sets a tone for a class that is difficult to change, it was useful to encourage civil discussions with an amusing topic. The knowledge that even professional scientists disagree on the exact reason or reasons for some events not only encouraged class participation, but also helped the students to feel that their opinions were respected. All of the students who completed student evaluations agreed that the “The instructor was open to other viewpoints.” However, 12% disagreed with the statement that “I felt free to ask questions or express my opinions.” There had been several occasions when student discussions had started to become acrimonious and it had become necessary to intervene. Although intolerance was not permitted in class there was no way to insure that the aggressive students would not verbally abuse other students outside class. The use of humor in the lectures seemed to minimize aggressive behavior between students while promoting class participation.

The word evolution was carefully avoided, but two students brought the subject up and aggressively insisted that there never were any such things as dinosaurs. It became necessary to tell them very firmly that it was not acceptable for them to engage in abusive name-calling of other students who disagreed with them. This included accusing their classmates of demonic possession for saying they had seen dinosaur fossils. Eventually they agreed that dinosaurs might have died out before the Ark. The pro-dinosaur, mostly anti-evolution group did a very good job supporting their arguments with evidence about climate change from seashells in mountains and descriptions of fossil dinosaur bones, footprints and eggs. Although it was unplanned, the class discussion did provide examples to explain the differences between beliefs, hypotheses, observations, data and theories. This issue has never been disputed by any other student population, but presented a challenge that semester.

Explaining the distinction between theories and beliefs is a critical part of the first lesson; normally it only takes a few sentences to explain that the class rule will be to treat everyone else with courtesy and respect no matter what beliefs they hold. Cheerful admission by the instructor that the Ark hypothesis would be covered under the category of changing sea levels (i.e., the fountains of the deep opened up) seems to

be amusing to students from all religious backgrounds. Fundamentalist students already expect that the science instructor will disagree with their particular set of beliefs, but this approach defuses some of their hostility toward taking a science course. They are typically surprised that science is neutral to religion, not hostile to it. Many other groups of students also hold other extremely strong and diverse views about various environmental issues even if they are unfamiliar with the scientific backgrounds. They all need to clearly understand that their beliefs will not influence their grades. Science is not as threatening if it is described like a game which requires fitting together facts to solve a puzzle, rather than being presented as a series of conclusions to memorize.

Themes for the First Exam

A theme or series of themes connecting new topics with previously introduced material improves attentiveness and retention. Drama is good, too. The major environmental theme for the first exam was catastrophic mass extinction. The chemistry theme was that matter and energy can be converted to different forms, but they are not created or destroyed. Basic ideas about elements, compounds, mixtures and chemical equations were also introduced.

The problem of global cooling due to volcanic dust was covered briefly at the beginning of the second lecture and the presence of iridium in asteroid dust was mentioned. The word element was mentioned with a promise to define the term and discuss other interesting elements later. This was followed by an introduction to electromagnetic radiation and global warming. The word molecule was defined during discussions of the effects of atmospheric carbon dioxide, methane and nitrous oxide. Someone asked if global warming could have killed off the dinosaurs. Students exhibited good recall of the first lecture during the ensuing discussion.

The third lecture started with energy flow and the first law of thermodynamics. This was tied in with global warming and global cooling due to dust clouds. Nutrient cycles involving the elements carbon, nitrogen, oxygen and phosphorus were also discussed. Several examples of balanced chemical equations from the textbook were used to introduce the conservation of matter in correctly balanced equations. The effect of dust clouds on photosynthesis was reviewed.

The student reaction to the fourth and fifth lectures was less enthusiastic, but they all did learn the material after they were promised that the interesting stuff would be back soon. Some education majors insisted that rote memorization of abbreviations for selected elements is a very bad way to teach. (Informal conversations with members of the education faculty indicated that they did not agree with the students' objection to memorization in this context.) Some objectors were persuaded by the explanation

that memorizing these abbreviations is like learning vocabulary in a foreign language course. The rest were persuaded by their inability to answer the question on the first quiz. Most students could also see that it was helpful to know the meaning of the symbols in chemical formulas and when balancing chemical equations. Figure II summarizes the material covered for the first exam.

