

Environmental Science, Technology and Decision Making

A. Project Summary

The general objective of this curriculum development project is to prepare material and a curriculum for teaching environmental issues to a wide range of undergraduate engineering and science students. The curriculum will include: a) modules that can be incorporated into individual disciplinary courses, and b) a complete curriculum for a self-contained course including a text.

The specific components of the project have the following objectives:

1. To develop teaching material that uses a project-based approach to understand the principles in science, engineering and policy that affect environmental decision-making. The materials will include: a) case studies using decision-making contents, b) team projects of realistic environmental issues, c) role-playing exercises that emphasize decision-making.
2. To demonstrate - teach and evaluate - the materials at two institutions: These institutions are Rose Hulman Institute of Technology (RHIT) and Carnegie Mellon University (CMU). The courses and student groups will include: a required course for all civil engineering juniors as a first introduction to environmental engineering (at RHIT); science and engineering students pursuing an environmental engineering minor (at CMU); and, a core course for environmental studies minors (students from all majors, including fine arts, humanities and social sciences, science and engineering at CMU).
3. To evaluate the outcome of this project-based teaching approach. This demonstration will include detailed evaluations by students as to benefits of the approach for learning and interest, changes needed for future courses of this kind, and what the possible effects may be on future careers/lives. Both formative and summative evaluations will be conducted during the project. We will also conduct evaluations pre-course, and post-course, and continue the evaluations after graduation for those students who took the demonstration courses - 2 years, and 5 years after graduation. A pilot workshop involving a few faculty will be used as part of this evaluation.
4. To prepare a handbook of the methods used in this curriculum for dissemination. In addition to the curricular materials, we will prepare a handbook of methods including the use of team projects and cooperative learning, concept maps and influence diagrams. This will be used and revised during the pilot faculty workshop

In addition, we will apply for grants elsewhere to do the following:

Faculty enhancement summer workshops where faculty across several environmental and science disciplines meet to develop material specific for courses to be taught the following year. We will include ongoing evaluations of those students and faculty as well.

Develop curriculum multi-media material for wide-scale distribution via the internet. This will be based on results of evaluations from #4 and #5.

In this project, we will develop and test a set of materials which will enable the student to learn and practice using the relevant science and engineering principles, as well as

provide several pedagogical techniques that address the affective dimensions of teaching and learning. These include case studies in which students role-play environmental decision-making scenarios, exercises such as development of concept maps to enhance understanding of connections, context and constraints in decision making, and integrative projects such as using life-cycle analyses to compare the environmental friendliness of consumer products.

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C. Project Description Introduction

Environmental issues affect, and are affected by, all of the science and engineering professions to varying degrees. The need to have a working knowledge of environmental issues is not confined to environmental scientists and environmental engineers. All educated citizens need to have a working understanding of the fundamental principles involved for responsible decision making in our technological society. The interconnected nature of environmental problems, and the interactions between social and individual decision making on the development of solutions for environmental problems require that a coherent course include the social, economic, organizational and ethical dimensions and how to deal with them. Thus an active project-based approach to learning is imperative if course material is to enable students to be capable participants in environmental decision making at the individual and social level.

For the purposes of this proposal, we use the term "environmental literacy" to mean the capability for a contextual and detailed understanding of an environmental issue in order to enable analysis, synthesis, evaluation and decision making to the level required. This means that "environmentally literate" students will have the knowledge, tools and sensitivity to properly address an environmental problem in their professional capacity, and to routinely include the environment as one of the considerations in their work. Environmental literacy is essential for general decision making in a participatory democracy in an increasingly technological world posing numerous environmental challenges. Thus environmental literacy is a requisite for student in all majors, although they may eventually use the learning in different contexts.

The central objective of this project is to develop and test materials which may be used either for a single course on the environment or as part of courses to be taught across engineering and science disciplines. These materials will help students develop an understanding and appreciation of the key dimensions of environmental issues. The emerging paradigm of design for the environment (DFE) and pollution prevention (P2), as well as several regulatory aspects, require all engineers to design to minimize the life cycle environmental impacts of processes and products. For example, civil engineers have to assess environmental impacts of construction and development projects; while chemical engineers working on polymer development and mechanical engineers designing automobiles need to have an understanding of the environmental aspects of materials and energy use during the product life cycle.

