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ABSTRACT

This paper describes an evaluation by two science educators of the pilot offering of an interdisciplinary critical issues course in Science, Technology, and Society (STS) designed to fulfill the natural science general degree requirements at a major university. This social science general studies course is an STS interdisciplinary course that emphasizes: how science and technology are stimulated and guided by social institutions and values, the interaction of science and technology and their impact on our lifestyles, and that responsible individuals can exert beneficial influences on technological developments and their social effects. The major sources of data for this evaluation came from interviews conducted with students, module instructors, unit instructors, and the graduate assistant. Topics covered include: interviews with students and the principal findings from these interviews including strengths of the course, changes recommended, and students' perceptions of their own understandings; student interests and desired outcomes; interviews with instructors; and assertions and recommendations. Interview questions are listed in the appendix. Contains 30 references. (JRH)

A SCIENCE-TECHNOLOGY-SOCIETY (STS) CRITICAL ISSUES COURSE FOR GENERAL STUDIES NATURAL SCIENCE CREDIT: THE EVALUATION OF A PILOT OFFERING

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Paper presented at the Annual Meeting of the National Association for Research in Science Teaching
San Francisco, CA

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A SCIENCE-TECHNOLOGY-SOCIETY (STS) CRITICAL ISSUES COURSE FOR GENERAL STUDIES NATURAL SCIENCE CREDIT: THE EVALUATION OF A PILOT OFFERING[1]

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This paper describes an evaluation by two science educators of the pilot offering of an interdisciplinary critical issues course in Science, Technology, and Society (STS), developed through a project funded by the National Science Foundation (NSF). The course was designed to fulfill the natural science general degree requirements at a major university, and in so doing, responded strongly to the reformation call issued by The Study Group of the American Association for the Advancement of Science (AAAS) on General Education and the Sciences: Radical reform of the natural science general education component of the undergraduate curriculum is in order (AAAS Study Group, 1990).

The AAAS Study Group makes clear that science is a liberal art and science instruction that satisfies general education requirements must foster an understanding of concepts unifying the sciences with other disciplines as well as interactions of science with technology and society. Critics contend that postsecondary education in the United States generally has failed to provide college graduates with the science and technology background they need to be liberally educated, and as responsible citizens and workers, serve a technological and informational society (Fol:z & Roy, 1991; Hetherington, Miller, Sperling, & Reich, 1989). Science instruction pays insufficient attention to the applications of science in society and permits ignorance of science, technology, and society interactions (Bernstein, 1993; Ellis & Ellis, 1991). Hurd (1992,1993) and Ramsey (1993) provide strong support for utilizing the STS approach in the reconceptualization of science teaching and in providing for the scientific literacy needs of a general education. Ellis and Ellis believe that all liberally educated citizens should be "lay scientists" as evidenced by their ability to understand and make informed decisions about societal issues dominated by science and technology.

[1]A paper presented at the 1995 (April) Annual Meeting of the National Association for Research in Science Teaching, San Francisco, CA. This paper is based upon work supported by the National Science Foundation (NSF) under Grant No. NSF-DUE-9254108. Any opinions, findings, assertions, and recommendations expressed in this paper are those of the authors and do not necessarily reflect the views of NSF.

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Background

The project *"Critical Issues in Science, Technology and Society: An Integrated Course Sequence"* (NSF-DUE-9254108) was awarded to the STS Program at a major university in the Summer of 1993 by the NSF Undergraduate Course and Curriculum Development Program. The STS program is interdisciplinary, housed in three of the university's Colleges (Engineering, Agriculture, and Earth and Mineral Sciences). The primary mission of this project was to develop an interdisciplinary natural science general studies education course that focused on critical STS issues. This course was to be integrated with an exisiting social science general studies education course (three credits) at the university and become the second half of a six-credit critical issues course sequence taken over two semesters. The social science general studies course is an STS interdisciplinary course that emphasizes (a) how science and technology are stimulated and guided by social institutions and values, (b) the interaction of science and technology and their impact on our lifestyles, and (c) that responsible individuals can exert beneficial influences on technological developments and their social effects. As such, this social science general studies course would provide the STS "foundations" for the investigation of the critical issues targeted in the natural science general studies course, hereafter known as STS 251—the actual course number was different.

The issues proposed as foci for the STS 251 course were global or "greenhouse" warming (GW), energy options (EO) for the future, and biodiversity conservation (BC). These issues were chosen because they present a breadth of interrelated scientific content, are politically interdependent, and are socially urgent on a global scale. They provided a personal and societal context for the learning of science. Additionally, faculty who commanded world-class s[illegible] and technological expertise relative to these issues were available at the university, and interested in collaborating as an interdisciplinary team of instructors for the course. Ultimately, the goal of the project was to disseminate this six-credit critical issues course seqence as a model within and outside the university's system.

STS 251 Course Development and Instruction

Beginning in the Summer of 1993 and through the Fall Semester of 1993, a group of faculty from the STS Program who would teach STS 251 developed the pilot version of the course. This group was headed by the Director of the STS Program and the professor who authored the NSF proposal, and included instructors and a graduate assistant from the Departments of Geography, Fuel Science, and Entomology. The course evaluators were invited to sit in on the faculty meetings that guided course development; such involvement contributed to the prolonged engagement (Erlandson, Harris, Skipper, & Allen, 1993) the evaluators had with the course and informed the evaluation design for the pilot offering of the course. At these meetings, the evaluators were viewed as resources on pedagogy and were asked to provide the course developers (i.e., the instructors) with references and two workshops that dealt with current reform thrusts in science teaching, including authentic assessment, concept mapping, constructivism, cooperative learning, and the STS issue investigation and action model (Rubba & Wiesenmayer, 1985). The course evaluators asked the instructors to keep a journal, in which they would enter their reflections on each of the course development meetings, and at a later time, provide to the evaluators journal entries that they felt comfortable in sharing.

The course was organized as a responsibility spiral (Waks, 1992) and grounded in the evaluation research of Rubba and Weisenmayer (1985, 1993). Relative to the critical issues of GW, EO, and BC, the course was to place emphasis on the underlying science, interrelationships, societal impacts, and public policy. Course development included the writing of booklets to serve as the principal course texts. Student outcomes proposed by faculty, relative to the three critical STS issues and their interrelationships, were as follows: (a) understandings of science and public policy concepts, technological impacts, and resources and methods for issue investigation; (b) skills in scientific and technological literacy for reaching informed decisions and taking citizenship action towards issue resolution; and (c) interests in learning more about STS issues.

The course was offered over the Spring semester, 1994, and met each week for one two-hour lecture and one three-hour laboratory period. The three critical issues (GW, EO, and BC) were scheduled as separate science and technology "modules": Each module comprised a sequential three to four week segment of study and was taught by a different science faculty member. Between each module, and at the beginning and end of the course, were placed one to two week "wrap-around" sessions, taught by the STS program director and author of the NSF proposal that funded the project. Collectively, these wrap-around sessions were known as a unit on Science, Technology, and Environmental Policy. This unit focused on social science and public policy concepts and the interplay of public issues associated with science and technology. It also provided forums that engaged students in critical thinking as it pertained to decision making and resolution of the three critical issues, and was intended to explicate interrelationships across these issues.

Methodology

Two science educators from the Department of Curriculum and Instruction at the university were the course evaluators. These science educators had professional experience in curriculum development, implementation, and evaluation that focused on STS themes, including GW. The evaluation design they developed was objective driven; that is, the objectives for STS 251 developed by the course faculty were used to focus the evaluation. To facilitate triangulation (Erlandson, Harris, Skipper, & Allen, 1993; Marshall & Rossman, 1989) of data, a variety of data sources/evaluation means were proposed: standardized open-ended interviews with course faculty and students (Gunstone and White, 1992; Patton, 1990; Rye, Rubba, & Wiesenmayer, 1994); student constructed concept maps (Edwards & Fraser, 1983; Novak & Gowin, 1984); student responses to 16 items from the Views of Science-Technology-Society (VOSTS) instrument (Aikenhead & Ryan, 1992; Schoneweg & Rubba, 1993); student input via electronic mail (e-mail); access to the course booklets and student exam results; and observer-participant (Merriam, 1988) observation of class sessions. The STS 251 course objectives and respective evaluation means that comprised the evaluation design are outlined in Figure 1. The evaluation means described therein target

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Insert Figure 1 about here

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the students who participated in the evaluation. Additional evaluation means relative to the course objectives were interviews with participating course faculty and the graduate assistant, as described more fully below.

Participants

The pool from which participants were recruited for this evaluation were the STS 251 course faculty, including the graduate assistant, and the students taking the course for credit. The number of students enrolled in this pilot offering of STS 251 was small. It initially consisted of 12 students (equally distributed across gender) who were enrolled for credit; two additional students sat in on the course. These students represented a variety of majors, but were not a cross section of the target student population for the course. For example, one student was a University Scholar who previously had taken two other STS courses and a non-technical course in college physics. Another student was a football player who had graduated and was in school awaiting the NFL Draft.

So as to limit interference with the course's curriculum and instruction, and to conform to the ethical requirements of research and evaluation involving human subjects, the participation of all students and faculty in all aspects of the evaluation was voluntary. Eleven of the 12 students enrolled volunteered to participate in the evaluation. Additionally, all five course faculty and the graduate assistant volunteered to participate in interviews surrounding their instruction. Informed consent was secured from all volunteers and monetary remuneration (five to seven dollars for a concept map and 10 to 15 dollars for each interview) was provided to those students who elected to participate, regardless of the quality of their participation or the information provided.

Interviews

Seven different standardized open-ended interview protocols were utilized by the evaluators over the duration of this evaluation to conduct private interviews with subjects. All interviews with students and most of the interviews with course faculty were audio-taped. The interviewers (who were the two course evaluators) took notes during the interviews and subsequently listened to the audio-tapes as needed to verify and supplement their notes. Most of the audio-tapes were not transcribed due to budgetary constraints.

The evaluators' experiences with protocols that guided the conduct of interviews early in the course informed the development of protocols utilized to conduct interviews at subsequent points in the course. The seven different interview protocols were as follows: (a) pre-module interviews with students; (b) post-module interviews with students; (c) course-drop interviews with students; (d) end-of-course interviews with students; (e) pre-instruction interviews with course faculty (the wrap-around unit instructors were interviewed at the beginning of the course and the module instructors were interviewed at the beginning of their module); (f) post-module interviews with module instructors; and (g) post-course interviews with the wrap-around unit instructors and the graduate assistant.

As described above, the course contained three modules (GW, EO, and BC). Budgetary and time constraints did not allow for the scheduling of pre- and post-module interviews with all student subjects.

Accordingly, a pool of six students was purposefully selected from amongst all student subjects to represent the diversity (gender, ethnicity, major, and academic standing) of students enrolled in the course. Subsequently, two different students (one female and one male) from this pool were scheduled for pre- and post-instruction interviews surrounding each of the three modules. There was a high degree of similarity between the pre- and post-module interview questions posed to students. The pre-module interview questions are shown in Table 1.

Insert Table 1 about here

The course drop and end-of-course student interviews originally were not a part of the evaluation design. The evaluators had planned to conduct course follow-up interviews during the Fall Semester with the six students chosen for the pre- and post-module interviews, chiefly to examine any impact the course may have had on students' level of interest in and taking action towards the resolution of STS issues. However, as explained in the findings section of this paper, student attrition from the course compromised the pre- and post-module interview data collection from student participants, and led to the need to interview student participants who dropped the course and to schedule "end-of-course" interviews with student participants who remained enrolled in the course. The questions that comprised the course drop interview are discussed in the findings of this paper and those comprising the end-of-course interview for the student are shown in Table 2.

