Kyoto Redoux: Assessment of an Environmental Science Collaborative Learning Project for Undergraduate, Non-Science Majors

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Abstract

How can we present science in a format that will allow college-level undergraduates not majoring in the sciences, including elementary education preservice teachers, to grasp an understanding of, and to gain, an appreciation for science in terms of everyday life and in the context that science is important in their own fields of interest? It is with these assumptions that "Kyoto Redoux," the major project for the course "Global Change," was chosen to be a simulation of the Conference of the Parties-3 (COP-3), sponsored by the United Nations Framework Convention on Climate Change (UNFCCC) in Kyoto, Japan. The purpose of this study was to examine students' perceptions of this collaborative course project as a component of a process evaluation of "Adventures in Science," a pilot program of a newly designed, interdisciplinary environmental science program for undergraduate, non-science majors. Non-traditional evaluation tools, including portfolios, focus groups, and team and self-assessments were employed. The research led us to a better understanding of practical, pedagogical applications in applying science content to non-science majors' career goals, promoting problem-solving skills in collaborative contexts, and structuring and assessing students' environmental course experiences.

Résumé

Comment présenter les sciences de façon à permettre à des étudiants universitaires de premier cycle non spécialisés en sciences, y compris des stagiaires en enseignement élémentaire, de comprendre et d'apprécier la science quant à son applicabilité dans la vie de tous les jours et à son importance pour leur propre domaine d'intérêt? En se basant sur ce questionnement, Kyoto Redoux, principal projet du cours ENV 102 – Changement planétaire, a été choisi pour simuler la troisième Conférence des Parties (CdP3) parrainée par la Convention-cadre des Nations Unies sur les changements climatiques à Kyoto, au Japon. Cette étude examine les perceptions des étudiants à l'égard de ce projet de cours collaboratif et s'inscrit dans le cadre de l'évaluation du programme pilote interdisciplinaire en sciences de l'environnement, « Adventures in Science », destiné aux étudiants de premier cycle inscrits dans un domaine non scientifique. Des outils d'évaluation non traditionnels ont été utilisés, notamment des « portfolios », des groupes de discussion (« focus groups ») ainsi que des évaluations collectives et individuelles. Cette recherche a engendré une meilleure compréhension des applications pratiques et pédagogiques liées à l'arrimage d'un contenu scientifique aux objectifs professionnels d'étudiants de premier cycle non spécialisés en sciences, à la promotion des aptitudes de résolution de problèmes dans des contextes de collaboration, ainsi qu'au développement et à l'évaluation des expériences des étudiants quant à ce cours environnemental.

While there have been several national initiatives to improve environmental literacy at the elementary, middle, and secondary levels in the United States and around the world for many years (e.g., McKenzie Group, 1995; Mortensen, 1995; O'Connor, 1995; Paraskevopoulos, Padeliadu, & Zafiropoulos, 1998), these initiatives have had little impact at the college level. College level environmental programs typically draw heavily upon faculty from other disciplines and fields. According to Corcoran and Tchen (1999), the low number and duration of interdisciplinary environmentally-oriented programs in American higher education is due largely to the guarding of disciplinary territory, academic politics of tenure and promotion, and a lack of administrative support and resources for faculty, facilities, and funding. Although interdisciplinary perspectives enable students to study the complex interdependence of individual, social, cultural, economic, and political activities and the biosphere, they require changes in the leadership and commitment by colleges to support new partnerships, professional development, and quality environmental programs (Elder, 1998).

While teaching ecological literacy and modeling activities for teachers to replicate in classrooms is an important science reform effort, (Bowers, 1996;

Wideen, Mayer-Smith, & Moon, 1998), there are few opportunities for pre-service teachers not only to learn about science, but do science by thinking and acting like scientists, exploring multiple scientific perspectives (Raizen, 1994). Rather than offer environmental education as an add-on to teacher education, or as a course only for environmental specialists, all students must understand that humans are an integral part of nature. They should have opportunities for working on real-world environmental problems in collaborative settings (Cortese, 1998). Numerous studies reviewed by Davis (1993) report that, regardless of the subject matter, students working in small groups learn more of what is taught, retain it longer, and appear more satisfied with their classes when collaborative learning activities are used. Although the National Science Foundation (1993, 1996, 1997) recommends collaborative and small-group work in science course and field experiences, few college educators have developed or assessed such experiences (Springer, Stanne, & Donovan, 1999). We contend that science instruction should include cooperative learning projects and that process evaluations should be employed to assess ongoing project activities, non-science majors' attitudes towards science, problem-solving, and laboratory skills.