We plan to develop a flexible curriculum that can be used either to supplement existing traditional science and engineering curricula, or as a self-contained course. For example, at CMU, the "Environment across the curriculum" initiative is working on infusing environmental units into core courses in several disciplines [Davidson 1996]. The material to be developed in our project would include stand-alone units that could be used in this context as well. The project objective also includes an emphasis on obtaining input from faculty and students, and facilitating widespread distribution of the material that is developed.

I.1 Motivation and Background

An environmental curriculum provides a good ground not only for teaching environmental issues and the relevant science and technology; it also provides the ideal setting for

teaching in context. Teaching in context is increasingly recognized as an essential feature of education in a complex society [Yager 1996]. In this materials development project, we adopt an interdisciplinary project-based approach that is essential for an environmental course but also useful in courses designed for general scientific literacy. Both the PIs have used prototypes of the materials to be developed in engineering and in general education courses. We have seen in our classes that by careful design, the processes and set of pedagogical techniques to be described below can promote a number of educational objectives. There is also a general often unstated assumption, that educational objectives are best attained by teaching "expert" knowledge to specializing students (i.e., environmental engineering or at least engineering or science majors) and broad-brush "issue" knowledge to other "naive" students. The work by one of us on student mental models of environmental issues have shown that while engineering freshmen may have more confidence and know more technical details than their counterparts in other majors, they are no different in misconceptions and understanding of the context of environmental issues [Atman 1996]

Incorporating an understanding of environmental issues into the college curriculum fits into the NSF paradigm for engineering education in the twenty-first century which emphasizes a) placing environmental, health and safety issues at the front end of designs, b) thinking across disciplines, c) becoming adept at group problem-solving strategies, improving communication skills, recognizing the relationship between engineering and the social/political/economic context in which we live, and making active learning the predominant learning mode [Engineering Report 1995]

If we want a larger part of the population to be able to participate in the decisions on some of the most important issues of our time, the courses have to include the "practical, civic and cultural" dimension [Shen 1975]. In this context, the objective of teaching science and technology is to enable student citizens to understand and assess the "practical" scientific and technological information and the "civic and cultural" information including social and individual behavior, ethics and regulation in order to derive the evaluative judgment needed for informed decision making. Several authors have pointed out the shortcomings of the narrow disciplinary, hierarchical, subject-centered (as opposed to learner-centered), and monolithic approach to the teaching of science and technology, even in general education courses. They cite this approach and the failure to place the science and technology skills and knowledge in the context of relevant issues as reasons for the disenfranchisement of capable students, particularly women and minorities, from engaging in learning and applying science and technology, and for the absence of scientific literacy among the majority of the educated public [Tobias 1990, 1992; Rosser 1990]. Environmental courses provide a natural setting to teach scientific and applied principles, and decision-making skills and also to promote cooperative learning and the higher skills of analysis, synthesis and evaluation. The obvious relevance of the subject area elicits high degrees of participation and active development of critical thinking skills, group process and communication skills.

I.1.1 Instructional Materials AvailableWe plan to produce material designed for use in a variety of different types of institutions. There is a paucity of materials appropriate for a diversity of student and teacher preparation and interests. The material and texts currently available are described briefly below with their specific problems. There are several introductory texts to environmental science and environmental engineering. However, they are either lacking in the scientific dimensions, or in the technological dimensions of environmental issues. And, both types of books lack the policy/social science aspects. In addition, neither type of text addresses the contextual basis for

environmental issues as affecting the broad field of engineering and science. Environmental issues are multidimensional, dynamic issues. As a result, in our introductory courses, we routinely need to supplement texts with additional readings borrowed from journals and other publications that are often not written for the college audience.

Attachment 1 outlines the main texts currently available in environmental science and engineering and as overall environmental studies texts. There are also numerous books (usually edited volumes) on specific aspects such as environmental ethics, sustainable development, and environmental policy, chapters from which we have used in our classes to cover topics such as environmental ethics and global environmental issues.