Insert Table 2 about here

Most of the questions in the end-of-course interviews for the students were very similar to those posed in the end-of-course interviews for the wrap-around unit instructors and the graduate assistant. For questions that asked students to provide self reports of their pre- and post-course understandings relative to course content (Table 2, question 4), corresponding questions were posed to the wrap-around unit instructors where they were asked to describe major understandings that they thought students developed in the course. For queries to elicit what students believed to be important interrelationships amongst the three module topics (Table 2, question 5), the wrap-around unit instructors were asked to describe understandings of important interrelationships that they believed student's had actually developed. Additionally, these instructors were asked to describe how they would have wanted students to answer the testimony simulation question (Table 2, question 6).

The questions that comprised the pre-instructional interviews (Table 3) for all course instructors were aimed at identifying (a) the outcomes instructors desired students to achieve by completing their module or the wrap around unit, (b) the concepts in their module or the wrap-around unit that they wanted students to understand, and (c) the interrelationships between these outcomes and the course objectives and all of the course modules. The post-module interviews (Table 4) for the module instructors revisited the questions about module outcomes and interrelationships and elicited further changes and recommendations instructors had in mind for future teaching of their module and the course.

Concept Maps

During the developmental stages of the course, faculty had expressed some interest in concept mapping and the evaluators were asked to provide a related workshop. Use of the concept map tool (Good, Novak, & Wandersee, 1990) held the potential to facilitate course planning and certain emphases of the course: critical thinking, creativity, and developing an understanding of the interrelationships amongst science, social science, and public policy concepts. Course faculty utilized concept maps to some degree in planning their course modules and in conveying knowledge in their respective course booklets (see Figure 2) and class presentations.

Insert Figure 2 about here

However, concept mapping activities were not planned or executed as part of any instructors' course assignments or tests.

Therefore, in order for the evaluators to employ concept mapping as an evaluation tool, enrolled students needed instruction to develop mapping skills. Accordingly, the evaluators developed a self-instructional packet on concept mapping. The packet embraced an inductive approach, where students learned the features and attributes of concept maps while engaged in constructing concept maps on a familiar topic: household waste. The packet culminated in students preparing a concept map of the topic "concept map" (Novak & Gowan, 1984). This packet was provided on the second day of class to all students who volunteered for the course evaluation.

Accompanying the concept map self-instructional packet was the first of four concept map "assignments" to be completed voluntarily as a part of the course evaluation. This assignment instructed students to map several concepts central to the first module and that cut across the entire course. Most of the concepts to be mapped were provided to students by the evaluators, who had gleaned them from pre-instructional interviews (Table 3, question 4) with the instructors of the first module and the wrap-around unit. This assignment, shown in Figure 3, was intended to elicit students' understandings of these concepts at the beginning of the course; the additional concept mapping assignments were to explicate students' understandings at the end of the first module and surrounding the other modules and at the end of the course. The instructors of the course modules agreed to prepare a concept map of the concepts provided in the student concept map assignments, after they completed the instruction of their modules. These instructor-prepared concept maps, which were to set forth the understanding that each instructor hoped enrolled students had developed as a result of instruction to date in the course, were to be used by the evaluators in assessing the student prepared maps.

Insert Figure 3 about here

As shown in Table 1 (questions 5 and 6), the student-prepared concept maps were also to be utilized as an auxillary visual in the student interviews. The maps were to serve as a basis for probing students' understandings about concept relationships explicated in their maps.

Class Session Observations

As set forth, the evaluation design (Figure 1) did not include class observations as a major data source. However, these observations did contribute in important ways to the course evaluation, as discussed below. Class sessions included lectures, forums, and laboratories. Collectively, the two course evaluators attended the majority (21) of these sessions, however, the evaluators did not stay for the duration of the laboratory periods. The evaluators kept each other informed, via electronic mail and conferences, on their class observations.

The principal reason for the evaluators attendance of class sessions was to keep abreast of "what was happening" in class. This included taking notes on class attendance, course content conveyed, teaching methodologies employed, and student-instructor interactions. This immersion of the evaluators in the course class sessions was viewed by the evaluators as important to the conduct and interpretation of the interviews with students and instructors.

To limit their influence on course instruction, the course evaluators did not pose or answer questions, or comment otherwise, during class sessions. However, the students and faculty knew the evaluators' identities: Their presence during class sessions was obvious, and this presence may have had impact on instruction.

Electronic Mail

Electronic mail (e-mail) was a planned component of STS 251. Students were provided with a "hands-on" orientation and user account for the duration of the course. Students and faculty could post messages for other STS 251 students and faculty to read, and respond to as desired, on a course bulletin board; students and faculty also could correspond privately with any other students, faculty, and the course evaluators. Course evaluators monitored the e-mail postings. They also solicited, via announcements in class, private e-mail messages from students participating in the evaluation on how the course was going (e.g., likes and recommended changes).

VOSTS Instrument

Data were collected on students' views about STS interactions at the beginning and end of the course using 16 multiple-choice items selected from the 114 items in the Views on Science-Technology-Society (VOSTS) item pool, Form CDN.mc.5 (Aikenhead & Ryan, 1992). These were the same 16 VOSTS items used by Schoneweg and Rubba (1993; Bradford-Schoneweg, Rubba & Harkness, in press) to assess students' views about STS interactions in the preceding course, STS 200--Critical Issues in Science,Technology and Society. From that work, it was assumed that the VOSTS items possessed validity and were reliable for the purposes of this assessment. The data analysis procedures followed are described by Bradford-Schoneweg, Rubba and Harkness (in press).

In summary, this evaluation design, as conceived and modified as needed by the evaluators, represented their efforts to carry out a "practical evaluation" (Patton, 1980) that involved stakeholders and was creative yet situationally responsive. The qualitative emphasis of this evaluation provided for an in-depth examination of multiple and unique perspectives of the course faculty and enrolled students. The prolonged engagement that the evaluators had with the course, and the awareness they maintained of the course content and dynamics from observing class sessions, were considered very important to the trustworthiness (Erlandson, Harris, Skipper, & Allen, 1993; Patton, 1990) of the assertions and recommendations that emerged from the findings of this evaluation.

Findings

Over the period of the semester, two students who had volunteered for the evaluation dropped the course after completing a portion of the course. Given the small size of the course, these drops had a greater than normal impact on the availability of student participants for the interviews. Interview data were not available for some modules from the same students pre- and post-instruction. Additionally, two other factors compromised carrying out the evaluation design as conceived: (a) Few students elected to complete the concept map course evaluation "assignments" at the beginning of the course (Figure 3) and at end of the first (GW) course module; and (b) Most students elected not to provide input to the evaluators on the course via e-mail, despite a number of requests made by the evaluators to do so. As a result of the above, several measures were taken. Two student subjects who dropped the course agreed to and followed through on their commitment to a "course-drop" interview, which queried them on reasons for dropping the course as well as perceived strengths of and changes needed in the course. An attempt was made to interview at the end of the course all student subjects who remained in the course: Six of the students agreed to an interview and four followed through with their commitment. The concept maps (and corresponding interview questions, Table 1, items 5-6), e-mail, and the course follow-up student interviews were abandoned as data sources. Additionally, the reflective journals that the evaluators asked the course instructors to keep during course development were not used as data sources by the course evaluators.

The major sources of data for this evaluation came from the interviews conducted with students, the module instructors, and the wrap-around unit instructors and the graduate assistant. Additional information was gleaned from the informal class observations, the course booklets, and the VOSTS item responses. Findings from each of these sources are summarized below.

Interviews with Students

The course evaluators were able to obtain a pre-module interview on five students, but only able to obtain both pre-module and post-module interview data on three students. Still, the experience of conducting, and data obtained from, these interviews were very useful to the course evaluators in formulating interview questions to comprise the end-of-course (Table 2) student interview protocol. Data from these end-of-course interviews was obtained from four of the six students who had agreed to this interview. The evaluators do not make the claim that these four students were representatives of all students enrolled in the course. However, these four students did represent the gender distribution of the students who remained enrolled in the course and included students who matched the target audience for a 200 level science course for non-science majors.

Some of the questions that comprised the pre-module, post-module, and "course drop" interviews were aimed at collecting or revealed data on some of the parameters targeted by the "end-of-course" interviews. Two of the six students who had agreed to but did not follow through with an end-of-course interview did complete a pre-module or post-module interview during the last month of the course. Additionally, the evaluators did have interview data from two other students who had dropped the course after completing a portion of the course. These four students' responses, where appropriate, were pooled with data obtained from students who completed the end-of-course interview. This pooled data, which represents the reponses of from four (33%) to eight (67%) of the students who enrolled for credit in the course, constitutes the principal findings of the student interviews and is described as such in the section that follows. Subsequently, additional data from the pre-module interviews is presented that regards students' reasons for taking and outcomes they desired to obtain from the course.

Principal Findings

Most of the parameters on which the interview questions elicited student reponses are presented below. The total number of students (e.g., four of seven) who comprise the data-base for the findings on any parameter is noted when this number exceeds those four students who completed the "end-of-course" interview.

Major Strengths of Course. All of the students (six) stated directly or inferred that the course instructors as individuals were a major strength. In connection with this, various students perceived the instructors to have certain "positive" characteristics, e.g., flexible, receptive, very intelligent/experts, and to care about teaching. One of the students had this to say about the instructors:

> You know, one of the strong points of the class was the fact that all the teachers seemed to pretty much care what they were doing . . . . [Y]ou'd see a lot of the professors of the other modules sitting in on the class, even if it wasn't their module and to me that was a sign they were, you know, interested.

Two students cited "small class size" and the course topics and various resources as strengths.

Changes Recommended. The question (Table 2, question 2) to elicit students' suggestions for changes in the course did not ask students about any specific aspects of the course, i.e., it did not "direct" their thinking towards any given course parameter. Therefore, student responses likely reflected what was most pressing on their mind in terms of modifications they would like to see made in the course. Four of the eight students inferred that it would be good to get students more involved. One student described this as a need for the course to be more "thought provoking." Another student suggested requiring students to keep a journal in response to thought provoking/reflective questions and hand it in periodically. Three students talked about the need for the course to be more organized; two of them referred to the course as being too "scattered." Three students also suggested that the EO module was too technical or there was a need to reduce some of the concepts therein. Another suggestion, mentioned by two students and that surfaced again later in these findings, was that both faculty and students needed to be more active on e-mail.

Course Scheduling. Although two (of eight) students did state that they liked the schedule as is, three others stated that the two-day, two and three hour time blocks over which the course was scheduled made it difficult to schedule other courses. Three students also voiced the need to have class meet three times per week. One of the students put it this way:

> I keep on feeling that this time is being wasted. I'm not quite learning as much as I could. It probably has to do with the fact that it's [class] on Mondays and Fridays. So, a whole half of a week goes by and I don't retain.

Number of Instructors. Most (four of six) students favored having at least three instructors for the course. Reasons cited included the array of expertise and the different viewpoints the instructors presented. However, students did bring up the concern that it was hard to adjust to the changes in professors and that they needed to coordinate moreso.

Lecture. The most frequent comments made (by three to four of six students) were that the lectures were either good or interesting or that they were reiterations, or at least represented the majority, of what was present in the readings.