Toward this end, in fall, 1997, undergraduate, non-science majors embarked on the "Adventures in Science," a pilot program for the development of a newly designed college-level environmental science program and a middle-sized, urban, Catholic university. In spring, 1998, students participated in Kyoto Redoux, the major course project of ENV 102, Global Change, the second course in the Adventures in Science program. Here, we examine the progress of our program development by documenting the strengths and weaknesses of the Kyoto Redoux project as identified through students' self-reporting using non-traditional science assessments, i.e., portfolios, focus group interviews, student and team evaluations, and faculty observations and notes. First, we give a brief program overview of Adventures in Science. Second, we describe the science-based learning activities of the Global Change course to situate the Kyoto Redoux project in the larger context of Adventures in Science. Third, we explain the Kyoto Redoux project and students' individual and cooperative assignments. We then share the research study and offer implications of our work to others interested in adopting similar approaches.

Adventures in Science: Program Overview

Students in Adventures in Science complete three sequential courses with each course based on the general theme of environmental science: ecosystems, global change, and environmental health, respectively. Basic scientific/environmental concepts and principles (e.g., nature of elements, bonding, Periodic Table, characteristics of plants and animals) are included in each course since science content knowledge is deemed essential. The primary goal of the Adventures in Science program is to investigate an integrated, thematic-based and hands-on learning approach improves the scientific and environmental literacy of college students. Program goals are consistent with those of the National Research Council (1996), the American Association for the Advancement of Science (1989), and Costa's (1991) educational goals for the 21st century, specifically that students learn how to reason, how to cooperate, and how to conserve our planet as a delicate, fragile ecosystem.

The specific goals of Adventures in Science are:

- to increase the scientific, including environmental, literacy of students by providing an integrated approach to the study of science, with an emphasis on the many ways science is interwoven with everyday life and public policy,
- to improve higher-order thinking skills of students,
- to promote increased student appreciation of and ability to apply mathematics and computer skills,
- to develop cooperative skills and provide shared learning opportunities for students,
- to give students meaningful experience in the laboratory and to expose them to methods employed in the field, and
- to give prospective teachers a more integrated and engaging curriculum in the sciences.

While these six goals are integral to each course, the present study focuses on the fourth goal of developing cooperative learning opportunities.

The evaluation of Adventures in Science has three phases. Phase 1 is the content evaluation, which monitors the development of the program, its courses and their instructional material, and associated activities. Phase 2 is the process evaluation, which monitors the program's implementation. Phase 3 is the product evaluation, which assesses the overall success of the program's implementation and its effectiveness for its users. This paper reports on one aspect of the process evaluation.

The purpose of a process evaluation is to ensure the appropriate implementation of the program, to detect weaknesses in its design, and make appropriate modifications to increase the probability that the program meets its objectives. This phase of the evaluation is particularly critical so that the pilot project can properly document the nature of the program, describe its strengths and weaknesses, and most importantly, make any changes in the program that are necessary before the program progresses too far. The primary methodology for this phase consists of obtaining feedback from students and instructors using interviews, logs, journals, and self-evaluations regarding associated experiences, such as cooperative learning research projects, and course evaluations. In addition, the progress of students is monitored by quizzes, tests, and grades received on assigned projects to determine if any changes are required in the program's design. Kyoto Redoux, the major course project in the Global Change course, was examined as part of this process evaluation.

Global Change: Course Overview

Global Change presented students with an overview of how to interpret the cycles and events, which make up the dynamic influences of change in the Earth's atmosphere, surfaces and oceans. The course included classroom lectures one-hour twice a week, a two-hour laboratory experience once a week, field trips, and a final project. The course began with a look at the various forms of energy, in their physical and chemical aspects. An introduction to the history of the formation of fossil fuels and the effects of their current usage rounded out this section of study. Laboratory exercises incorporated the measurement of energy, from calibrating thermometers to observing the effects of temperature and light on dark and light objects, to testing of automobile exhausts based on EPA standards.

