

## Chemistry, Society, and Civic Engagement (Part 2): Uranium and American Indians

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*As undergraduate students at the University of Wisconsin–Madison look through course catalogues for the upcoming semester, they'll come across one in chemistry that meets the ethnic studies requirement. This is no mistake.*

These lines, excerpted from a campus news item entitled “Course Blends Chemistry, American Indian Studies,” announced a new chemistry course (1). This was the first course, both in our department and in our state university system, to meet a general education requirement for diversity. The working title for our course is “Uranium and American Indians.” Officially, however, the title is “Environmental Chemistry and Ethnicity,” one broad enough to encompass both ours and similar courses in the future.

In 2004, Environmental Chemistry and Ethnicity was named a model course for the national dissemination project, Science Education for New Civic Engagements and Responsibilities (SENCER) (2). As described in the first article in this series, SENCER courses teach science through current, complex, and contested real-world issues (3).

New courses come into existence through a combination of curricular needs, intellectual challenges, and personal interests. Ours was no exception. On our campus, administrators called for more courses that fulfilled the ethnic studies requirement. Personally, we were intrigued by the challenge of connecting chemistry and ethnicity, something not done before in our department. And our interests both in nuclear chemistry and in Navajo (Diné) culture helped sustain us through the lengthy development and approval process.

We first describe the local and national events that preceded the course and inspired its creation. We next present the syllabus, student demographics, and course outcomes. Finally, we offer a model for designing other courses that teach chemistry through larger cultural and societal issues.

### Background

Like many colleges and universities in the 1980s, the University of Wisconsin–Madison was confronting issues relating to race and campus climate. In 1987, a racist incident at a campus fraternity (one in a longer string of such incidents) demonstrated the severity of the issues. As one of several responses, our Faculty Senate passed a resolution in 1988 requiring all undergraduate students to complete a three-credit ethnic studies course. In the years that followed, over 175 courses were recognized as meeting the requirement, most in ethnic studies programs or in history. According to

a recent report by the Association of American Colleges and Universities, over 60% of U.S. institutions now have (or are in the process of developing) such a requirement (4).

A decade later, one of us (CHM) was appointed to a committee charged with reviewing the Ethnic Studies Requirement (ESR) from the perspective of students, their advisors, and the course instructors. In 2002, after an extensive analysis, this committee recommended the continuation of the requirement. The final report of the committee stated that “the ESR has played a valuable role in increasing awareness of diversity on campus, that students are generally positive about the requirement and the specific course that they take to fulfill it, and that the courses are academically challenging and substantive” (5). In 2003, the Faculty Senate unanimously accepted the recommendation and ratified the statement excerpted in Textbox 1 (6).

### Course Proposal

On our campus, chemistry clearly fit the description of a discipline in which diversity had been absent (Textbox 1). For many years, two of us (OB and CHM) had noted the distress expressed by students over the fact that chemistry

#### Textbox 1. UW–Madison Statement on Undergraduate Ethnic Studies General Education Requirement<sup>1</sup>

The University of Wisconsin–Madison is committed to fostering an understanding and appreciation of diversity, in the belief that doing so will:

- Better prepare students for life and careers in an increasingly multicultural U.S. environment
- Add breadth and depth to the University curriculum
- Improve the campus climate

One of the University's overarching goals is to infuse the curriculum in all disciplines with diversity, including those where traditionally it has been absent. The Ethnic Studies Requirement (ESR) is one of several key elements in reaching this goal. This is a requirement that all students take a 3-credit course that considers ethnic/racial minorities that have been marginalized or discriminated against in the U.S.

<sup>1</sup>From University of Wisconsin Faculty Document 1736

courses tended to be “culture free”. But we had no remedy to offer; in fact, we were stumped in two regards. First, how could we create a course that blended chemistry with culture and ethnicity? And if successful, where in the curriculum might we find a home for such a course? In 2002, when our university requested that more departments contribute courses meeting the ESR, the answer to our second question was practically handed to us. Thus only the first question remained.

In large part, the release of a book, *If You Poison Us, Uranium and Native Americans*, helped us to move ahead with our agenda (7). The author tells the history of uranium, why it was mined in the southwestern U.S., how the miners and their family members contracted lung cancer, and how the natural harmony and their homelands were destroyed. Clearly, *If You Poison Us* could enable us to blend nuclear chemistry with the issues that American Indians faced and still are facing today.