Readings. There was no trend present in the comments received about the course readings. Some students found the need to have more readings and to have the booklets standardized across the modules. Other students found desirable the technique employed in one booklet of "boxing in" certain information, or that the modules presented information that was worthwhile keeping as a reference.

Forums. Two students saw these to be the "most valuable" part of the course. A response from one of these students follows:

> [T]hey gave out questions, they split us up in groups and it was really cool because, for example, the EO module—I was in charge of the big business part of it and it was really fun because even though I was against it, we were the people . . . who were putting all the crap in the air . . . all we wanted to make was money. We didn't care about the environment. [E]ven though I completely disagree with that, I had to be placed in that situation and I had to think of what the big businessses are saying to environmental groups and to the government.

A third of the students mentioned elsewhere in the interview that the forums were a very positive aspect. Attributes of the forums cited by students included the open discussions, the instructor feedback, and the focused questions provided.

Laboratory and Associated Reports. Most frequently (five of six students) comments were made that pertained to the need to make some modifications surrounding the GW laboratories, e.g., two students remarked that the quantity of work was too much "all at once" and one student said more needed to be done with computers. Three students remarked that the EO and BC laboratories were liked a lot/well put together. One student remarked that the lab enhanced his/her writing skills.

Amount of Work. The majority (four of seven) of students commented that the course was either a lot of work, too much work, or more work than the amount expected. Yet, three students stated the quantity of work was not excessive.

E-mail. There was no distinct trend in the responses student provided. Two (of eight) students remarked that they loved it or that it was the favorite part of the course. However, other students were critical of various aspects surrounding e-mail use in the course. Two of these students inferred that having e-mail competence as a course prerequisite, or helping students get "up to speed" more quickly, would have been advantageous. Two other concerns voiced by individual students were that the faculty were not responding enough, and that it should be mandatory for students to post one mesage on a certain day each week. Yet another student had this to say about e-mail:

> I mean it's kinda neat to be able to sit down and write someone . . . and see their viewpoint, but we should be able to do that as a class in person. . . . If we can't do that in from of each other ther's something wrong. . . . that's part of our problems as a society, I think.

Absences. Three (of six) students inferred that student absenteeism, in part, may have been due to the fact that the lectures were reiterations of or pretty much the same as the readings. Other reasons attributed to class absenteeism were that attendance was not expected, in part due to the course being a pilot offering:

> I think that a lot of people just thought this was a pilot course [and] it didn't mean anything. . . . [That] they can get away with a lot of things.

Course Prerequisites. There was no trend apparent in students' responses. One (of five) students believed a basic physics course should have been listed as a prerequisite; another, that e-mail "literacy" should be a prerequisite.

Natural Science General Studies Nature of Course. All students stated that this course should count towards fulfilling the undergraduate general studies "natural science" credit requirements. Most students gave as a rationale that this course presented a diversity of and interrelationships between science disciplines and topics.

Students' Perceptions of Own Understandings. Students cited several ways in which this course <u>added to</u> their prior knowledge. The understanding cited by most (four of six) students was that they now knew the mechanisms that accounted for the greenhouse effect or how GW "really works." In connection with the latter, one student remarked:

> Now I can now talk with people on a pretty intelligent level.

The second most frequent (three students) knowledge gain described was an understanding of energy efficiency. Two students stated their understandings had increased relative to nuclear power, the greenhouse gases, and how power plants worked.

Interrelationships Amongst Course Topics. The most frequently cited (five of six students) interrelationship was that our energy consumption effects GW and/or biodiversity. Additionally, three students remarked that GW, EO and BC do not stand on their own: They are interconnected.

Testimony Scenario. The four students who participated in the "end-of-course" interviews were asked to choose one of three testimony topics, "walk" the interviewer through the preparation and delivery of this testimony, and answer other related questions (see Table 2, questions 6-8). In addition, the student who completed the post-module interview near the end of the course was placed in a similar scenario: The exception was that the post-module interview specified, as opposed to allowing students to choose, the topic of the testimony. Thus, the findings reported below represent five students.

It is important to acknowledge that this course did not attempt to teach students how to prepare and deliver a testimony. Thus, the purpose of this "testimony scenario" was not to assess students' abilities to prepare and deliver a testimony. Rather, this scenario provided an applied setting through which the evaluators could examine student's abilities relative to certain course objectives (Figure 2, items 1d, 2b, and 2c). In a broad sense, this scenario provided data relevant to the assessment of all of the "knowledge and understanding" course objectives. The results from these five "testimony scenarios" are presented and discussed below.

All but one of the students selected "EO for the future" as their testimony topic. The reasons provided by students for making this selection included the following:

> It is one of the most feasible areas to make changes in at the personal level.
>
> I think it affects the other two issues.
>
> The root of the problem seems to be our energy uses--that's what's driving thoses two things [GW and problems associated with BC].

As a means of preparing for their testimony, all students indicated that they would do library research. Most students indicated that they would (a) speak to professorsor other experts in the field as another means of researching their topic, (b) contact governmental centers or utilize government resources that deal with environmental issues, and (c) survey the public to ascertain public opinion. Additionally, most students identified specific resources or knowledge from STS 251 that they would utilize in testimony preparation, e.g., the GW emissions lab, the course readings, the professors, alternative fuels research, and the video tape *After the Warming* (Ambrose Video Publishing).

When asked what they would do with a resource that they discovered during their preparation that ran contrary to their position on the issue, most students said they would "present it" as part of their testimony so as to represent both sides of the issue. Comments made by these students surrounding the use of "the opposite view" included the following:

> And we learned in psychology that a well rounded discussion that gives all sides of a debate--intelligent people are a lot more receptive to that type of a presentation. People are a lot more distrusting of a presentation that is all one sided.

> Well, I would read it, see if I could find some sort of other information about it--see what's going on here. Then [I would] look at how my ideas are beter, if I thought they were better, and figure out ways of addressing that opposite viewpoint.

The major points students said they would make in their testimony revealed a variety of concepts inherent in STS 251, however, students tended to make different as opposed to similar points. The only distinct point made by more than one student was that they would focus on the hidden/environmental costs of EO and energy consumption, e.g., traditional energy sources look cheaper now, but if they reflected "real" costs, alternative energy sources would be competitive. Other concepts and concept interrelationships mentioned by individual students included energy efficiency, energy conservation, the negative effects of GW on biodiversity, and the potential of the solar energy option to combat GW.

All but one student stated they would recommend actions be taken towards the resolution of their testimony issue. The only action stated by a majority of the students was the need to practice energy conservation. Two students stated "recycling." Two students also described political involvement, e.g., write legislator.

Three of the students said their preparation for the testimony would have been the same or similar regardless of whether or not they had taken STS 251. However, one of these individuals did say he/she would have been less likely to survey the public prior to this course and another remarked that this course would enable him/her to prepare a testimony more quickly. One of the students said preparation of his/her testimony would be very different as a result of what was learned in the course, due principally to a much greater understanding gained of the issues that comprised the course.

In order to validate students' perceptions of the effect STS 251 had on how they would prepare a testimony, pre-course data from these students on testimony preparation was necessary. The course evaluators lacked such data, however, three of the students did participate in pre-module interviews early in the course and also in subsequent (post-module and/or end-of-course) interviews, all of which placed these students in this testimony scenario. A study of such pre-module and subsequent interview data regarding student preparation of testimonies suggested that students did not change appreciably the way they would go about preparing for the testimony, thereby lending support to the students' perceptions. For one student no changes were obvious, but the other two students did make additions that reflected course content and resources, e.g., using the professors in the course as a resource and researching greenhouse gases.

A much greater difference between the pre-module and subsequent interviews was obvious in terms of the "key points" students would make in their testimony and the actions they would recommend towards issue resolution. In terms of the key points, students tended to be more organized and grounded in a science base: The points reflected a substantial amount and variety of course content and generally an accurate understanding of that content. Such key points in one testimony on the threat of GW included citing the potential consequences of GW, in an effort to get the audiences' attention, and explanations of the feedback processes related to such consequences, e.g., deforestation leads to a decreased sink for atmospheric carbon dioxide. Key points made in the subsequent interview testimonies on EO for the future included the separation and definition of EO as fossil, nuclear, renewable, and a focus on energy efficiency and conservation. Actions for issue resolution included supporting different environmental organizations, simple (physical) things folks can do in their everyday lives that don't require a lot of effort, and policy formulation at the community level.

Interest in STS/Related Courses. Students reported being more interested in STS now and attributed this to being more aware of ways people affect and can help the environment. Two students specified they would be interested in taking future courses along the lines of BC and EO. One student remarked that he/she had been thinking that STS would be a great major, but cited "ability to do the science" as a barrier and acknowledged that he/she could be part of "the movement" regardless.

Resolution of STS Issues/Lifestyle. Three students reported that the course influenced their thinking about the resolution of STS issues. Examples of explanations given by these students follows:

> First, I didn't realize that the problem was this serious. I think they can be resolved. . . .I didn't think that was possible before the course..

> Before I thought that global warming was something people agreed upon. . . .I now realize how difficult it will be to resolve these issues because people do not realize how complicated these issues are.

One student said the course generally had little impact on his thinking about issue resolution because it dealt little with the philosophical aspects, e.g., how we need to come up with new ways to view ourselves as a part of nature.

All the students reported the course influenced their thinking about their own lifestyle and provided several examples. All students spoke to their own use of energy (e.g., being more cognizant of how much energy they use) and related efforts to conserve energy (e.g., drive less and buy a bike). Two students discussed their interest in joining an environmental organization. One student remarked that he/she now watches and reads more environmental shows/articles because of the knowledge and interests gained throughout the course.

What Else Evaluators Should Know. The questions that led up to this last item encouraged students to reflect on and talk about many course aspects, and thereby informed in a broad sense their thinking about "what else is <u>important</u> for the evaluators of this course to know." Accordingly, we believe the student responses to this last item are very credible and the positive nature of these responses speaks highly of the pilot offering of this course.

Six of the eight students specified that the course was either very informative or worthwhile. Individual students reported "learning a lot," that the course presents knowledge that students "should have," that the forums were a very positive aspect, and that what was learned would "stick with" the student longer because it was related to real world problems. One student had this to say:

> [L]et's face it: Most students who are taking "Geology ___," they are not dealing with that once they are done with class, you know. They don't understand--there is no sense of importance of what they've learned--whereas at least with this class it does certainly give you that. I don't see how it couldn't, you know?

Five students gave suggestions for various improvements that should be made in the course. Most frequently the need was cited for better course organization and/or better communication with the students. One student suggested there was insufficient emphasis on making the course content "thought provoking" and another student suggested that the quality of the information could be a bit more rigorous. Two suggestions were made that could potentially impact future enrollment in the course: (a) Use the word "environment" in advertising the course, as many students are already interested in helping the environment; and (b) The course may be of interest to students in the agricultural sciences, as each issue presented is agriculture related.

Student Interests and Desired Outcomes

The pre-module and course drop interviews attempted to disclose students' reasons for taking STS 251 and what they hoped to get out of the course. A total of six different students completed these interviews. Student responses were seen as potentially useful to the identification of salient features for future marketing of the course. All but one of the students mentioned the environment (e.g., interest in/concern) in articulating reasons for taking STS 251. Most of the students also mentioned, as a reason for taking the course, that they perceived a relationship between the content of this course and a college major (undergraduate or anticipated post-graduate) that emphasized the environment or ecology. One-third of the students mentioned that they liked the idea of several professors teaching the course and the interactive or interdisciplinary nature of the course.