Changes to the Earth's surface were then examined; changes based the chemical and physical reactions of natural and humanmade objects on Earth. Students learned about rock types, building, monuments, and other humanmade structures. Then they examined these objects for changes in their structure due to human-induced atmospheric manipulation, such as acid rain and ozone layer depletion. A field trip involved students observing and documenting the effects of pollution on older buildings in Washington. With a basic understanding of the physics and chemistry, which form the basis for climate studies and climate change, the class began a section in meteorology, e.g., interpreting weather maps, constructing topographic maps, laboratory activities with weather instruments and means of remote sensing, accessing several satellite web sites. The class topics at this point examined the impact of weather changes on biological and ecological systems on Earth, by looking at such problems as deforestation, the ozone hole, El Niño, icebergs, jetstreams, and global warming. With the foreword to global warming, Kyoto Redoux was introduced to the class.

Kyoto Redoux: Project Overview

Kyoto Redoux was designed as a simulation of collaborative scientific research in an interdisciplinary knowledge building community attempting to improve the environment. The project was a reenactment of the United Nations (UN) Conference of the Parties-3 (COP-3), held in Kyoto, Japan, December 1-11, 1997. The actual Kyoto conference was a global gathering of representatives from the governments of over 160 nations and individuals representing many public interest groups. The goal of this conference was to identify and put limitations on the emissions of greenhouse gases by participating countries at the conference. The science of global warming provided the foundation for these individuals to debate the effects of climate change in such areas as national and global economies, political factions, demographics, standards of living, and ethics. After heated negotiations, the first steps for controlling the problem of human-induced climate change by reducing the emissions of greenhouse gases that contribute to global warming were made, with a follow-up conference in Buenos Aires in 1998.

In preparation for this project, students completed forms during the first week of class indicating their majors, knowledge of other areas, such as language other than English, public speaking, and environmental action activities. The information sheets were used to determine a role of participation for each student and assignment to one of six working groups for design, preparation, and achievement of the conference simulation. These six groups were:

- Representatives of Countries and Coalitions,
- Representatives of Special Interest Groups or Non-Governmental Organizations (NGO's),
- Science Background and Policy Task Group,
- Production and Protocol Task Group,
- Design and Facilities Group, and
- Public Relations and Press Task Group.

Assignments to groups were made with an emphasis on students' majors, extra-curricular strengths, and interests, and faculty observations of group dynamics. For example, at least one political science major was included in each country and NGO group; an English major served as a conference reporter; drama majors prepared the design and facilities and coached speeches; communication majors filmed the presentation and presented speeches. This approach used was in agreement with the National Research Council's (1996) science teaching standard A: "Select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students" (p. 30).

Kyoto at CUA information booklets were given to each student. These booklets included the identification of each student's role, responsibilities and deadlines for each group, evaluation criteria, and background information and terminology regarding the actual COP-3. A great deal of other science information was also provided including: scientific reports from the Kyoto conference as well as from other COP-3 conferences, greenhouse statistics, science-concerned groups, internet sources, and resource books. Students began working on this long-term project in tandem with the rest of the course until early April, at which time all classroom and laboratory time was devoted to the project.

Each of the groups had specific responsibilities for the success of the conference. For example, representatives of the Countries and Coalitions group were required to write a position paper that included their country's interests and the effects and adaptations of climate change on their country's economy, trade, and lifestyles. This paper was written after first meeting with the Science Background and Policy Task Group, and that group's faculty advisors, as well as after hearing from the NGO's. Kyoto Redoux was carefully designed to provide students with multiple opportunities to work within their task group as well as across groups. Multiple assessment measures included: individual, peer, and group evaluations, students' participation, weekly reports, research and position papers, information kits prepared, promotional materials gathered, and portfolios.

In the classroom, students continued learning about the history of Earth's formation and the different events and cycles that are constantly altering Earth's surface: plate tectonics, volcanoes, earthquakes, tidal waves, and the impact of fossil fuel use. This information naturally led into an introduction to oceanography, with an emphasis on sea level changes, dynamics of ocean currents and waves, beach structure, and fresh and seawater interactions.

In conjunction with these classroom and laboratory exercises, two field trips to the "real world" demonstrated the power of the oceans and climate on landforms and how geological finds are used as monitors of the story of life on Earth. Field trips were taken to the Atlantic shores of

Maryland and Delaware on a day when a forceful "Nor'easter" roared into the area, to Calvert Cliffs on Chesapeake Bay, and on a canoe trip on the Anacostia River. Classroom lectures and laboratories concluded with a look back at the beginnings of events on Earth, by examining the impact of geological forces on our planet then and now, using fossil and rock analysis to provide visual evidence of these changes.