Each of the available texts has several strengths. Overall, the scientific treatment of ecology is good, and all the books provide good graphic and pictorial representations of environmental problems and of relevant data such as pollution or toxic material use trends.

I.1.2 Need for New Course Material

In our use, we have found several common drawbacks in the available material from the point of view of a course designed to promote the environmental literacy of a diverse student population:

- Most of the books tend to have qualitative discussions of the data presented rather than the appropriate quantitative analysis where possible.
- Most have only a sketchy treatment (when there is any at all) of some of the central concerns for environmental decision making. These include relevant details of: risk, economics, and the behavioral and regulatory elements.
- Most of the texts lack a systems perspective which is key to an integrated approach to environmental decision-making.
- Discussions of science and engineering principles such as materials and energy balances are at best qualitative and lacking in detail in most of the general textbooks. This is particularly problematic since most engineering problems (and solutions) are based on a few similar principles.
- Many of the emerging paradigms such as pollution prevention and design for the environment are not treated at all.
- While societal values are treated in some way in each of the books, there is no attempt to introduce a coherent framework to incorporate the value and ethical dimensions into environmental decision-making.
- Most of the material is designed for passive learning of facts by students rather than to develop and exercise critical thinking and decision-making skills.

II. Objectives and Components of Project

To address environmental issues in a professional and responsible fashion, students need to understand the fundamental natural and social science dimensions of those issues, and the interaction of those with technology. The teaching methods need to be "experiential, or hands-on" and provide students with the relevant skills and frameworks, and meet the needs of diverse styles of learning.

II.1 Overall Project Objectives

This curriculum development project has four objectives under the premise of this proposal:

1. To prepare material and a curriculum for teaching environmental issues to a wide range of undergraduate engineering and science college students to include: a) modules that can be incorporated into individual disciplinary courses, and b) complete curriculum for self-contained course including text. To concurrently prepare material for general environmental education.
2. To develop the teaching material with a focus on understanding several key dimensions in science and policy that affect the broad range of environmental issues using: a) case studies, b) team projects of realistic scenarios. The emphasis will be on project-based learning.
3. To demonstrate - teach and evaluate - the materials at two institutions. These institutions are Rose Hulman Institute of Technology (RHIT) and Carnegie Mellon University (CMU). The courses and student groups will include: as a required course for civil engineering juniors (2/3 not interested in environmental engineering careers) (at RHIT); science and engineering students pursuing an environmental engineering minor (at RHIT and at CMU); and, a core course for environmental studies minors (students from all majors, including fine arts, humanities and social sciences, science and engineering).
4. To conduct detailed evaluations by students as to benefits of course, changes needed, and what possible effects may be on careers/lives. Both formative and summative evaluations will be conducted during the project. We also plan to conduct evaluations pre-course, and post-course and continued evaluation after graduation of students who took demonstration courses - 2 years, and 5 years after graduation. We will also conduct a pilot workshop for regional faculty as part of the demonstration.
5. To prepare a handbook of the methods used in this curriculum for dissemination. In addition to the curricular materials, we will prepare a handbook of methods including the use of team projects and cooperative learning, concept maps and influence diagrams. This will be used and revised during the pilot faculty workshop

In addition, we will apply for grants elsewhere to do the following:

Faculty enhancement summer workshops where faculty across several environmental and science disciplines meet to develop material specific for courses to be taught the following year. We will include ongoing evaluations of those students and faculty as well.

Possible development into multi-media material for wide-scale distribution via internet. This will be based on results of evaluations from #4 and #5.

In this project, we will develop and test a set of materials which will enable the student to learn and practice the use of the relevant science and engineering principles, as well as several pedagogical techniques that will address the affective dimensions of teaching and learning. These include case studies in which students role-play environmental decision-making scenarios, exercises such as development of concept maps to enhance understanding of connections, context and constraints in decision making, and integrative projects such as using life cycle analyses to compare the environmental friendliness of consumer products.

While the primary focus is on majors in engineering and the sciences, our experience has shown that the material and methods can be easily adapted to general environmental literacy courses. This adaptation will happen in one course at CMU. We believe this will be an advantage to leverage this project work to have broader impact.