The majority of the students identified as a desirable course outcome an increased or better understanding of the course subject matter and environmental problems. Two students identified each of the following as desirable outcomes: (a) Knowledge of the details of what goes on "inside" or beneath the surface—how things really happen; (b) The ability to pass course knowledge on/get others to understand the problem; and (c) Learn things that I can do to help the environment.

Individual students talked about wanting to increase their ability to think critically and look at issues from all sides as well as how to relate the content of this course to the present. In connection with the latter, one student described as a desirable feature:

> It made me think more about the world than [text] books.

Interviews with Instructors

These interviews consisted of pre-instruction interviews with all course faculty, post-module interviews with the module instructors and post-course interviews with the wrap-around unit instructors and the graduate assistant.

Pre-Instruction Interviews

The pre-instruction interview protocol (Table 3) targeted desired outcomes for students, concepts central to instruction, and interrelationships across the entire course. A summary of the three module and the two wrap-around unit instructors' responses are presented below.

Insert Table 3

Student Outcomes Desired and Their Importance. In response to question 1 (Table 3), each of the three module instructors provided between five and six outcomes that he desired students to achieve as a result of completing his module. The majority of outcomes appeared to be at the knowledge and comprehension levels of Bloom's Taxonomy (Hassard, 1992), and are set forth in Figure 4. The category headings generally reflect the labels used by the instructors in their actual description of each outcome.

There appeared to be little overlap across the three modules in terms of the specific outcomes desired by each instructor, i.e., any outcome articulated by one instructor generally was not mentioned by the other two instructors. A discussion of the importance of these outcomes (Table 3, question 2) with the module instructors led to a disclosure of additional student outcomes that the instructors deemed important as well as some interrelationships of these outcomes across the science modules and with society and technology. The following exemplify the previous and stand out amongst the instructor responses: (a) Students need to come to a common understanding of the physics behind greenhouse warming; (b) Students need to understand that social and economic forces, such as consumption of fossil fuels, drive greenhouse warming and the achievement of energy independence by the United States will not solve greenhouse warming; (c) Students need to know the reasons—political, technological, and societal—why the soft energy path is often not chosen as well as the real cost [of energy], which includes the environmental impact of energy consumption; (d) BC presents a gate keeper approach to ecology in that it is [more] concerned with individual species within the ecosystem as opposed to the dynamics of the entire system; and (e) Students need to be able to participate in political discussions on BC and understand regulatory issues related to BC.

The two wrap-around unit instructors expressed similar views concerning desired student outcomes and the importance of these outcomes. Both instructors expressed the need for the course to be intellectually exciting for the students and for themselves. This was seen as important for the students in order to stimulate involvement in the course during class meetings, and long term retention and application of the content in life. Each instructor also indicated that they personally desired intellectual stimulation and excitement when teaching.

Both instructors emphasized the need for the course to emphasize higher-order goals. For example, one instructor voiced the belief that college students are already environmentally aware but feel disempowered—students knew issues existed, but did not know what they could do to help resolve them. He saw a need for the course to help students appreciate the complexity of policy formation, with respect to each of the three STS issues, as a way of empowering them to act. The other instructor noted, in particular, that he wanted students to understand (a) how the various institutions that make decisions in our society work, (b) that there are a variety of ways for individuals to enter into those decision making processes, and (c) because these are very complex issues, the issues are not easily resolved and the outcomes can be equally complex.

One wrap-around unit instructor also indicated that the course and the anticipated outcomes were crucially important to preparing citizens for decision making. Complementary to this, the other instructors noted that GW, EO, and BC were not the problems university undergraduates of a hundred years ago needed to be able to face. But, as society has faced new problems, the charter of the university must change as it has in the past to help graduates meet the extant demands of citizenship. As a result, he indicated, these goals have legitimacy in general studies science courses like STS 251.

Outcomes and Course Objectives. The three module instructors were asked (Table 3, question 3) to identify the relationships between their desired student outcomes and the course objectives (Figure 1) for the entire course. All three instructors specified that the student outcomes desired would facilitate student knowledge and understandings of GW, EO, and BC (Figure 1, objective 1a) and skills and interest in reading more about and taking additional course work in these three areas (Figure 1, objectives 2a, 3a, and 3b). The following were instances of relationships between "student outcomes desired " and course objectives mentioned by just one instructor: (a) Investigate a problem related to GW (Figure 1, objective 1d); (b) Develop skills in accessing and retrieving library information on BC (Figure 1, objective 2b); and (c) Promote interest in taking more STS courses (Figure 1, objective 3b).

Both of the wrap-around unit instructors saw close ties between the outcomes they noted and the course objectives. Both instructors saw the two goals they noted as corresponding to the knowledge and skills sections of the STS 251 objectives, and pointed to particular correlations.

Central and Interrelated Concepts. As part of the evaluation design for this course, the evaluators intended to examine concept maps constructed by the students of concepts identified by the module instructors to be "central to each module" and "interrelated across the modules." These concepts, as well as concept maps, were also intended to form the basis of some of the pre-module and post-module interview questions with students. Therefore, each instructor was asked (Table 3, question 4a) to identify the most central/important concepts for his module. These concepts are set forth in Figure 5. One module instructor also provided a concept map (Figure 2), illustrating a greater number of important concepts than is reflected in Figure 5 for his module.

Furthermore, each instructor was asked (Table 3, question 4b) to identify, amongst these big ideas/concepts, the three concepts that were most interrelated with at least one or both of the other modules. Each instructor identified three concepts, resulting collectively in the following nine concepts: fossil fuel consumption, agricultural production, land use changes, efficiency, exponential growth, pollution, carbon dioxide cycle, energy flow, and primary productivity.

As explained previously, the concept mapping evaluation component was not implemented successfully. Still, the concepts identified by the instructors may inform course revision efforts to interrelate further the three modules.

The wrap-around unit instructors saw the central concepts in their unit also as being big ideas in the entire course. These concepts/big ideas included the following: public/collective good, the public policy formation process, and the involvement of governmental environmental agencies, Non-Governmental Organizations, and international meetings and agreements (e.g., United Nations Conference on Environment and Development and the BioDiversity Treaty).

Interrelationships Across Course. The module instructors were asked (Table 3, question 5) to identify interrelationships across the modules and the wrap-around unit that comprised the course. The interrelationships identified were as follows: (a) Energy use plays a large role in global climate change, e.g., fossil fuel combustion leads to carbon dioxide accumulation, thereby enhancing GW; (b) The environmental impact of the generation of energy threatens biodiversity; and (c) The environmental problems addressed share base causes.

All of the module instructors spoke to the need for the policy wrap-around unit to help pull together and make visible the interrelationships between the three modules. Indeed, one instructor specified that the surfacing of significant interconnections among the modules would depend on whether or not the wrap-around unit "built the bridges." One module instructor spoke to the need for the instructors of the modules, as well as the wrap-around unit, to bring out interrelationships with and implications for society.

Another module instructor voiced concern that faculty were working too independently and expressed a desire to integrate the modules into a single unit. The latter was seen as a way to enhance greatly the coordination of GW, EO, and BC and preserve the logical progression of the presentation of science concepts, as opposed to that progression inherent in teaching separately three interrelated modules. An example was provided: The concept of fossil fuels and related utilization should be developed fully during the presentation of GW, not several weeks later.

One of the wrap-around unit instructors compared the wrap-around unit to the glue that held the three modules together. The other instructor referred to this unit as the comfortable window into the course for those students who are shy with science. He saw two other connections: (a) He expected the unit to handle the intersections needed between the three modules that the module professors would not handle or could not take time for—that is the focus on social decision making related to the issue; and (b) He expected the wrap-around unit to set-up the learning context for each unit and to link it to the previous one. Both unit instructors saw the need for them to understand the other modules and their interrelationships. They also saw the potential for a lot of "snafoos" in the course given the number of instructors involved.

Other Important Aspects. In response to question 6 (Table 3), two other course related aspects surfaced that the module instructors felt the course evaluators should be appraised of. Two of these instructors brought up concept mapping, which was a topic in pre-course workshops for the instructors and was a planned (but unsuccessful) component of the evaluation design set forth by the evaluators. One instructor commented on his exposure to concept mapping and specified that it helped him to identify, through the linkage process inherent in concept map construction, the central concepts in his module. While making reference to the concept map (Figure 2) he had prepared as an organizer for his module, he had this to say:

> Instructor: And I found this pretty useful, this idea of concept maps. I don't know about—[you will] still have to see what happens if you teach with it or try to evaluate it. But just as a way of outlining the course, I thought it was very useful.
>
> Interviewer: So you found it useful as an organizer for yourself?
>
> Instructor: Yes. Because it forced you to try to come up with the important outcomes here, as opposed to just—because they had to link together in this way. Then things you felt you would have had fun talking about but didn't fit nicely into this, you suddenly realized weren't as important as . . . . So I thought it was useful in that way—it lets you concentrate on what you really need to get over in a short period of time.

Another module instructor said that he had planned to prepare concept maps of his lecture topics and provided a suggestion: If the evaluators were going to employ concept mapping as one means of collecting data for course evaluation, they need to have some way to assess student competence in the concept map construction process.

The other topic that surfaced had to do with one module instructor's dissatisfaction with straight lecture as a mode of teaching. He planned to explore with students the everyday definitions and ideas they had for various concepts in his module and believed such explorations may facilitate learning the scientific definitions for such concepts. He also wanted students to come to realize how scientists conceive of and approach problem solving and believed such awareness would help the students relate better to the science in his module.

Post-Module Interviews

All three module instructors completed an interview (Table 4) subsequent to teaching their module.

Insert Table 4 about here

As indicated by a comparison of the pre-instruction (Table 3) and post-instruction interview questions, instructors were asked to provide their perceptions on some of the same parameters before and after instruction. Although not reported below nor indicated by the post-module interview questions (Table 4), two of the three instructors also were asked to and did submit concept maps of specific concepts, which reflected an understanding that each instructor hoped students had developed up to that point in time in the course. A summary of the module instructors' responses relative to the parameters investigated follows.

Student Outcomes Desired. Instructors were queried (Table 4, question 1) as to what, if any, changes they would make in the student outcomes desired, as identified during their pre-module interview (and reported above in this paper). Furthermore, the instructors' perceptions of the degree to which these outcomes were achieved was obtained. None of the instructors deleted or changed any of the outcomes. However, one instructor specified that he should have emphasized to a greater extent the social context of EO.

Collectively, the instructors perceived that the majority of these outcomes were achieved. Time was reported to be a limiting factor by all instructors in regards to enabling students to achieve, to the extent desired by individual instructors, these outcomes: (a) the role of social factors in driving as well as constraining solutions to greenhouse warming; (b) an understanding of alternative options for future energy policy; and (c) evolution. One instructor also discussed two additional outcomes that students did not achieve to the degree desired: (a) Students perceptions of global climate change as a problem did not appear to have changed; and (b) Students appeared to not be able to communicate to others very well the problem of global climate change.

Evidence that instructors cited to support their perceptions of student achievement of the desired outcomes included e-mail postings by students, class participation, course examinations, and course lab reports. Problems were cited in regards to some students' ability to write in an organized and effective manner.