The culminating event of the course was the reenactment of the Kyoto conference and the activities, which led up to its presentation. University faculty, staff and students were invited, as well as members of the United States Congress, embassy officials from represented countries, and representatives from environmental groups. The student NGO representatives provided information about their respective organizations with lobby displays. Information from the embassies of the represented countries was available for all attendees. The Countries and Coalitions participants presented their final position papers and student United Nations representatives summed up the *Kyoto Protocol*, the legally binding agreement carried back by over 160 countries to their governments for ratification.

Prior to the course's take-home final exam, students participated in a campus trash clean-up and noted evidence of erosion on campus. Student reports and a letter was directed to campus maintenance with recommendations to encourage environmental improvement. By the completion of this course, students had studied long and short-term environmental changes, from a personal, local level to international levels. Summaries of ENV 102 and other Adventures in Science course lectures, laboratory experiments, digital photos of course and field trip highlights are documented on the Adventures in Science Web site (http://www.geocities.com/College Park/Lab/8822).

Theoretical Perspective

The importance of an interdisciplinary approach to the study of environmental science, utilized in this program design and implementation, has been stressed by numerous studies, including Project 2061 sponsored by the American Association for the Advancement of Science (1989), and the National Science Teacher Association's Scope, Sequence, and Coordination Project (Pearsall, 1992). The National Research Council (1996) and Hazen and Trefil (1995) also emphasize the importance of an integrated approach to the study of science that nourishes a community of learners. Kieg (1994) argues that a theme provides a broad perspective on science by connecting concepts and applications across the traditional science disciplines. This project incorporated both pluridisciplinary study (the juxtaposition of disciplines assumed to be more or less related [Jacobs, 1989]) and in this project, physics, chemistry, meteorology, oceanography, engineering, geology, biology, computer science, and astronomy. Interdisciplinary study, or a curriculum approach that applies the methodology and language from more than one discipline to examine a central theme, issue, problem, topic, or experience (Jacobs, 1989) was also employed. Interdisciplinary group work encouraged students to experience the interconnections across the sciences and other subjects, and in particular as it related to their own major area of study.

Faculty advisors from various disciplines nourished the interdisciplinary development and nature of the project. Politics faculty were a resource for the Countries and Coalitions group and NGO's; a drama professor oversaw the activities of the Design and Facilities and Production and Protocol Task Groups; a faculty member from the Department of Communications directed students in the Public Relations and Press Task Group. An environmental lawyer with the U.S. Department of Justice, who had participated in the actual Kyoto conference, shared his experiences and knowledge of COP-3. The coordinator of the grant project was responsible for oversight of the conference. An education professor served as project evaluator, with particular interest in preservice teachers' environmental education experiences in science courses.

Constructivist theory (Piaget, 1965) and sociocultural theory (Vygotsky, 1978) each support the view that dialogue and interaction with peers is essential to students' developing cognition, construction of knowledge, and personal theory building. Students of all ability levels had opportunities to interact in a shared task and to promote group success towards a mutual goal. Because new scientific ideas often emerge out of collaborative processes, the simulation allowed students to submit ideas for group consideration, build on each other's ideas, and reach a consensus for group action. The development of thinking skills is far more effective when students' thinking is challenged by real problems and real decisions (Berman, 1991). Creativity was encouraged within the framework of the assigned tasks—style of reporting, set and design features, use of theatre resources, and the design of promotional material by NGO's.

A cooperative learning model was utilized for the purpose of motivating and empowering learners to high levels of achievement while encouraging them to support, not compete, against each other in a democratic, team fashion (Baloche, 1998). Essential to the cooperative design was team and individual accountability (Johnson & Johnson, 1994, 1999). Group investigation, a method that goes beyond answering factual questions, was utilized. The method dates back to Dewey (1938) and was later refined by Thelen (1954) and Sharon and Sharon (1976) and is appropriate for integrated study projects that deal with the acquisition, analysis, and synthesis of information to solve a multi-faceted problem (Slavin, 1995). The method includes: topic selection, cooperative planning, implementation, analysis and synthesis, presentation of final topic, and evaluation (Arends, 1998). The role of the instructor includes introducing the broad topic, assigning subtopics according to student backgrounds and interests, serving as a facilitator, assisting the groups throughout the project in class, and helping locate resources.