Our experiences with *Chemistry in Context* (8), a project of the American Chemical Society, also helped us answer our first question. This textbook teaches chemistry through issues such as global climate change, genetic engineering, and energy sources—topics that interweave chemistry with fields such as politics, economics, or ethics. Consider, for example, the chapter on nuclear chemistry. It opens by questioning whether nuclear power is poised for a revival, given the growing concerns about greenhouse gas emissions and global climate change. Will the public accept nuclear energy? The process of nuclear fission is explained in conjunction with how a nuclear power plant operates. The issues of nuclear terrorism and nuclear waste continue the story line. The topic of radioactivity is introduced *only* after a “need-to-know” has been established.

Thus armed with a certain comfort level in using current issues to teach the underlying scientific principles, we were reasonably well prepared to tackle the larger task of teaching chemistry through the issues facing a particular community of people, their land, and the relevant cultural issues. We schematically represent the approach we took with the Diné uranium miners in Figure 1. The section that follows describes the course, its students, and its outcomes. We return to the theme of *teaching through* in the final section, offering a revision of this figure.

## Environmental Chemistry and Ethnicity

Selecting a title for a new course can be problematic. In our case, we did not want one as narrow as Uranium and American Indians. Nor did we want Environmental Chemistry, as this omitted a significant portion of the content. After extensive discussion with our curriculum committee, we selected Environmental Chemistry and Ethnicity. The course would include any issues in environmental chemistry as they relate to ethnic groups or communities in the U.S. or its territories. We placed the course in the 200-level series, indicative of the one-semester general chemistry prerequisite.

Finding suitable teaching materials was the second problem we faced. Funded by two course development grants, we traveled to the Four Corners Area (the border conjunction of the states of Arizona, New Mexico, Colorado, and Utah) to speak with local experts, visit uranium mining and milling

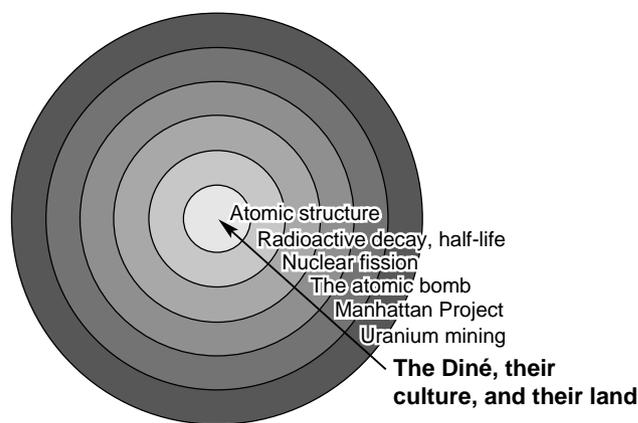


Figure 1. Diagram representing the teaching approach for the course Uranium and American Indians. This course is taught *through* the context of the Diné, their culture, and their land, to the underlying scientific topics.

sites, and take digital photographs illustrative of the land and its people. We also visited the National Atomic Museum in Albuquerque, the Bradbury Science Museum at Los Alamos, and the New Mexico Museum of Mining in Grants, NM. We selected three texts: *If You Poison Us* (7), an oral history of the uranium miners (9), and a history of the Diné (10).

In spring 2002, we piloted the course as a one-credit reading group. In spring semester 2003 and again in spring 2004, we taught the course for the full three credits, with the enrollment capped at 20 students. As such a small course quickly would fill with seniors, we saved half the spaces for freshmen and sophomores coming from our department's chemistry course for non-science majors. As a result, students varied widely in their college experiences, major fields of study, and chemistry background. Roughly 40% had taken only one or two semesters of general chemistry for science and engineering majors. Another 20% had taken more advanced chemistry courses. Interestingly enough, the remaining students were non-science majors who would not have been expected to take an additional chemistry course, but who elected to do so after completing their previous course, *Chemistry in Context*.

Both years we assessed student background knowledge with an anonymous survey on the first day of class. We asked questions relating both to nuclear chemistry and to the culture of the Diné. Although the recall of prior chemical information was not as high as we had hoped, notably the nonmajors from the *Chemistry in Context* course performed well on the nuclear chemistry section. In contrast—across the board—students demonstrated little knowledge of the Diné. Fewer than half could correctly label the states of the Four Corners (UT, CO, NM, AZ), about a quarter knew that Diné was the name the Navajo call themselves, and very few could list even a single event in Diné history (such as the Long Walk to Fort Sumner in 1864 or the Code Talkers in World War II). Students seemed unwilling to hazard a guess on the history and culture questions, leaving most of them blank.