Two of the instructors reported (in response to question 2) that they would not change the list of student outcomes desired if they were to teach the module again. One instructor inferred that he would add an outcome related to the utilization of space, or more specifically, land use. The latter was seen by this instructor as a unifying concept in regards to biological and socio-political aspects of biodiversity.

Changes in Modules. All three instructors identified, more broadly, changes they would make in their segment (module) of the course for future instruction. These changes were in the areas of laboratory resources and assignments, as well as course lecture and written materials. In regards to the laboratory, changes recommended included procurement of computer software on (a) emissions relative to energy consumption and GW and (b) land use (e.g., a program that contains variables such as population density and type of human diet and calculates the required land area and fossil fuel inputs). One instructor specified he would increase the time spent on the external costs of energy consumption, such as the environmental impact of mining and the effects of air pollution on human and animal health. Another instructor said he would give students a more extensive pretest in order to determine their prior knowledge in the chemistry and biological aspects important to an understanding of his module; and that he would like to work more so on building instructor-student rapport.

One instructor also made suggestions pertinent to the entire course: (a) Three 50-minute lecture periods and one 2-hour lab period should comprise the course schedule; (b) The distinction between the lecture and laboratory components should become more obvious to the student; and (c) The character of industrial society should be given more attention in the course.

Interrelationships Across Course. Although instructors were asked about this during their pre-instruction interview, this was posed (Table 4, question 3) again to note any changes in perceptions about course interrelationships. This question revealed little new information. Two of the three instructors specified again the need for the policy wrap-around unit to pull together the three modules; to make visible the interconnections between them. One instructor felt he needed to read the other two modules and the wrap-around unit more extensively before commenting. This instructor specified that the science and technology modules were interrelated in that they were each instances of how industrial changes impact the environment; fossil fuel consumption and land use were identified as concepts that cut across these modules.

Recommendations to All Faculty. Because these post-module interviews occurred part way through as opposed to at the end of the course for two of the three instructors, the recommendations they made in response to question 4 (Table 4) do not collectively represent views based on the entire duration of the course. Nevertheless, this data enriched the pool of suggestions that can inform course revision. Responses to question 5 (Table 4) have been collapsed with the question 4 data, as they also provided recommendations towards course improvement. These recommendations, summarized in outline form below, provided specific suggestions for the policy wrap-around unit, issues forum, first day of class, harmonization of the modules and assignments, quantity of course content, e-mail, number of course instructors, and student evaluation.

(1) The policy wrap-around unit should bring out, more so, the interconnections among the three modules. The latter might be facilitated if the wrap-around unit devoted more time to *Agenda 21* (United Nations Conference on Environment and Development, 1992)

(2) The issues forums provided a positive atmosphere in which students voiced their opinions and views. Accordingly, this component of the course should be strengthened. One idea is to establish groups at the first forum and students would remain in this group for the remainder of the course. To each group, a topic of investigation would be assigned at the beginning of each module. Group members could be assigned specific roles (so as to equalize the workload) and meet at various points throughout the course with instructors and/or the graduate assistant. A genuine interest must be shown by the instructors in each group's activities.

(3) The showing of the video tape should be omitted from the first day of class. This is a "passive" experience and one similar to that which students have experienced before. Instead, considerable time should be spent articulating the rationale for why GW, EO, and BC were chosen as the critical issues, as opposed to any three science and technology topics, to comprise the bulk of this course. Furthermore, the course topics in the syllabus should be examined and ways identified in which the three science and technology topics are interconnected.

(4) Students need to be very clear, from the start, on the course basics, e.g., testing, assignments, etc. The text of the modules and course assignments need to be harmonized. One evaluation component was described that, if added, may enhance student interest in the course: Students could declare an optional personal objective that would specify an outcome which could be graded. This would comprise a portion of their course grade and may take the place of one of their examination grades (e.g., possibly the final exam). This would require a meeting with a course instructor in order to identify the project and the criteria and standards for evaluating it.

Some projects possibly could be dove-tailed with forum activities. Ideas for specific projects were cited.

(5) The course, as it stands, is too crowded. Some of the content from each module that does not interconnect with the content of the other modules needs to be eliminated. The points of interconnection to focus on need to be determined collectively. Therefore, faculty must spend some time planning together.

(6) The e-mail aspect of the course gets students to talk amongst themselves and to faculty; it gets them "involved" and that is an important goal. However, students must monitor e-mail postings frequently and with regularity.

Two of the instructors felt that it might be more desirable to have one as opposed to several instructors for this course. Reasons cited included the following: (a) Perhaps so many different teaching styles were jarring to the students; and (b) Perhaps the degree of difficulty associated with the science modules is such that science "experts" are not needed to deliver the instruction. The suggestion was made that if the course had but one instructor, experts could still come in for occasional panel presentations or question and answer type sessions where the class would "interview" the expert.

Post-Course Interviews

Both of the wrap-around unit faculty and the graduate assistant (collectively referred to as instructors in what follows) completed a post-course interview. As explained in the methodology section above, these interviews posed questions similar to those that comprised the post-course interview for students (Table 2). A summary of the instructors responses are categorized below. In some instances, only the two wrap-around unit instructors were asked the question, and accordingly, reference is made to just two or the "unit" instructors in describing the findings.

Major Strengths of Course. Each of the instructors made reference to the three modules and the respective instructors as strength. One instructor emphasized that the students had been exposed to three prominent and complicated STS issues from a strong science basis. Another saw as a major strength the interrelationship that developed naturally among the three modules as the course proceeded. The third instructor saw the students being exposed to three different science faculty members within the context of STS issues and their perspectives on the issues as a prominent strength.

The two wrap-around unit instructors pointed to the graduate assistant as the major strength, referring to her as the person who held the course together, who was sensitive to the needs of the students, and who met those needs on a daily basis. The forums were noted as a strength by one instructor, given they required students to synthesize information, including science concepts, and various views on the issue of focus.

Major Limitations of Course. The wrap-around unit, lack of a strong professor-in-charge image, large number of instructors, low number of students, course schedule, labs, and different standards across the modules were listed by the three instructors as limitations. Two of the instructors did not believe the wrap-round unit served its intended purpose of tying the modules together, possibly because some of the time that was to be allotted to the unit had to be used for the modules. Similarly, they did not believe a strong image was presented for the students of one person being in charge of the course. One instructor noted the number of instructors as a limitation in terms of students having to adjust to a new instructor every few weeks. Another also noted this as a limitation in terms of establishing consistent expectations of students and course policies. The continuity experienced with a single instructor was missing.

One of the instructors was concerned that as much was not going to be learned from this pilot offering of the course given the small non-representative or atypical sample of students who registered. The degree to which students were required to prepared for the forums and did prepare for the forums was noted as a limitation by an instructor. Finally, two instructors described the final exam as approaching a level of assessment that required students to apply knowledge they developed in the course in ways that required higher-order thinking. However, they both did not believe it separated out those students who were able to meet the objectives of the course from those who could not—it was a good first approach, but needed revision.

Suggested Changes. A larger number of suggested changes were noted than limitations. Two of the instructors suggested that the course be scheduled in a more traditional format (e.g., two 50 minute sessions and one two-hour laboratory period). Two also suggested the need to make better use of e-mail, such as by establishing small groups of students that correspond with each other and greater involvement by the instructors in reacting to student comments and sharing their comments on e-mail.

The following suggestions were made by one of the instructors: (a) The grading system and other exceptions need to be standardized across modules/units and clearly articulated for the students; (b) Linkages that the instructors desire students to see across the modules need to be identified and overtly articulated in the instruction and booklets; (c) Students should begin work on the forum activities, possibly in the form of an individual or group position paper, half way through a module; (d) A course attendance policy is needed that encourages and positively support class attendance; and (e) To the degree possible, greater emphasis needs to be placed on helping students develop a qualitative understanding of quantitative relationships in the course lecture, booklets, and laboratories.

Absences. One instructor described the high number of absences by a certain portion of the class (about 50%) as, "disappointing and somewhat baffling." Another used the word, "puzzling." All three saw it related to the length (2 3 hours) and days (Monday and Friday) the course met. Two instructors indicated that labeling the course as "experimental" may have influenced the absence rate. All three recommended that an attendance policy be instituted.

Required Work. All three of the instructors believed the number of assignments and amount of work required of the students was about right. They recognized that two to three students complained, but attributed the complaints to emotional reactions, absences from class, and laziness on the part of a few students. Two of the instructors indicated that they had talked with students who openly repressed complaints. One instructor recommended adding to the course several intensive writing assignments in which students thought about connections across/among the issues of GW, EO, and BC.

E-Mail. The instructors' responses were diverse as regards e-mail as a course component. One instructor heavily endorsed the use of e-mail, though indicated that it was not used to its full advantage by the students, instructors, and within the course. Another was neutral on e-mail's value and just indicated that it was not used to its full advantage in the course. The third instructor stated that he saw the use of e-mail as an interference in the course and was against it.

Exams. All three instructors perceived the exams were fair. Two of the instructors noted that the exams after each of the three modules were structured differently because they were prepared by different instructors. In recommending that they should have been more similar in format, they implied that this might have affected student performance. Two of the instructors expressed pleasure that the final exam involved students in learning activities (e.g., analysis of written material), rather than simple recall of information.

Forums. All three instructors felt the forums were a great idea in terms of having the student approach the issues from a societal perspective. Also, one instructor noted that it helped prepare the students to speak publicly on issues. Each recommended having the students prepare in advance for them. The degree of that advance participation varied. One instructor recommended having the student begin a position paper that would serve as a basis for their forum testimony at the mid-point of each module. Another instructor noted that the groups should have been established sufficiently in advance for the student to be able to meet to prepare their position statement. One instructor recommended that the graduate assistant or professor-in-charge run the forums in the future so there is continuity.

Instructor Coordination. One instructor rated the coordination as very good:

> We had planning meetings and people got along well.

This instructor indicated, however, that from a logistical point of view during delivery of the course that the coordination was weaker, given that one module instructor was replaced and another recently had been promoted to an administrative position. Additionally, the two wrap-around unit instructors were not available as frequently as was anticipated.

A second instructor indicated that more was needed—that each instructor did his thing in isolation. This instructor suggested that at least there needed to be more references to up-coming and formerly covered connections in the other modules and the unit, and in the booklets. He expressed concern that the writing editor for the module and unit booklets never had all four booklets at once to look for the connections.

The third instructor indicated that it needed to be made clear to all instructors what the policies should be across all of the modules—the "nuts and bolts stuff". This instructor felt the transition between instructors went well because the instructors made an effort to attend other class sessions.

Laboratory Activities and Reports. One of the instructors felt he had insufficient information to critique the laboratory activities and the two others were basically pleased. In particular the field trips and computer-based laboratory sessions were noted as both educationally valuable and highly interesting by one instructor. This instructor also suggested that what constitutes a lab in this type of course needed to be more clearly defined for the students early in the course, given some students apparently raised questions.

Lecture. One instructor described these as being too long. A second felt that lectures may not be conducive to this type of course and that perhaps the instructors felt the students could get into the issues faster than they actually were able to. A third instructor had this to say about the lectures:

> [They were] probably the single best done part of the course. Each [instructor] had a different style. My impression was this was not a problem, in fact worked to our advantage in terms of variety.

Natural Science Credit for the Course. None of the instructors questioned that the course deserved to be recognized as a general studies course for natural science credit. One instructor made direct reference to the course module exams and the final exam as evidence that the enrolled students learned science concepts at an appropriate level of rigor for a general studies science course.