Kyoto Redoux was designed to present science in a format that allowed students to understand and appreciate science better in terms of its applicability to their everyday lives and their major fields of study. McCaslin (1996) states that simulation exercises help students develop critical judgement and a sense of personal responsibility. According to Heller (1995), a formal recreating is like a play where students learn on the most basic level—by seeing, hearing, and doing. A simulation format was chosen so non-science majors could see science in action as related to their major and how global science issues affect sociological, political, and economic development and policy. Since the majority of students were political and economic majors, a reenactment of the Kyoto Conference was a good fit.

Methodology

Participants

Participants were 59 undergraduate students (39 females, 20 males) enrolled in ENV 102. All students were United States nationals; however, through the project enactment they had opportunities to take on the perspectives of other countries. One of the requirements for enrollment was no previous college-level science instruction, consequently resulting in a population of mainly freshmen: 52 freshmen, six sophomores, and one junior. Students represented a variety of disciplines including: anthropology, communications, English, politics, American government, pre-law, international business, drama, music, psychology, social work, history, and education. There were 19 students majoring in education who were required to participate, since Adventures in Science was deemed essential to their science teaching. All students committed to completing the three sequential science courses, which also satisfied university distribution requirements in science.

Data Sources and Collection

This was a naturalistic study (Lincoln & Guba, 1985) designed to describe students' perspectives of a project-based curriculum in an environmental science course. A qualitative method was chosen to acquire participant statements as data. The argument being that traditional educational evaluation strategies in science education that rely exclusively on quantitative data, exclusively measure student achievement, or attribute any impacts to a single source, "are not as directly applicable to the majority of the research-oriented, ground breaking inquires that make up the portfolios of many of the Foundation's efforts" (National Science Foundation, 1995, p. 1).

The method for process evaluation was based on information gathered during and after the project. According to Arends (1998), evaluation of student achievement in Group Investigation can include either self or group assessment or both and investigate students' affective experiences, (e.g., motivation, personal contribution), and higher-level thinking and reflection about their learning (e.g., methods of investigation, application of knowledge, problem-solving, decision-making). To this end, during Kyoto Redoux, two assessment instruments were used: (a) team and self-assessment during the project, and (b) group and faculty observation and assessment of the negotiation phase of the project. After Kyoto Redoux, evaluative instruments employed were: (a) student portfolios and (b) focus group interviews.

As a dynamic assessment activity, students were required to keep a portfolio of their work that included: a progress journal, a clear description of their role and responsibility in their group, a summary of their investigation and application of research to the group's respective task, and their reflection and assessment. The portfolio rubric, which students received beforehand, was developed by the authors and graded by the first author, who served as program evaluator. The purpose of this developmental portfolio was to chronicle and document students' contributions and performance for Kyoto Redoux, to promote self-analysis and critical reflection, and allow faculty to view and monitor students' integration of content knowledge. Portfolios assist in the evaluation of new instructional approaches which promote students' personal construction of knowledge and the support received in that process (Office of Educational Research and Improvement, 1993). Slater, Ryan, and Samson (1997) found that portfolios in a college science course were as accurate a measure of student achievement as were traditional assessment procedures (i.e., objective exams).

A second assessment method utilized in this study was focus group interviews. Focus group interviews have become an increasingly popular technique for gathering information and describing the current progress of projects. They are particularly revealing concerning the dynamics, within groups and across groups, affective measures such as attitudes, dispositions, motivation, and the identification of project strengths, weaknesses, and recommendations (Stewart & Shamdasani, 1990; Morgan, 1993; National Science Foundation, 1993, 1997).

Six groups of intact Kyoto Redoux groups were designated for the focus groups and responded to questions about the planning, implementing, and assessment procedures that were used for the Kyoto Redoux project. Two class instructors and one program consultant served as focus group moderators and conducted 30-45 minute audiotaped recorded focus group sessions. Tapes were transcribed and analyzed. Students submitted their portfolios and participated in focus group interviews during the final exam week. At that time, they also turned in their final take-home exams and completed course evaluations.