Figure II. Topics covered for the first exam in Chemistry and the Environment

Lecture	Chapter(s)	Pages	Topic(s)
1	2 3	83-85 56-57	The Eruption of Krakatoa Dinosaur Extinction Controversy
2	1 13	18-22 419-422	Electromagnetic Radiation, The Scientific Method Global Warming
3	3	69-83	The Flow of Energy Through Ecosystems Nutrient Cycles
4	1	1-17	Science, Technology and Chemistry Properties of Matter, Pure Substance and Mixtures, Elements and Compounds, Chemical Formulas, Chemical Equations
5	4	99-104	Subatomic Particles, Atomic Numbers, Mass Numbers and Isotopes, The Atomic Mass Unit and Atomic Masses
6	6 15	149-158 482-484	Nuclear Chemistry The Chernobyl Nuclear Power Disaster
7	6	158-177	Nuclear Chemistry (continued)
8	19	606-613	Radioactive Waste
9			Review
10			EXAM 1

Nuclear chemistry really caught the interest of the whole class. The subject was introduced with a reading of an entire translation of a school essay from John Hersey's book *Hiroshima* (4). The essay was written by an eleven-year-old schoolboy who had been buried under his house the year before by the Hiroshima bomb. "The day before the bomb, I went for a swim. In the morning, I was eating peanuts. I saw a light. I was knocked to little sister's sleeping place. When we were saved. . . . They were looking for their mothers. But Kikuki's mother was wounded and Murakami's mother, alas, was dead." This has also been an effective introduction to nuclear chemistry in general chemistry and nursing chemistry courses. It is always followed by a minute of spontaneous silence.

Then the students are asked quietly if any of them have known a relative or family friend who had received radiation treatment for cancer. Several students invariably share descriptions of cancer survivors. Nontraditional students sometimes share recollections of “duck and cover” drills. This approach effectively convinced even the least motivated students in Chemistry and the Environment that nuclear chemistry is worth studying.

Exams and Quizzes

Two quizzes were given before the first of the four hour exams. The style of the quiz questions was similar to the questions on the exam. Quizzes from the first semester were also available to the students in the spring semester. Quite a few students did poorly on the first quiz. Students who also did not do well on the second quiz were referred to the tutoring center and were encouraged to come to office hours for extra help. Exam scores showed that students had learned the material and most of them could answer at least some of the questions that required them to apply the material in new ways. A comprehensive final exam was given to encourage students to consider the relationships between topics covered on different exams. About two thirds of each exam only required the students to accurately remember the material presented in lecture. An overall score of 60% was required to pass the course for the general education requirement. Figure III shows the type of material on the first hour exam.

Although the process of food irradiation was covered in lecture and the text, quite a few students missed the question about whether or not irradiated food becomes strongly radioactive. Many students had firm opinions on the issue before the class started and they often had great difficulty applying new information in ways that would require them to modify their earlier perceptions. Several students were unhappy that they had not been told the exact answer to that question (and several other questions) prior to the exam, although they admitted that the topics had been covered. The exam scores were generally quite satisfactory, though, and the complaints were typically attempts to get a few more points for incorrect answers.

There was not enough time in lecture to cover biographical material in the textbook about Marie Curie. Students were told that there would be a difficult, extremely picky two-point bonus question over the material. A surprising number of them got the two points. Each of the exams had a two-point bonus question, although sometimes the students were asked for the punch line of a chemistry joke told in class.

Figure III. Summary of questions for Exam I.

1.) (10 points) Give memorized abbreviations for selected elements.

2.) (10 points) List three theories discussed in class about why the dinosaurs became extinct.

3.) (5 points) List given electromagnetic radiation types from highest energy to lowest energy.

4.) (30 points) Fill in blanks covering first law of thermodynamics, photosynthesis, effects of asteroids and volcanic eruptions on climate, states of matter, types of mixtures, food chains and webs, and atomic number.