Number of Instructors. One instructor indicated that having separate instructors with expertise in the area they taught was a great opportunity for students, especially in a 200-level course. Each of the three instructors still appeared to feel that there were too many instructors in terms of course continuity and that it would be difficult to justify the number beyond the course pilot period. Two instructors recommended one for each module, with one serving as the professor-in-charge, and one graduate assistant for the wrap-around unit.

Prerequisites. One instructor noted that it was not appropriate to think about prerequisites for a general studies course—that is, by university policy, the course has to be taught so students can pick up any so called prerequisite concepts in the course. Another continued this idea:

> In a course like this, you have to accept that students come from very different backgrounds, and you have to be willing to adjust.

Reading Material. Although one instructor felt they were pretty good as a first edition, two others expressed concerns that (a) connections across units need to be built into the booklets and (b) that probably students did not read them.

Course Scheduling. All three of the instructors preferred moving to a three-days per week schedule. One instructor observed the following:

> [T]he students got bored and the instructors digressed; neither were use to the long periods.

Graduate Assistant's Role and Functioning. The graduate assistant felt she was respected as a member of the team and had the freedom to contribute as she saw fit. The wrap-around unit instructors confirmed this notion:

> Without K_________, the course would have been a flop.

She could have taught it all, but she is an unusual person.

She was able to take on more than we can expect.

Understandings Gained. The instructors focused on the students gaining a broader perspective on the issues dealt with in the course. One instructor noted:

> By the end of the first forum the students were very aware of three things: Simple policy options, such as those noted in the paper, are too simple to be workable; These options are backed by various groups, not necessarily the good and bad guys, many of whom had our best good in mind; and These are very complicated issues.

Similar views were expressed with respect to the GW module by another instructor who said the students learned this:

> [T]hat it is not global warming. That it is global climate change. . . .They learned about the limitations of our knowledge and modeling, and that the media presentation is over-simplified.

With regard to the EO module, this instructor felt the learning was more focused on the amount of energy we waste and carbcn dioxide we put into the air. The energy audit lab was pointed to as a key activity here. With regard to student learning in the wrap-around unit, one of the instructors indicated that students learned most about the United Nations system, given that was a main emphasis, and that there was no direct science learning here because that was not the focus of the wrap-around unit.

Important Interrelationships. One instructor pointed to the realization that there are interrelationships among the issues dealt with in the course, as the most important interrelationship learned. The second instructor saw EO as the key module, and interrelationships among the wrap-around units as being very important. Both instructors referred to the final exam results as indicating the students were aware of primary interrelationships among the three issues at the end of the course:

> [T]he students could explain the connections among the modules at least at a surface level, such as the impact of X on global warming and biodiversity, and some basic ecological concepts, and how waste impacts these.

Preparation for Testimony. The instructors did not have a preference as to which issue the students elected to testify about, anticipating that one would have provided an entry into the other two because of interrelationships. One anticipated that more students had selected EO, given energy appeared to be the most central issue to him. The other instructor anticipated that GW was selected by more students with BC second given these are more glamorous than EO.

The instructors' responses on how they anticipated the students would prepare for the testimony were different. One hoped they followed a model something like the forum: (a) they summarized what we know and don't know about the issue, (b) laid out the two to four options we have, and (c) picked one option and argued for it, especially as it has implications for other options, thus expressing an understanding (pros and cons) of different options. This instructor felt the booklets would have been good resources for the students to use, as would the *Race to Save the Planet* (Annenberg/CPB Collection, 1990) video series, e-mail gophers, and course handouts. This instructor inferred that utilization of the library as a resource was something that the course should have emphasized more so.

The other instructor would like to have seen the student start at the library: (a) find out the positions of various groups on the issue and why the position is held by going to references found in *Readers' Guide*; (b) look at the arguments made by each group and formulate their own position; and (c) prepare notes for the testimony in which they support their position while arguing against other positions. This instructor saw the previous as something the students should already know—"a first cut of Research 101." Still, the instructor added:

> We should have had training sessions on this, along with preparatory assignments in each forum. I anticipate that their actual level of performance was weak.

Effect on Students' Interests, Action and Lifestyles. The instructors indicated that the students came to the course with interest in STS issues, particularly one or more of the environmentally related issues focused on in the course. Still, they were not sure exactly how the course might have impacted students' interests in STS, actions on STS issues, or lifestyles. Yet, they hoped the students had moved from the doom and gloom perspective they saw as typical among undergraduates and the general public. One instructor commented on the course's focus on these outcomes by saying:

> Not very much; the piece that was missing is they did not get hands on experience with actions, only through videos. The forums need to extend students to action taking groups.

Additional Data Sources

In addition to the interviews with the students, instructors and graduate assistant, the evaluators administered a 16 item VOSTS instrument pre and post to student subjects, made informal class observations, reviewed the course booklets, and examined the course exams.

The 16 item VOSTS instrument was the same one used by Schoneweg (Schoneweg & Rubba, 1993) to assess college level students' understandings of STS interactions. Six students completed both the pre- and post-test. The mean score on the pre-test was 36.00 and 36.17 on the post-test, out of a possible 48 points. While these were not found to differ significantly, the scores are similar to the pre-instruction scores of the students in the introductory STS and physics (non-majors) courses in the study by Schoneweg. That is, these six students initially held views on the interactions among science, technology, and society that expressed a number of legitimate points, but were not considered fully appropriate or legitimate. Additionally, these limited views did not appear to change over the period of the semester.

Collectively, the two course evaluators attended the majority (21) of the individual class sessions (lectures, laboratories, and forums); some general observations follow. These and other class session observations were utilized in concert with student and instructor interview responses to formulate assertions and recommendations for future offerings of STS 251.

For the majority of the lectures and forums, more than one of the course instructors were in attendance and participated to varying degrees in class discussion. The module instructors appeared sensitive to the complexity of their topics relative to the science backgrounds of the students: Material usually was presented slowly and the instructors regularly asked students if they had any questions. Additionally, instructors attempted to disclose students' prior understandings of various science concepts through classroom dialogue and in one case, a pre-test. The amount of teacher-student discourse during lecture varied across the modules, but overall was believed to be considerably more than what would have occurred in the vast majority of other undergraduate courses taken to fulfill a portion of the university's natural science requirements. Additionally, the forum sessions provided ample opportunity for and resulted in considerable dialogue amongst the students: They placed students in various scenarios and provided focus questions for small group and class discussion. The instructors also were sensitive to students' interests and allowed students' requests and questions to direct portions of class lecture.

Course attendance began to drop quite a bit by the end of the first module and students often came late to class. Mid-way through the course, the lead instructor discussed this attendance problem in lecture and sent a related memorandum to each student, encouraging future attendance. Course attendance subsequently increased to some extent.

Assertions and Recommendations

The course evaluators posed the following 12 assertions and corresponding recommendations concerning STS 251, based upon their interpretation of the evaluation data. Readers of this paper may believe the evaluation data reported herein supports assertions and recommendations in addition to or alternative to those presented. Recognizing the limitations of all evaluation processes and procedures, the evaluators have made an attempt not to overextend the data, and so have limited the assertions and recommendations to those they believe are strongly supported by the data.

The presentation of some of these assertions and recommendations should not be misinterpreted as a condemnation of STS 251, but rather as constructive review. Even though the evaluators identified certain limitations associated with STS 251 during this first offering, the strengths of the course far outweighed the shortcomings. Overall, the students indicated that they found the course to be interesting, worthwhile, relevant, and useful. Beneath the caution apparent in the points expressed by the instructors, the evaluators perceived that they were pleased with the first offering of the course. Additionally, the evaluators perceived a great and genuine interest on the part of the course developers/instructors to capitalize on the course's strengths, limit the weaknesses, and test new ideas in future offerings.

Assertion 1—Course Focus, Content, and Marketing

The focus and content of the course were exemplary relative to the kinds of courses this or any post-secondary academic institution should offer as a means for students, as citizens of a global and informational society, to fulfill undergraduate general studies natural science credit requirements. The course provided content from a breadth of science disciplines (e.g., biology, earth science, and physics); interrelated science content across the disciplines and to technology and major societal issues that are global in scale; and attempted to empower students towards taking citizenship action to resolve these major societal issues. The science content was contextualized in real world problems: The three STS issues focused upon in the course—GW, EO, and BC—are critical issues facing humankind and hold great interest for the potential STS 251 student population. Students emerged from the course with a sense of the importance of what has been learned. Overall the course was of considerable value to the majority of the students. However, course enrollment was low for this first offering partly because course advertising did not capitalize sufficiently on the students' interest and concerns about "the environment."

Recommendation 1a

Retain and aggressively market the course as a highly viable option for students to use in fulfilling a portion of their undergraduate general studies natural science credit requirements at this institution.

Recommendation 1b

All course ads should take advantage of connections that can be made between course content and the potential/target audience's concern for and interests in environmental issues, especially as these relate to lifestyle decisions. The word "environment" needs to be emphasized in all course marketing.

Assertion 2—Course Objectives

The STS 251 Course Objectives (Figure 1) were appropriate for a college general studies STS based science course and the intended student population. However, the instruction provided in the course focused mainly on the lower order cognitive objectives (1a through c). The higher order objectives, 1d, 2a through c, and 3a through c, were not addressed sufficiently in the course instruction. Relative to objectives 1a through c, students perceived that the course enhanced especially their understandings of the mechanisms underlying the greenhouse effect and GW, and the concept of energy efficiency. Furthermore, the student interviews revealed that students emerged from the course with an understanding of the "hidden or real cost" of EO and viewed the following as a key interrelationship amongst the three course modules: Energy consumption is central to and drives GW and problems associated with biodiversity. In regards to the objective (1d) on reaching informed decisions and taking positive citizenship actions on course related issues, students believed "energy conservation" to be a key citizenship action they and others could take towards the resolution of the related issues, and the course appeared to impact positively their desire to take such action on a personal level. However, beyond this, it generally was not apparent that the course enhanced the students' research skills in investigating issues or related decision making and action capabilities (objectives 2b and c).

Recommendation 2

The basic factual information on each of the issues can be presented in the course booklets. The lecture/discussion portion of the course should go beyond and extend the material dealt with in the booklets. Instructional strategies that involve students in higher order learning (e.g., cooperative groups, debates, simulations) should be used extensively. Use of instructional strategies that facilitate higher order thinking likely would realize the additional benefits of increasing the intellectual excitement of the course and reducing absenteeism. Two additional suggestions for strategies and assignments that address the higher order course objectives of 1d and 2a through c are described below. These suggestions are in the form of "general ideas" and are not intended to provide complete descriptions. If implemented in some fashion, these strategies/assignments simultaneously should encourage student interests as identified in course objectives 3a through c; engage students moreso in the learning process; facilitate "transfer" to other contexts and application of what is being learned; and reduce absenteeism. Furthermore, these assignments each result in evidence that can be used along with course tests and lab reports to determine students' course grades. They would provide alternative and authentic means for assessing students and their inclusion would respond positively to the nationwide call to reform science assessment. Each project also may be interfaced with the class forums.

Suggested Assignment 1. Students keep a "responsive" journal and turn it in weekly or bi-weekly. Herein, each student responds to a question posed weekly by an instructor, which is related to one or more of these course objectives and that requires students to reflect, think critically, and do a little research. Students should be encouraged to make other entries in the journal, such as reflections on course content and related current events.