Data Analysis

In regard to qualitative analysis, the multi-data source was read and reread with marginal remarks and memos. As each data source was read, repeated statements were coded and checked with other statements. This process allowed for an analysis of patterns of similarities and differences and the marking of preliminary categories. Once categories were identified, the data were re-analyzed more systematically with line-by-line coding. Pattern coding was used to group overarching categories of students' views about the Kyoto Redoux project and to cluster views across informants (Bogdan & Biklen, 1992). Pattern coding, analogous to the cluster-analytic and factor-analytic devices used in statistical analysis, is a way of grouping summaries into a smaller number of constructs that identify an emergent "theme" (Miles & Huberman, 1984). Each data set was read again, with continuous refinement and reduction of categories.

Findings

Five major themes emerged from the qualitative analysis:

- Learning about environmental science issues,
- Making connections,
- Collaboration,
- Confusion and problem-solving, and
- Portfolios as a positive assessment tool.

Learning about Environmental Science Issues

Overall, the students viewed Kyoto Redoux as a valuable learning experience in learning about environmental issues. By the end of the semester, each student recognized the purpose, goals, and results of the actual Kyoto conference. They noted that they could now identify the causes and effects of global change, which gases cause environmental problems and why, while also recognizing that "this particular science consists of more than just formulas and equations." Students expressed their appreciation, awareness, and a sense of responsibility in learning and caring about the environment and the immediacy for worldwide reform and action. The project appeared to spark an interest in the environment as obvious in the following remarks:

> This project was not proposed by the professors simply to keep us busy, but instead to show the class through the redoux, what it takes for the entire world to make a conscious effort to help save our environment . . . This conference occurred so all countries would make an effort to reduce the amount of pollution and waste that has caused so much change that could be fatal to Mother Earth very soon.

> I feel privileged to have learned about an important issue that troubles many environmentalists, politicians, and many citizens around the world . . . there must be hope, determination, and education in which others will learn the truth of our living and being.

A student shouted out in the focus-group interviews: "We better care about the environment! I am aware of that now." This is a viewpoint we hope to develop further for all students.

Making Connections

Students explained how they appreciated the applicability of the project to the real world and to their area of study. During Earth Week when people came to campus, students were able to talk about the Kyoto conference and how it applied to a variety of disciplines. For representatives of the Countries and Coalitions, the nature of the project required the application of scientific knowledge in order to explain and justify their country's position on levels of gas emissions, as noted here:

> I think just the fact that we had to come up with positions that were based on science—like the reasons why certain countries were in favor of different policies was because this is what their strengths and weaknesses were and were based on science and the economy.

There were numerous comments about the connections that students made between Kyoto Redoux and their major area of study. An education major states, "I can see myself going into a fourth grade class and doing the same (project)." Another education major reflects in her portfolio, "broadening your perspective will help make you a better teacher." An undecided major expressed his realization of the interdisciplinary connections he had made:

> That's what the whole experience was about—like the politics of environmental issues, educating people about the environment . . . from a communication standpoint giving a speech, from an education standpoint learning to reflect, and from a drama standpoint, being able to deliver a speech.

Our interdisciplinary pedagogical approach appeared to create a sense of competitiveness between the disciplines for several students and a sense of cohesiveness for others. For example, students who worked in the task groups, for example, Production and Protocol and Design and Facilities, indicated they had not learned as much about science as they did about their major. One student felt that "there was not enough science and a lot of the work that we had to do on Kyoto was politics-oriented and economics-oriented." Nonetheless, another student, working in the Design and Facilities Task Group, stated that she researched the actual conference thoroughly to better understand how to prepare the design. Other students explained that they "saw environmental issues through politics" and enjoyed being able "to view the scientific world through another discipline" and "to see the important role of policy in environmental issues." The differentiated tasks and learning experiences in the cooperative learning groups may also have enabled some students to make the connections more easily than others.

Collaboration

Peers and faculty supported students in their developing understanding of environmental science. From a Vygotskyan (1978) perspective, students learned by listening, questioning, and negotiating. "I learned more about where I stood by hearing about other countries' points of view and working together." A student, who had difficulty in understanding Kyoto, claims "Talking with my peers helped me understand it better and contribute to the project." A student representative from the European Union coalition stated: "Our coalition bonded in an odd sort of way and I left excited when arguing with my friend about emissions trading."