## Course Organization

The class met twice weekly for 1.25 hours and included lectures, discussion, small-group work, guest speakers, and student presentations. The course syllabus and teaching materials are available on the Web (11). Each year, the semester was divided into three sections. During the first section, the instructors alternated between teaching topics in uranium chemistry and those topics in the history and culture of the Diné. The chemical topics included radioactivity, uranium and its ores, the uranium mining and milling processes, and the nuclear fuel cycle. The Diné topics related to culture, geography, history, and daily life, such as the forced resettlement to Fort Sumner, NM, the return to their homeland, the formation of the Diné reservation, spirituality, and health care. The chemistry and Diné topics, while initially distinct, quickly converged with discussions of the uranium mining and milling processes and their effects on the land. As Table 1 shows, the issues discussed connected to public policy as well.

During the second part of the course, guest speakers addressed specialized topics. For example, a medical physicist spoke on the biological effects of radiation exposure, a pulmonary oncologist detailed the progression of lung cancer, and a law student explained the problems the Diné faced in meeting the legal requirements of the Radiation Exposure Compensation Act. Nationally known speakers included

Doug Brugge (Diné Oral History Project), Jennie Joe (health researcher), and Manuel Pino (environmental activist).

For the third part, students were charged with finding a topic that involved both science and indigenous people, researching this topic, and then developing a 35-minute class presentation. Each presentation was accompanied by a hand-out and a list of study questions for the class. Independently, students also wrote a self-assessment and a 4–5 page paper that was turned in mid-semester, returned with comments, revised, and later resubmitted. Given the difficulty of the assignment, the instructors helped students prepare for it by starting early in the semester.

The students chose a wide range of topics, all blending science and culture. For example, one student described the current conflict between an Australian aboriginal group and the Australian government over a proposed uranium mine near aboriginal land (12). Another described U.S. nuclear weapons testing in the 1950s and its effect on the indigenous Marshall Islanders whose homeland became too radioactive to inhabit (13). Still another told of Project Chariot, a federal plan in the late 1950s to use atomic weapons to blast a harbor out of the northwestern Alaskan shoreline (14). And one described the 1993 outbreak of the *Sin Nombre* virus, a mystery that was solved by utilizing both the traditional knowledge of Diné elders and the clinical evidence of epidemiologists (15).

**Table 1. Distribution of Course Content by Topics**

Topics Relating to Chemistry	Topics Relating to People and Their Culture	Topics Relating to Public Policy
<i>Uranium</i> Natural occurrence Oxidation states Composition of ores Naturally occurring isotopes	<i>The Four Corners Area</i> Geography Geology Climate	<i>American Indian Affairs</i> Past and present policies of the U.S. Federal Government
<i>Uranium Extraction</i> Mining sites Types of mining Milling and tailings Yellow cake	<i>The Diné</i> Culture, history, lands Spirituality Tribal government Health care systems	<i>Environmental Protection</i> Site identification and clean-up Remediation of land
<i>Radioisotopes</i> Radioactive decay Half-life Natural abundances Radioactive decay series	<i>Diné Uranium Miners</i> Economic realities Mining conditions Oral histories	<i>Public Health</i> Radiation exposure standards Epidemiology of lung cancer
<i>Ionizing Radiation</i> Units Biological exposure effects Dose-response curves	<i>Effects of Cancer on People and Communities</i> Radium dial painters Uranium miners	<i>Occupational Health and Safety</i> Identification of occupational hazards Compensation of victims Protection of future workers
<i>Nuclear Fission and Fusion</i> Nuclear fuel cycle Enriched and depleted uranium A-bomb, H-bomb	<i>Indigenous People</i> Who they are Where they live or have lived Common issues	<i>Defense</i> National security needs The Manhattan Project The Cold War Weapons testing worldwide

## Student Assessment

Student learning was assessed throughout the semester. During all three parts of the course, biweekly quizzes provided feedback to students (and their instructors). By design, the quizzes included questions relating both to chemical concepts and to the Diné. Prior to each quiz, study questions were posted on the course Web site.