Suggested Assignment 2. Early in the course, each student identifies some type of project he/she will complete by the end of the course that has the potential to demonstrate competence has been gained relative to these objectives. Two or three students could collaborate on a project, if it appears constructive. The project must be "worked out" with and verified as acceptable by the instructor. Subsequently, a succinct description of the outcomes of the project and criteria for assessing these outcomes must be put in writing by the student and submitted to the instructor. Brief progress and terminal oral reports on each project could be given by each student (or group) midway through and at the end of the course, respectively.

Assertion 3—Course Leadership

The students were unclear about who was the course leader and were not presented with a "united front" in terms of course policies.

Recommendation 3

One faculty member needs to be identified to the students and function as the professor-in-charge of the course. The joint development and application of consistent policies (e.g., attendance, assessment and grading) across the modules/units should come under this individual's leadership.

Assertions 4—Course Instructors

The quality and variety of instructors, including the graduate teaching assistant, enriched the course and were major strengths. Beyond their content expertise, they were concerned about the quality of their teaching, were receptive to students input, and showed a genuine interest in teaching this general studies course.

Recommendation 4

Retain four instructors, one as the "expert" for each module and one to conduct the wrap-around unit. If the present instructor of the GW Module is not available for future offering of the course, the present GA has the background and expertise, plus the teaching skills, to serve as an instructor for the GW Module. One of the four instructors also must serve as the professor-in-charge.

Assertion 5—Interrelationships Across the Course

Interrelationships across course content, including those necessary to make the transition from one module to the next, were not made to the extent that the course faculty desired and anticipated that they would be made. For the most part, the students developed a relatively unsophisticated perspective on the interconnections across the three science and technology issues—that energy consumption is central and drives GW and problems associated with biodiversity.

Recommendation 5a

Faculty need to spend time in advance of the next course offering planning for the more extensive coverage and integration of course interrelationships. The faculty should decide upon specific important interrelationships that can be carried through all modules. The outcomes and concepts identified in faculty interviews and reported herein previously, and the concept maps used by two of the three faculty in their components of the course, may be useful in this endeavor.

Recommendation 5b

Each course booklet needs to make visible and emphasize the important interrelationships identified through the faculty planning activity recommended above.

Recommendation 5c

The first day of class should devote substantial time to setting forth a rationale for why these three science and technology issues (GW, EO, and BC) were chosen (as opposed to other issues) and the various interrelationships that cut across these three issues.

Recommendation 5d

The wrap-around unit needs to emphasize moreso the interrelationships across the three science and technology modules. However, one should not expect that the wrap-around unit alone will serve as the "glue" that holds the three science and technology modules together and elucidates the interrelationships among the three issues. Class introductions and ending statements should be used that provide a type of course "road map" for students.

Recommendation 5e

Additional learning activities and assignments (e.g., concept mapping) should be added to the course to facilitate student understanding of the important interrelationships. Also, these interrelationships should be focused upon in student assessments.

Assertion 6—Content Density

The EO module, and to some extent the GW module, were too information packed. The instructors of these modules appeared not to have sufficient time to do much more than "cover" the material. This, combined with a quantitative emphasis, made the EO module somewhat overwhelming to the type of students who are anticipated to comprise the future enrollment of the course.

Recommendation 6a

More dialogue and discussion that is directly related to course interrelationships and the higher order course objectives, needs to be initiated with the students during the lectures and labs.

Recommendation 6b

The set of concepts that are most critical to students' understanding of EO need to be identified, and the module reworked to focus on these. Though not necessary, such a review also is recommended for the other two modules and the wrap-around unit. Identifications of conceptual linkages across the four modules/unit would be facilitated if all instructors participated in these reviews.

Recommendation 6c

To a greater extent and where possible, quantitatively based concepts in the EO and GW modules need to be approached qualitatively. The very successful physics textbook, *Conceptual Physics* (Hewitt, 1993) is an exemplar of how this might be done.

Assertion 7—Lectures and Booklets

The course lectures generally covered the same material as could be obtained from the course booklets. Because many students believed it was not necessary to both read the booklets and attend lecture, this negatively affected course attendance. It also resulted in some students not reading the booklets. Additionally, it compromised the engagement of students in critical/thought-provoking activities during class time.

Recommendation 7

As stated in the recommendation for Assertion 2—The basic factual information on each of the issues can be presented in the course booklets. The lecture/discussion portion of the course should go beyond and extend the material dealt with in the booklets Instructional strategies that involve students in high order learning (e.g., cooperative groups, debates, simulations) should be used extensively. Use of instructional strategies that facilitate higher order thinking likely would realize the additional benefits of increasing the intellectual excitement of the course and reducing absenteeism. Other recommendations made in this report also speak to the lectures and booklets.

Assertion 8—The Laboratory

Overall, the laboratory activities were meaningful to the students, and to some extent, personally applicable to their lives. However, the amount of out of class work associated with one of the GW labs was perceived as being too much work all at once.

Recommendation 8

Spread out and/or streamline the amount of out-of-class work associated with the GW labs. Throughout the unit and course, consider adding more or modifying existing labs to apply or reveal student lifestyle, especially computer-based modeling and ones with environmental implications. A computer-based simulation for the emissions lab and a new lab on land use, which were recommended by instructors, should be seriously considered.

Assertion 9—The Forums

The forums were a major strength of the course in that they encouraged application of understandings developed in the respective modules to related real world problems and provided an opportunity for students to express their views. Nonetheless, student attendance at the forum sessions was compromised by not routinely making some assignment to the students in advance as necessary preparation for and to be utilized during and in follow-up to each forum.

Recommendation 9a

For every forum, establish small groups and provide a small group assignment in advance (e.g., at the beginning or mid-way through the previous science and technology module) that is to be utilized/delivered at the forum and in a follow-up activity. An example assignment could be the preparation of a position paper or testimony that sets forth and supports a pre-assigned stance on the issue targeted by the forum. As follow-up, students might suggest and explore the viability of certain individual and group actions. The forum assignments and related presentations should be considered as important evidence of student learning, and accordingly, be utilized in the assessment of students and determination of grades.

Recommendation 9b

All of the forums should be led by the same faculty member. The professor-in-charge of the course is the most likely candidate.

Assertion 10—Course Organization

The course syllabus delivered on the first day of class was not sufficiently comprehensive and clear in terms of the "day to day" course content, related dates for assignments and exams, and how grades would be determined.

Recommendation 10

One comprehensive course syllabus should be provided to all students at the first class session, as opposed to separate syllabus components for each of the three modules/unit distributed at different times over the course of the semester. The course syllabus also should discuss the unique nature and aspects of the course and describe how grades will be determined in clear detail.

Assertion 11—Course Scheduling

Course enrollment was affected negatively by the days and time blocks within which the course was scheduled.

Recommendation 11

The course should be scheduled as two 50 minute lecture/discussion periods and one 100 minute lab period per week. If more instructional time is needed the course should be made four credits.

Assertion 12—Use of E-Mail

As used, e-mail made little contribution to the course.

Recommendation 12

The purpose of using e-mail needs to be clearly defined and e-mail should be implemented in accordance with that purpose and the power of this technology. The instructors should initially focus on using e-mail for between class communications among the students and instructors, and the exchange of views on aspects of the STS issue under study. This use should be implemented if and only if: (a) all students receive training in the use of e-mail, and (b) all members of the faculty and class agree to read and respond to their e-mail on some specific regular basis. Once an e-mail communications link is established and functional, it may be possible to use e-mail for other related purposes (e.g., as a support for groups work, to locate resourses on the university's electronic information access system and the Internet).

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1. After course completion, students will possess greater knowledge and understanding of:

   a. science facts, concepts, and processes central to GW, EO, biodiversity, and their interrelationships.

      EM *Evaluators interview volunteer students pre and post each module, and at the end of the course.*

      Concept mapping exercise completed by volunteer students prior to the first and at the end of each module.

      Evaluators have access to student exams.

   b. technology as it impacts GW, EO, biodiversity, and their interrelationships.

      EM *Evaluators interview volunteer students pre and post each module, and at the end of the course.*

      Concept mapping exercise completed by volunteer students prior to the first and at the end of each module.

      Evaluators have access to student exams.

   c. key social science and public policy concepts that underlie decision making about GW, EO, biodiversity, and their interrelationships.

      EM *Evaluators interview volunteer students pre and post each module, and at the end of the course.*

      Concept mapping exercise completed by volunteer students prior to the first and at the end of each module.

      Evaluators have access to student exams.

   d. resources and methods for investigating the science, the technology, and the society issues related to the three course topics (i.e., GW, EO, and biodiversity) and their interrelationships.

      EM *Evaluators interview volunteer students at the beginning and end of each module and at the end of the course, placing them in simulated issue investigation*

(Continued)

Figure 1. STS 251 Course Objectives and Corresponding *Evaluation Means (EM)* that Comprised the Evaluation Plan Conceived by the Course Evaluators

(Figure 1 continued)

2. After course completion, students will possess greater skills:

   a. in scientific and technological literacy.
   (This primary skill outcome, which is presupposed by the others, can be measured by assessing student ability to read and comprehend science articles in both the general press such as the New York Times or Time and, for the specific module issues, general audience scientific publications such as Scientific American or New Scientist.)

   EM Evaluators have access to course final exam, which will include a technical article. (This is a very limited definition of scientific literacy.)

   b. in pursuing knowledge about GW, EO, and biodiversity issues.

   EM Evaluators interview volunteer students at the beginning and end of the course, placing them in simulated issue investigation.

   c. in reaching informed decisions and taking positive citizenship actions that can be taken toward the resolution of public issues related to GW, EO, and biodiversity and to STS issues in general.

   EM Evaluators interview volunteer students at the beginning and end of the course, placing them in simulated issue investigation.

3. After course completion, students will possess greater interet:

   a. in reading about other science- and technology-related issues.

   b. in taking other STS or related courses.

   c. in becoming more informed for the sake of getting involved.

   EM Evaluators interview volunteer students at the beginning and end of the course, placing them in simulated issue investigation.

   Evaluators administer 16 VOSTS items at the beginning and end of the course.