5.) (5 points) Recognize anions.

6.) (20 points) Identify the number of protons, electron and neutron for given isotopes.

7.) (20 points) Balance simple equations.

8.) (10 points) Know risks and penetrating power of alpha, beta and gamma particles.

9.) (10 points) At Chernobyl nuclear power station why did the supervisor slam the control rods down into the core right before the accident? (HINT: Draw a picture of a nuclear reactor and explain *in detail*the cause of an uncontrolled chain reaction.) What might have happened if the control rods had not been slammed all the way into the core?

10.) (5 points) Describe a storage facility for high-level radioactive nuclear waste, types of materials contained and current storage arrangements.

11.) (10 points) What would happen if the atmosphere of Earth was made of 99% carbon dioxide instead of 99% nitrogen and oxygen? Why?

12.) (10 points) For 80 grams of technetium-99 with a half life of 6.0 hours how many grams will be left after several given periods of time?

13.) (5 points) After food is irradiated with beta particles does it become radioactive?

BONUS (2 points) What is the name of the ore that Marie Curie extracted to discover polonium?

Themes for the Second Exam

The second exam covered a variety of typical introductory chemistry topics. After the students successfully completed the first exam, there was much less complaining about memorization. The topics covered for the second exam are shown in Figure IV.

Figure IV. Material covered for Exam II.

Lecture	Chemistry Topic	Environmental Topic
11	Periodic table	C, N, O cycles and bonding, Na vs. Mg ions in ocean, etc.
12	Lewis dot, octet rule	C, N, O compounds, Global warming, ozone hole
13	Ionic, covalent and polar covalent bonds, Polar molecules, intermolecular forces	C, N, O cycles and bonding, Oil spills, solubility in water
14	Balancing equations	Environmental equations, Everything recycles
15	Spontaneous reactions, reaction rates, equilibrium	C, N, O cycles, Environmental equilibria
16	Solutions, acids, exponents	Aquatic chemistry, Frog deformities
17	Logarithms, pH	
18	Acids and bases, review	Acid rain, mine drainage
19	EXAM II	

In addition to introducing education and humanities students to basic ideas of chemistry, the course was to be used to prepare students who had not taken high school chemistry for success in general chemistry. This dual purpose for a general education course is not unusual in smaller schools, but it greatly adds to the challenge of designing an effective course. The math component in Chemistry and the Environment was extremely weak for this purpose, although some general chemistry students who have completed high school chemistry courses do not appear to have adequate preparation either. Students who planned to take general chemistry were given tutorial materials to work on during the summer and were advised to arrange for extra help before the first general chemistry lecture.

Faculty advisors from some humanities departments and some members of the curriculum committee had indicated that they felt that there should not be any math requirement for Chemistry and the Environment. The students (and curriculum committee) were promised that the only math skills needed were counting and simple arithmetic. However, an understanding of pH does require some understanding of logarithms so the topic was introduced in lecture. The numbers from 1 to 100,000 were written in a column on the board. Then the students were asked to count the number of zeros in each number and these numbers were placed in the next column. Exponents and logarithms were reviewed in more columns. Students were able to yell out answers to additional examples without difficulty. The same approach was used to cover negative logarithms, except that students were instructed to count both the

decimal point and the number of zeros. Nearly all of the students were able to correctly answer questions like the one about the relative number of hydrogen ions in solutions of pH 2 and pH 4. One student commented that chemistry math is a lot easier then college algebra. A great deal of the math anxiety seemed to involve the appearance of mathematical equations and the use of symbols rather than the mathematical concepts themselves.

Although the students accepted the increased amount of chemistry content in the lectures, they appeared to regard learning chemistry as an unfortunate necessity before they could understand more of the interesting stuff like nuclear chemistry. This was alleviated somewhat when they realized that they could understand the issues in a *Chemical and Engineering News* article about frog deformities (5) . There had been some concerns among the science faculty that the students would complete the course without understanding the nature of chemistry unless some of the material was taught as a separate unit. Teaching the material in this format was also more familiar to the instructor and decreased student disagreements. However, it became increasingly clear that integration of each chemistry lesson with at least one environmental issue gave the students a more positive view of the value of learning chemistry.