The "truly collaborative effort" as an individual described it, was required in order to prepare one major paper. Operating like a "tag team," tasks could be easily separated but synthesized for a team report and presentation. The idea of going public motivated many students to do their best, get serious, and polish their writing and speaking skills. A student remarked, "Knowing we had a big presentation meant we had to do a good job so we all got together and said, "Yea! Let's do this. Let's make it work." According to students, the cooperative effort required that they learn to deal with each other's attitudes, feelings, and perspectives. It involved searching and working with material, being responsible for a personal contribution "because you don't want to let someone else down," arranging out of class meetings, and making deadlines. Problems arose across groups when deadlines were revised but ultimately "the groups had to work interactively to make the conference happen." Students repeatedly mentioned that the structure for cooperative learning needed more thought, particularly the classroom arrangement of a large auditorium with unmovable theatre-like seating. Ideally, smaller classrooms not in regular use, would have better accommodated the group work.

Confusion and Problem-solving

Students remarked that they were confused about the purpose of the project and their assignments, especially in the beginning. The "big words" were intimidating and the big picture was not in focus. For several students there was too much information to sort through and for others, there was limited information available (for example, the unresponsiveness of some embassies and the special visitation passes needed to enter the World Bank). For the most part, the inquiry approach was novel and caused tension, as did the use of multiple instructors. Students, who may have been accustomed to a traditional format of science teaching in their previous schooling, expressed their frustrations to the project coordinators. Students also attributed some of their confusion to other factors including: the distant project goal, the particulars that led up to the final conference presentation, the large class size, the lack of input in reshaping the final positions of countries during the negotiation and presentation phases, the time allocated for the project, negotiations, and reflections, and revised schedules and deadlines. The majority recommended a tighter course structure in the future, for example, laboratory work directly connected to the Kyoto project, better organization, clarity, and direction. Many students reported their disappointment in the poor turnout of visitors to the presentation, the length of the re-enactment, and the high-grade value allocated to the project.

As in any course, there was a large variance in students' scientific knowledge and sense of competence in dealing with scientific content. Much of the confusion was alleviated through students' own ingenuity and problem solving efforts, e.g., collaboration, peer coaching, and finding alternative information sources. For instance, students found additional information at bookstores and on the Internet, especially when the link-up for translations from Spanish and French was not available. They shared research material, rearranged meetings, negotiated, and made compensations. Gradually, things became much clearer:

> I started very slowly and confusingly and ended with a bang. I learned more in the negotiation process. Once I understood the point of everything, then I became more interested. In the last few weeks everything really pulled together.

The simulation was a cathartic exercise in problem-solving environmental dilemmas—the role-playing enabled them to feel as if they were actually participating in the conference:

> This project let me pretend I was really there and helping the Earth along with all of the other countries in the world (a drama major).

> I wanted to let the audience know and believe that I was an actual representative of Japan . . . I next found myself thinking like I was really from the Japanese coalition. (a politics major)

Nonetheless, being from another country was not always a comfortable or choice role. A representative from the Developing Countries coalition complained: "I couldn't stand the fact that China really didn't want to make an initiative to help stop gas emissions." When a representative from India found out "India had spoiled everyone's plans!" (by not agreeing to any set gas emissions standards), she exclaimed:

> How was I to defend a country that crushed the plans of my home? (The United States) . . . I wrote a letter to all the professors of Kyoto stating my disgust for having to defend a country [to which] I was randomly assigned and that goes against my views. I wanted to quit, but I didn't. Instead, I researched. I began to see the light . . . .

A new-found confidence evolved as students conducted research and negotiated more effectively, "I learned that I truly do like politics and that I should not be intimidated by those who appear more affiliated with the world than me." A student asserted, "I think if people really understood the true meaning behind the conference, they would have been a lot more excited about it." Another writes, "I can't believe these words as I type them but, I had fun and learned a lot about international diplomacy. Next semester I plan to join the model UN (United Nations) club on campus and do some more negotiating."

Portfolios as a Positive Assessment Tool

In the focus group interviews, students stated that the portfolios helped them successfully organize, synthesize, and review their newly-acquired scientific knowledge. Through the developmental portfolio process, students commented that they were "able to access and really bring everything together." It enabled them "to look back, see, and think about what was important" and helped them realize how much they had learned:

> I think one of the most interesting points was when you look back at the different drafts you turned in for one paper and see how each draft was different and how much you progressed, that really helped. You could go back and see what you learned from someone else.

Several students commented that they were pleased for the opportunity to showcase and document their individual efforts, which might not have been obvious to the instructors because of the nature of the group work.