In addition to the quizzes, term paper, and class presentation, students did self-assessments that contributed to their grade. For example, students awarded themselves points on a biweekly basis for their class preparation and participation. Occasionally, the instructors would adjust the value assigned, although this was seldom necessary. Similarly, students assessed their own performance on the class project citing their personal goals, their efforts, and any other factors relevant to the outcome. For example, some students noted they had selected topics that were too narrow; others wrestled with ones that were too broad. Several commented that they wished they had spoken more slowly, practiced their presentation beforehand, or spent more time preparing their slides. We passed along these types of comments to students in subsequent years.

## Course Evaluation

The students evaluated the course using two instruments: a departmental survey form and the Student Assessment of Learning Gains (the SALG) (16). The former focused on the

course and contained items relating to how well the instructor prepared for class, clarity of lectures, ability to hold student interest, and so forth. Students rated the course highly. The SALG focused on the students and their perceptions as to what helped them learn. Their responses were also highly positive. For example, one question asked how much the class added to their skills in thinking about complex issues that involve both people and chemical principles. Here, 70% selected either the response “a lot” or “a great deal”. Another question asked how the way in which the course was taught contributed to their learning; 84% selected either “much help” or “very much help”. Figure 2 reports the data.

We solicited written comments from students as well. Almost across the board, students reported that the process of doing class presentations as well as learning from the presentations of others was especially valuable. For many, this assignment offered their first opportunity to prepare a 30-min class presentation; several described giving their talk as a significant accomplishment. In her self-assessment, one student wrote:

At the beginning of the semester ... I was convinced that relying on the students so heavily for teaching the course's content would be less valuable than conducting class in a more traditional format. However, as the semester went on, I began to notice the worth of having everyone share their hard work with each other ... I became increasingly convinced that not only was the class better with these projects, but even defined by these projects.

Students also responded favorably to learning science together with its societal relevance. Many students praised the course's unique combination of science and societal impact. For example, one student wrote, “The context of the course is nice to see in the chemistry department. It has social relevance, which is something often missing in science courses”. Another wrote, “I spend a lot of time in the chemistry building, and I needed to see society work its way into this building. I think that the most important part of learning chemistry is learning why it matters to people.” Finally, a student commented, “It was the perfect combination of culture and how science impacts it”.

## A Suggested Model for This Type of Course

Earlier, with Figure 1, we represented the process of *teaching through* a societal issue using an arrow pointing straight through a set of concentric circles. Although this model clearly represents the ever-widening contexts that surround core chemical principles, it is too simplistic. For example, a single arrow does not do justice to the complexities of the course, as we took many different and sometimes circuitous pathways in relating chemistry and culture. More importantly, a concentric circle model necessarily places something at the center: in this case, chemistry. To a chemist, our science-centric model may feel appropriate. However, one of the course instructors (OB) rightly questioned why Diné culture was not at the center. To give parity to both areas of intellectual in-

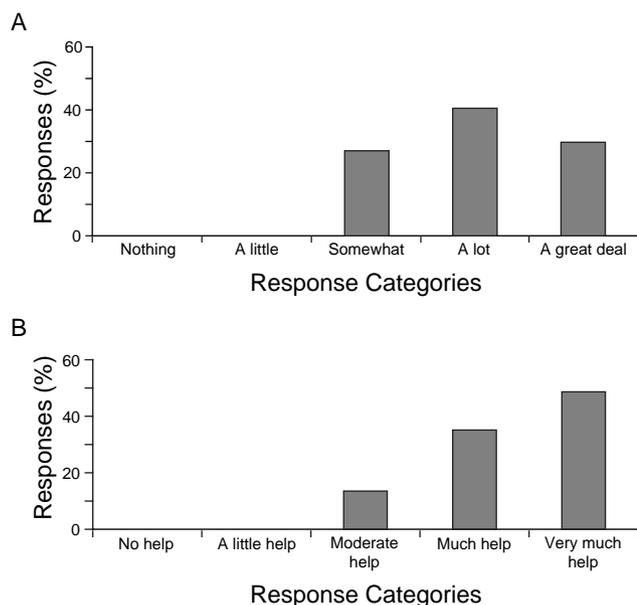


Figure 2. Distribution of student responses to two questions on the SALG instrument. A: How much did the course add to your skills in thinking about complex issues that involve both people and chemical principles? B: How much help in your learning was the way the course was taught overall?