Integration of Environmental Topics and the Third and Fourth Exams

Petroleum chemistry and CFCs were used to introduce organic chemistry. There were no serious objections to memorizing the alkanes from methane to hexane and several functional groups. Several students indicated that they had assumed there would be something difficult and incomprehensible about the structures for propane and butane. Methane had already been mentioned several times that semester, and both methane and CFCs were familiar from the global warming lecture. Most students were under 21, but indicated with some amusement that they had at least a theoretical knowledge of the existence of ethanol (the least toxic of the alcohols).

Many students were surprisingly pleased to discover that they had no difficulty understanding the systematic nature of organic nomenclature. Although none of the students raised their hands when asked if they wanted to take a year of organic chemistry to learn more functional groups and the types of chemical reactions for each group, nearly all agreed that normal people like them can learn organic chemistry if they want to work hard at it. A first-year sociology major asked that the material be left on the board at the end of a lecture so her friends coming in for the sociology lecture could see it. An impromptu “practice session” ensued as the next class started filing in and she was delighted when she correctly wrote several long, scary-sounding chemical names on the board herself. A major unstated goal of the course was to convince students, especially pre-service teachers, that chemistry is an interesting subject for normal people to learn. Demystifying organic nomenclature seems to make

chemistry much less intimidating. Nontraditional students and students with excellent academic records at another university also seemed to feel empowered by an understanding of the general rules for naming organic compounds.

Although only one lecture was scheduled for an introduction to biochemistry, the students voted to spend more time on the topic and drop the three lectures scheduled for agricultural chemistry. Student interest in cloning was intense. This was partially due to the perception that cloning involves evil cartoon people with mad-scientist hair making human babies in mason jars. Some of the students expressed the view that a cloned human would not have a soul. This view was also found later in a newspaper article (3) among other places. The two students who had not believed in dinosaurs also believed that in naturally occurring identical twins one individual does not have a soul. Fortunately other students argued against this concept since the instructor was rendered speechless. Most of the students did not realize that the term cloning also refers to taking a cutting from a geranium or the reproduction of cancer cells to allow testing of chemotherapeutic agents. All of the students agreed that there is nothing wrong with rooting cuttings from geraniums or using DNA testing to convict the real murderer. Only a couple of students were opposed to making cell cultures from cancer cells. Everyone also agreed that it is important to know what a word like cloning means before making all forms of cloning illegal. Even students from less conservative backgrounds may be somewhat hostile toward science because of their misconceptions about the broader meaning of words like cloning. The mixed reaction to environmental issues associated with agricultural biotechnology was similar for students at another institution, although the logic of objections to biotechnology varied.

The air pollution chapter provided a review of equation balancing, Lewis dot structures, and acids. Difficulties of colonizing Mars were covered in the textbook, and a *C & EN* article (9) was used to cover the possibility of native life on Mars. Pictures and meteorological data from Venus were obtained from the NASA website. The class voted that the place sounded like a close approximation of Hell. Some of them meant it. Everyone was amused. Two elementary education majors asked for photocopies of a picture of the surface of Venus (6).

The lectures for the rest of the semester were mostly based on the environmental chapters in the textbook. The chapter on water pollution included some discussion of thermodynamics and phase changes, and some solution chemistry. The fossil fuel chapter provided an opportunity for more discussion of organic chemistry. The alternative energy, toxicology and waste disposal chapters were also covered. Photographs and material from sources other than the textbook were used to spice up the lectures over these chapters as well. For some reason students paid more attention to anything that did not come from their textbook, which had very good material that

was later found to be popular with students with other textbooks. During office hours one student explained that reading the textbook was like a job.