A student from the Public Relations and Press Task Group writes in his portfolio, "It's different for everyone. I mean what you get out of an experience. Me, personally, I thought it (the portfolio) was more work." Another member of the same group reflects in her portfolio, "The project made me look at the Earth with a smile . . . I learned a lot about global warming and what we need to do."

Quantitative Analysis

Quantitative analysis was conducted using SPSS stepwise regression and correlation analysis to explore for relationships in students' majors, gender, and grades on portfolios, Kyoto Redoux, and the course. Significant findings were found only in relation to gender and portfolios. A correlation analysis indicated a statistically significant correlation between gender and portfolio grade with females receiving higher grades; $r = .334$ ($p < 0.05$). Perhaps the portfolio, as an assessment tool, offers opportunities for relational ways of knowing common to many women (Belenky, Clinchy, Goldberger, & Tarule, 1986). Female instructors designed the rubric and a female professor graded them. Also, the portfolio may be a less competitive way of learning (Seymour, 1995) or being evaluated.

Incorporating portfolios is a part of an assessment system reform in science evaluation—a feminist pedagogy that shifts some control to students by representing their diverse experiences, perspectives, and abilities (see Roychoudhury, Tippins, & Nichols, 1993-1994). For those working with preservice teachers, portfolios provide a unique lens for learning about future teachers' diverse linguistic and learning styles, cultural backgrounds, and personal experiences (Garcia & Pearson, 1994). This alternative form of documenting one's learning may help foster females' positive attitudes toward science which have been found consistently lower than that of males (Weinburgh, 1995).

Conclusions

In this study, we gained much information in employing cooperative learning and simulation exercises and in refining and improving our course work in the development of a prospective environmental science program. According to students, the Kyoto Redoux project was useful in providing opportunities for the development of cooperative skills and shared learning experiences, which was one of the Adventures in Science program goals. Qualitative analysis and measures were sensitive to evaluating this larger program goal in terms of both cognitive and affective outcomes. In terms of quantitative analysis, the significant correlation between females and grades on portfolios is an interesting area for further research on possible gender preference in science assessment.

Science education has historically involved students in proposing a hypothesis, conducting an investigation, answering a question, writing results, and stating a conclusion—whether the hypothesis was correct, incorrect, or undetermined. Science learning typically occurs in structured laboratory experiments and from information gathered from lectures, textbooks, and decontexualized experimentation. Global Change was a science course in which students were active participants, researchers, and decision-makers concerning human-induced climate change. They had to make a plan, partition tasks, share expertise with team members and other teams, and reach closure of their investigation for a campus-wide presentation. There was a great deal of interactive work necessary to inform each other of the scientific, historical, and economic decisions reached. It was an event that had an immediate impact on their personal lives, as world citizens, living and protecting life-sustaining processes.

The larger program objectives of Adventures in Science may seem rhetorical, that is, one might expect that an integrated, thematic-based and hands-on-learning cooperative approach would be successful. However, Kyoto Redoux, as one course project in Adventures in Science, exemplifies the difficulties in the implementation of such approaches. Our research corroborates the widely held and must tested view that “doing” is an integral part of learning science, even at the college level. However, it suggests to those interested in adopting this approach to think carefully about their own planning. Organizing for cooperative learning, above all, necessitates structured, long-term planning. It must involve: consideration for creating a conducive learning environment for peer interaction and review, consideration of group size and composition, frequent teacher monitoring of both scientific knowledge and group dynamics, and meaningful interactions between faculty and students—questioning, providing feedback, and encouraging self-regulation of student learning (Mandel, 1991).

In Kyoto Redoux, students freely reported on the weak aspects of the cooperative project and offered many recommendations for the radical and new pedagogy employed. Several students complained about the lack of structure, direction, and expectations. For many, this pedagogical shift may have been too much of a stretch—too uncomfortable, perhaps too much, too fast. There needed to be more attention given to its design and execution. Despite the confusion and discomfort, students’ self-reporting does suggest they acquired an understanding of environmental issues and scientific knowledge related to global change, an applicability of environmental science across disciplines and within their own discipline, and had opportunities in developing collaborative and problem-solving skills. Utilizing cooperative activities and simulations of environmental events at the college level, even those of a much smaller scale and complexity than Kyoto Redoux, is a promising science pedagogy that merits further investigation.

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