Figure 1 (continued). STS 251 Course Objectives and Corresponding *Evaluation Means (EM)* that Comprised the Evaluation Plan Conceived by the Course Evaluators

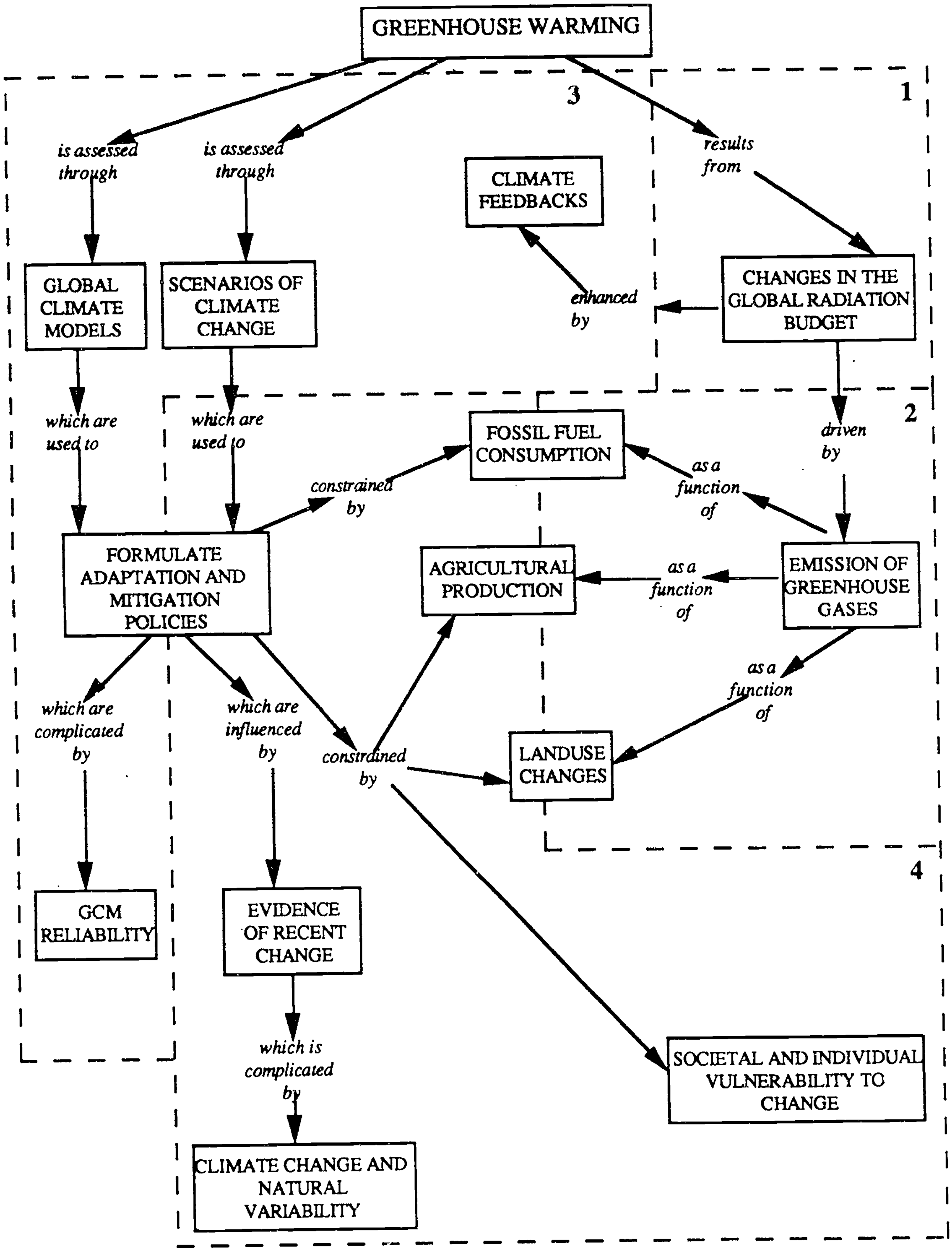

Figure 2. Concept Map Prepared by Instructor for GW Module

Concept Map Assignment #1

Below please find a list of terms which you should use to construct one concept map. In addition to the terms shown, please identify three others which you want to include in this map. Map these three additional terms along with those provided in the list below. You do not have to select these three additional terms before starting the map. It is likely that other terms will come to your ,mind as you are constructing the map. As these other terms come to mind, select the three that you believe are the most important and map them in.

The map should illustrate your current understanding of the relationships between these terms. So, we ask you, please:

a) do not consult with anyone else to help you prepare the map; and
b) do not "research" further any of these terms before or while you prepare the map.

The map is due on Monday, 1/17, at the start of class. You will be paid a total of $7.50 for completing the self instruction packet plus this first concept map assignment.

List of Terms:

Climate Feedback
Environmental Issue
Environmental Law
Environmental Policy
Food Production
Fossil Fuels
Global Climate Models
Global Radiatoin Budget
Greenhouse Gases
Greenhouse Warming
Land Use
STS Issue

Figure 3. First Concept Map "Assignment" for Students to Complete as Part of Course Evaluation.

Knowledge and Awareness

Greenhouse warming as international problem.

What is being proposed to conserve species.

Understandings

Greenhouse warming, related physical problems, and social factors that drive as well as constrain solutions of Greenhouse warming.

Energy: forms; types of units; laws of conversion; limits on resources; environmental impact associated with conversion; alternative options (soft and hard paths) for future energy policy.

Fundamentals of ecosystems, species diversity, evolution.

Reasons underlying species extinction.

Social, political, and economic context in which biologists work to achieve goals.

Perceptions

A change in perception of Global Climate Change as a problem.

Skills/Applications

Communicate to others that Global Climate Change is a problem.

Distinguish between the different forms of energy and interconvert units of energy.

Read (and comprehend) articles on biodiversity beyond the newspaper level (e.g., in *Scientific American*).

Appreciation

Complexity of our climate system and models employed to predict climate change.

Figure 4. Outcomes Each Instructor Desired Students to Achieve as a Result of Completing His/her Respective Module.

Global Warming Module

greenhouse warming
climate feedback
changes in global radiation budget
emission of greenhouse gases
global climate models
global climate modules reliability

Energy Options Module

energy
energy conversion
entropy
efficiency
exponential growth
power
work
pollution

Biodiversity Conservation Module

nutrient cycling
energy flow
continuity
discrete boundaries/bounded entities
space and area (as limiting factors)
primary productivity
levels of consumerism

Figure 5. Concepts Deemed by Instructors as Most Central to Each Module

Table 1

Questions Comprising Pre- Module Interviews with Students

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1) What influenced your decision to enroll in this course?

2) Thinking about the topics and modules of study in this course, what content is of the greatest interest to you?

3a) What would you most like to get out of this course--in other words, what are important course outcomes for you?

3b) (Cite each outcome provided in response to 3a) is important to me because:

4a) What, if any, relationships do you see amongst the three modules--Global Warming, Energy Options for the Future, and Biodiversity Conservation--that comprise this course?

4b) In what way(s) is the wrap-around unit on Science, Technol,ogy, and Environmenal Policy related to the three modules?

5a) What do you believe are the two most important relationships shown in your concept map?

5b) What is it about (cite each relationship provided in response 5a) that makes it so important?

6) In this map, you have included three terms which you believed were important but were not provided on the list of terms for this assignment. These terms are (cite terms). For what reasons did you choose to include each of these three terms?

7) (The student was asked what thoughts and ideas came to mind when the student thought about each of two concepts, e.g., " climate feedback" and "global radiation budget", that the module instructor had identified as being amongst those most central to the module.)

8) (The student was asked what thoughts and ideas came to mind when the student thought about each of two concepts, e.g., "efficiency" and "exponential growth", that the module instructor had identified as being amongst those most interrelated with the other course modules.)

9) (The student was asked what thoughts and ideas came to mind when the student thought about each of two concepts that the wrap-around unit instructors had identified as being amongst those most central to the wrap-around unit. These concepts were "environmental policy" and "environmental issue")

10) (The student was asked if they believed that the issue presented by the upcoming module of study, e.g., GW, was a threat and to provide reasons for their answer)

11) (Students were presented with a scenario where they were to walk the interviewer through the preparation and delivery of a testimony on the critical issue targeted by the module of focus, e.g., "Energy Options for the Future: Is it a concern? What should be done?" Refer to Table 2, question 6, for the script followed in presenting this scenario.)

12) Is there anything else you would like to tell me about the course STS 251 at this point?

Table 2

Questions Comprising End-of-Course Interview with Students

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1) What do you perceive to be the major strengths of the course? (Please explain.)

2) If you had the power to change the course, what changes, if any, would you make? For any change you mention, I would also like to know your reason for suggesting the change.

3) I would like your comments on various aspects of the course:
Scheduling
Number of instructors
Lecture
Reading material
Forums
Lab
Lab reports
Exams
Amount of work
E-mail
Absences
Course prerequisites

In your opinion, should this course count as a general studies natural science course? Why?

4) Prior to taking this course, each student probably had some prior knowledge and understanding of the course content. I would like you to consider your prior knowledge and understanding of the content in this course. Specifically, I would like you to tell me: What do you know and understand now that you did not know and understand prior to taking this course? Lets start with...

Global Warming
Energy Options
Biodiversity
Public policy

5) What do you consider to be very important interrelationships among all three course topics of GW, EO for the Future, and BC? (Describe how ____ is interrelated.)

6) Now, I have a scenario I am going to describe. Let's imagine it is the real thing. Suppose the University Student Government and Eco-Action were jointly sponsoring three different Forums in the future. The topics for these three different forums are GW, EO for the Future, and BC. At each forum, testimonies will be presented by concerned individuals.

In a testimony, the concerned individual sets forth and substantiates his/her views and position on the topic of concern. Testimonies on various topics of concern and on proposed laws are often given in front of Congressional Committees.

(Continued)

(Table 2, continued)

You have been selected at random from this class to give a testimony at one of these three forums on the topic of concern: GW, EO for the future, or BC. You must choose: Which one of the forums will you testify at? Your topic will be (depending on your choice):

"____________. Is it a concern? What should be done?"

a) I would like you to walk me through your preparation for this testimony. Please tell me how you would go about preparing to give this testimony.

b) In your preparation, suppose you ran across one or more resources which presented a view on ___________ that was contrary to your position. How, if at all, would you use such resources? (What are your reasons?)

c) Let's suppose that you have completed your preparation for this testimony and that your present knowledge on GW is what you have learned through this preparation. In presenting your testimony, what would be the key points you would make to your audience?

d) Would you recommend that the members of your audience take actions? (If so, which ones and for what reasons?)

7) For what reason(s) did you choose the above testimony topic as opposed to the other two?

a) Do you feel the topic you chose represents more of a threat than the other two topics? Please explain.

8) How would your preparation for the testimony have altered if you had not taken STS 251?

9) In what ways, if any, has this course influenced your interest in STS?

10) Has this course influenced your interest in taking other STS courses or courses related to the topics presented in this course? (Please explain.)

11) Has this course influenced your thinking about the resolution of STS issues such as GW, EO for the future, of BC? (Please explain.)

12) Has this course influenced your thinking about your lifestyle? (Please explain.)

13) Is there anything else you would like to tell me about the course STS 251--anything else you believe that would be important for the evaluators of this course to know?

Table 3

Questions Comprising Pre-instruction Interview for Course Faculty

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1) What outcomes do you desire for STS 251 students in your module?

2) Tell me about the importance of each of these outcomes.

3) What is the relationship between the outcomes you mentioned and the STS 251 course objectives?

4a) What are the most important or central concepts/big ideas in your module that you want students to understand?

4b) Of those central concepts/big ideas, which three do you consider to be most interrelated with the other modules in this course?

5) How do you see the relationship/interplay between all of the modules?

6) What else, if anything, would you like to say--anything you feel that would be important for the evaluators of this course to know?

Table 4

Questions Comprising Post-module Interview with Module Instructors

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1) At our pre-module interview, you identified several outcomes (provide list of outcomes) that you desired students would achieve as a result of completing your module. Now that you have finished teaching this module, please tell me:

   a) Are these (still) the outcomes that you hope students achieved? In other words, what, if any changes in this list are necessary to reflect the outcomes that you now hope students actually did achieve?

   b) To what degree do you believe students actually achieved each of these outcomes? What are your reasons?

2) If you taught this module again:

   a) How, if at all, would you change the list of outcomes that you desired students to achieve?

   b) What, if any, changes would you make in your segment of the course? These could be changes in the written materials, lab activities, etc. For any changes, I am interested in knowing your reason(s).

3) How do you see the relationship/interplay between all of the course modules?

4) For the next offering of this course, what recommendations would you make to all of the faculty involved? For each recommendation, please give me your reason(s).

5) Is there anything else you would like to say--anything you believe that is important for the evaluators of this course to know?