Simple lecture demonstrations generated enthusiasm and only took a few minutes of lecture time. For example, the toxicology chapter included a section on corrosive poisons which provided an excellent excuse to pour neat sulfuric acid on a coffee filter, a Kleenex and a paper towel. Concentrated acetic acid on baking soda provided a good opening to the lecture on acids. An oil-spill-in-a-bottle (cooking oil, food coloring, water, and a droplet of detergent to create some emulsion) and polymers samples made by the general chemistry students were good icebreakers for introducing new topics. Even a windup toy dinosaur obtained from a Happy Meal made the students (and instructor) leave the classroom laughing. The motto was that "since we have to do this we may as well enjoy it."

Plans for complete integration of the environmental material with the chemistry were completed for future sections of Chemistry and the Environment. This plan is summarized in Figure V.

Figure V. Material to be covered after the first exam

Chemistry Topic(s)	Environmental Topic
Periodic table	C, N, O cycles and bonding, Na vs. Mg ions in ocean, etc.
Balancing equations	Environmental equations, Everything recycles, waste disposal
Lewis dot, octet rule	Atmospheric chemistry, Global warming, ozone hole
Organic chemistry	Atmospheric chemistry, fossil fuels, Oil spills, energy resources
Ionic, covalent and polar covalent bonds, Polar molecules, intermolecular forces	C, N, O cycles and bonding, Oil spills, solubility in water
Spontaneous reactions, reaction rates, equilibrium	Energy, aqueous resources
Solutions, acids, pH	Water pollution, water use, frogs defects
Acids and bases	Acid rain, mine drainage
Biochemistry	Toxicology, agricultural cloning

Student Evaluations

Student evaluations were administered by the division secretary at the beginning of a class period before the arrival of the instructor. The results were tabulated by the secretary and students were assured that they would not be available to the instructor

until after grades were posted. Unfortunately, in the fall a biology instructor gave last minute notification of a field trip on the day of the evaluation, skewing those results. It is still clear that the students in the spring found the course as satisfactory as the students who took the more traditional version of the course in the fall.

Table I. Student Evaluations for Chemistry and the Environment (Number of People in Fall/Spring)

	Strongly Agree	**Agree**	**Disagree**	**Strongly Disagree**
Instructor uses class time well	4/10	5/5	0/1	1/0
Instructor knows when students confused	1/8	8/6	0/2	1/0
Lectures repetitive of text	2/1	3/5	5/7	0/2
Major points summarized or emphasized	3/10	6/4	1/0	0/1
Exams reflect important aspects of course	5/12	4/3	1/1	0/0
I have been putting a lot of effort in course	1/5	3/7	5/3	1/0

All but one of the students who wrote comments made favorable statements. For example, different students liked “Topics that involve the real world of chemistry”, “teacher made it easy to learn” and “the many examples and illustrations used in class in understanding things.” One student wrote that, “I am horrible at chemistry b’cuz I didn’t have any confidence in my abilities. . . . Now, I understand b’cuz I have confidence in myself.” Except for one student who complained about “sometimes boring lectures” the negative comments did not suggest unhappiness with chemistry. Two students complained that the course did not have a second section in the evening and one was unhappy that he/she “had to buy a $60 book and hardly used it.” As in Figure II, the lecture schedule given to each of the students listed the textbook pages for the reading assignment for each lecture. The only other complaint was from a student who said there was “no class discussion.”

Most students enrolled the Chemistry and the Environment either as a result of their “Faculty advisor’s recommendation” or because “It was required.” In the fall two students indicated that they had taken the course because the “Subject was of interest,” but only one student selected that reason in the spring. In the spring the students reported somewhat lower overall grade point averages than the students who enrolled in the fall. The information provided by at least some of the students about their grade averages and class standing was not accurate. Although students’ evaluations are likely to reflect their general attitudes, it does not appear that they took the evaluation process especially seriously. Their attitudes toward the labs that did not exist were especially interesting.