Figure 3. Diagram of the relationship between science and culture intersecting at issues of public policy.

quiry, we constructed a different model, Figure 3. It locates chemistry and culture as the two foci for the course, using the issues of public policy to connect them.

### Concluding Thoughts

As described in the first paper of this series about the SENCER project (3), courses can reveal the limits of science by identifying the public issues that a knowledge of science alone cannot resolve. Indeed, the course Uranium and American Indians raised as many issues as it answered. As we wrestled with them, we became painfully aware that some questions simply do not have answers that one can look up in the back of the book. A colleague who wryly appraised the issues involved with this type of course commented “The society desperately needs a more informed public ... and we teach ‘em stoichiometry” (17). Stoichiometry, of course, does involve learning a useful set of skills. Courses such as ours, however, push students beyond this type of problem solving. Equally importantly, our course pushed us to cross disciplinary and cultural boundaries. Together we were forced out of our comfort zones to make the connections between chemistry, a set of issues that affect a particular community, and similar issues that affect communities worldwide.

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### Literature Cited

- Carlson, E. Course Blends Chemistry, American Indian Studies. *Wisconsin Week*, Dec 11, 2002.
- Middlecamp, Catherine H.; Baldwin, Omie. Uranium and American Indians, SENCER model course, 2004. [http://www.sencer.net/pdfs/Models\\_Print\\_Web\\_2004/Chemistry\\_Ethnicity\\_Model.pdf](http://www.sencer.net/pdfs/Models_Print_Web_2004/Chemistry_Ethnicity_Model.pdf) (accessed May 2006).
- Middlecamp, Catherine H.; Jordan, Trace; Shachter, Amy M.; Lottridge, Susan; Oates, K. Chemistry, Society, and Civic Engagement (Part 1): The SENCER Project. *J. Chem. Educ.* **2006**, *83*, 1301–1307.
- Humphreys, D. National Survey Finds Diversity Requirements Common around the Country. *Diversity Digest*. <http://www.diversityweb.org/Digest/F00/survey.html> (accessed May 2006).
- Report of the Ethnic Studies Requirement Review Committee, University of Wisconsin–Madison, July 18, 2002; p 9. <http://mendota.english.wisc.edu/~dankylesr.pdf> (accessed May 2006).
- Annual Report to the Faculty Senate, 2002–2003, UW–Madison University Academic Planning Council, Faculty Document 1736; p 3. <http://www.secfac.wisc.edu/senate/2003/0929/1736.pdf> (accessed May 2006).
- Eichstaedt, P. H. *If You Poison Us: Uranium and Native Americans*; Red Crane Books: Santa Fe, NM, 1994; p xvi.
- Eubanks, Lucy P.; Middlecamp, Catherine H.; Pienta, Norb J.; Heltzel, Carl; Weaver, Gabriela C. *Chemistry in Context*, 5th ed.; McGraw-Hill: Dubuque, IA, 2006.
- Memories Come to Us in the Rain and the Wind; Oral Histories and Photographs of Navajo Uranium Miners and Their Families*, Brugge, D., Ed.; Red Sun Press: Jamaica Plain, MA, 2000.
- Iverson, P. *Diné: A History of the Navajos*; University of New Mexico Press: Albuquerque, NM, 2002.
- Middlecamp, Catherine H. Uranium and American Indians Course Web Site. <http://www.chem.wisc.edu/middlecamp/201-spring04/> (accessed May 2006).
- Australian Academy of Science, Prospect or Suspect—Uranium Mining in Australia. <http://www.science.org.au/noval/002/002key.htm> (accessed May 2006).
- Kiste, R. C. *The Bikinians: A Study in Forced Migration*; Cummings: Menlo Park, CA, 1974.
- O’Neill, D. *The Firecracker Boys*; St. Martin’s Press: New York, 1994.
- Harper, D. R.; Meyer, A. S. *Of Mice, Men, and Microbes*; Academic Press: San Diego, CA, 1999.
- Student Assessment of Learning Gains Instructor Web Site. <http://www.wcer.wisc.edu/sal/gains/instructor/> (accessed May 2006).
- Personal conversation between one of the authors (CHM) and Stanley Smith, Department of Chemistry, University of Illinois at Champaign–Urbana, September 15, 2004. <http://www.chemistry.uiuc.edu/gsmith.htm> (accessed May 2006).