Table II. Student Evaluations for Chemistry and the Environment (Number of People in Fall/Spring)

	Strongly Agree	**Agree**	**Disagree**	**Strongly Disagree**
Instructor uses class time well	4/10	5/5	0/1	1/0
Instructor knows when students confused	1/8	8/6	0/2	1/0
Lectures repetitive of text	2/1	3/5	5/7	0/2
Major points summarized or emphasized	3/10	6/4	1/0	0/1
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	Excellent	**Good**	**Satisfactory**	**Fair**	**Poor**
Textbook	2/2	7/9	1/3	0/0	0/0
Lecture	2/5	5/8	2/2	0/0	1/0
Exams	2/4	5/8	2/3	1/0	0/0

Labs*	1/1	3/6	1/4	0/0	2/1
Overall	3/3	4/6	2/6	0/0	1/0

*There was no lab for this course

Summary

A general education chemistry course organized around a subject which interests humanities students can capture the interest of unenthusiastic students. A successful general education course should recapture the insatiable curiosity most people had when they were four. Most students have heard of many of the major environmental issues although frequently they are not familiar with the scientific background. The connection of a familiar topic with the associated chemistry greatly mitigates negative student attitudes toward learning chemistry. Use of humor and drama creates a classroom atmosphere that promotes student participation and retention of material.

This particular group of students would not have worked well in small groups because several students had difficulty with appropriate interpersonal interactions. The use of lectures involving class participation worked well since there were only seventeen students (not including the student who had to be administratively withdrawn for ongoing absence after he violated parole). One problem came from the aggressive efforts of one student to impose his personal religious beliefs on everyone else. An extra effort to reassure students that they would not be penalized or attacked for their personal religious or ethical beliefs was important in defusing the antagonism of the rest of the students toward science. Many students had not realized that science is not hostile to religion. In other student populations individuals may have passionate political beliefs which make it difficult for them to respect people who disagree with them. Environmental chemistry does cover many controversial topics. A cheerful environment created by an amusing presentation and a rigid insistence on courtesy does prevent most incivility of students toward each other.

The enthusiasm for memorizing organic nomenclature was surprising. The students were also extremely gratified by their ability to understand pH. The widespread aversion to math seemed to be associated with equations rather than the mathematical concepts themselves. Anything that made chemistry seem less intimidating appeared to improve student performance and attitudes. Student evaluations indicated that by the end of the semester the students generally felt successful and had favorable attitudes toward studying chemistry.

Students frequently expressed considerable surprise when they discovered that chemistry has something to do with their lives. By the end of the semester students

had questions about issues they saw on television and wanted to know more about chemicals they saw in the ingredients of cereal or on toothpaste tubes. About half of the students expressed interest in taking an elective lab if one was developed, and several elementary education students wanted to know if they could take another chemistry course that would help them teach science. The most valuable thing humanities students can gain from any general education course is an understanding that science is a system for examining ideas by considering available evidence. Attitudes toward science become much more favorable when students are encouraged to use the information presented to draw their own conclusions about issues that matter to them. Environmental chemistry provides students with information about subjects they really care about and that they may consider when they vote.

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References

1.) Bakker, Robert T. *The Dinosaur Heresies*; William Morrow and Company, Inc.; New York, **1986**, 425-444.

2.) Buell, Phyllis and James Girard. *Chemistry An Environmental Perspective*; Prentice Hall; Englewood Cliffs, NJ, **1994**.

3.) Gannett News Service. “Experts Predict Cloning Debate Just Warming Up: Many Christian leaders believe clones would not possess spirits,” *Palladium-Item*, Richmond, Indiana April 2, 1997.

4.) Hersey, John. *Hiroshima*; Bantam Books; New York, **1946,** 115-116.

5.) Hileman, Betty. “Frog Deformities Pose A Mystery,” *C & EN*; November 18, 1996, 24.

6.) Moore, Patrick. *Travelers in Space and Time*; Doubleday & Co., Inc.; Garden City, NY, 1984, 37.

7.) Raup, David M. *Extinction: Bad Genes or Bad Luck*; W. W. Norton & Company; New York,**1991**, 112-113.

8.) Wilford, John Noble. *The Riddle of the Dinosaur*; Alfred A. Knopf; New York, **1983**, 212-220.

9.) Wilson, Elizabeth K. “Bitten by the Space Bug,” *C & EN*; November 18, 1996, 27-31.