II.2 Project Components

We briefly sketch here our approach to integrate subject matter and pedagogy to attain our objectives. Our approach is based on students attaining four areas of knowledge: core knowledge; analysis, synthesis and evaluation skills; learning to learn; confidence, autonomy and ownership. The philosophy for each of these is described below very briefly. We give some relevant examples of material developed under each category, although each of these exercises could also be used to illustrate the other points. Cognitive and affective learning objectives as well as pedagogical methods are interwoven in our description below as they will be in the curriculum we develop. This is to be expected in an integrated framework.

II.2.1 Core Knowledge

We have identified a fundamental core of principles and methods as the foundation for environmental literacy. This must be a small and manageable yet sufficiently comprehensive set so that all the issues in the problem area of "environment" can be understood with these principles. The generalizability of principles should be made explicit so that these can also form the basis for understanding a broad array of other problems. Ideally, the core knowledge should be interdisciplinary so that artificial disciplinary divisions such as science, economics, and technology will not be an impediment to the student facing a complex situation involving the interaction of science, technology and society.

These fundamental dimensions in the area of environment include an understanding of:

- energy, particularly the first and second laws of thermodynamics,
- the law of conservation of mass practiced as materials balance
- basics of ecology and ecological systems,
- growth, focusing on the interaction between population growth and resource consumption,
- risk, focusing on how quantitative risk is calculated, and how that is communicated,
- environmental justice, and environmental equity, and
- emerging ways of thinking such as industrial metabolism and industrial ecology, green design, and sustainable development.

We have used an array of readings to teach these topics, and developed various exercises. Over our several semesters of teaching, various modes of presentation have emerged. This project is to develop and disseminate the material and pedagogy into coherent teaching material that can be adapted to other college courses fairly easily.

II.2.2 Analysis, Synthesis and Evaluation Skills

The critical judgment to discriminate between options is normally a faculty developed with expertise and practice in a given subject area. Yet, here we want to develop this evaluative faculty in a "non-expert." This means that the student should learn not only the facts but also develop an understanding about the context, processes and their strengths and limitations.

The dimensions of the environmental issues described in Section II.2.1 have to be presented in a coherent, yet adaptive and flexible conceptual framework so students can learn to learn as issues emerge and paradigms change in the future. This framework rather than being a prescriptive and rigid structure, will be developed by students from the subject material they learn and the pedagogical techniques that place them in decision-making contexts and provide them with skills of constructing such frameworks. One framework we have used successfully to organize student learning is that of engineering design. Design can be considered a paradigm for teaching in general. Broadly, The five educational elements of design may be thought of as: (1) knowledge, (2) problem definition and solving, (3) ethics, (4) judgment and decision making, and (5) team work. Teachers can use this framework to design the content, process and environment of learning itself. At different levels of student learning, different relative emphases may be placed in these domains, depending on the student's knowledge, developmental stage and interests. Aspects such as needs assessment (problem definition), decision making and ethics which have received attention recently as central components of science and engineering education are brought in naturally into this "education as design" framework.

In addition to these cognitive goals, this approach also has value in the affective domain. Research on educational psychology has shown that "perceived self-efficacy" is a key to choice, performance and persistence of all students in any subject area including science, mathematics and engineering. [Betz 1983, 1990]. Design provides a setting in which these aspects can be fostered as an inherent part of the educational setting, and thus engender self-efficacy even in underrepresented populations of students. Pedagogical and motivational factors such as teaching knowledge in context, learning through trial and error, extended periods for observation and testing, seeing the use of the material learnt, ethical responsibility as part of the goal of the design engineer, are all automatically built into the design paradigm for learning. All of these factors have been cited by numerous authors as necessary for attracting and retaining female and minority students [Tobias 1990; Rosser 1990, 1995; Nair 1995].

The simple yet powerful tool of concept maps provides an example of providing the student with a method to map the concepts and connections. Again, this representation provides the student with a way to express and explore the frameworks to be learnt in the course. [Novak 1984]

Example of an exercise we have used very successfully to teach analysis, synthesis and evaluation as well as research skills is one in which a team of students do a "comparative life cycle analysis". They take two options of a familiar consumer product (e.g., soft drink bottles of plastic or glass; cloth or plastic diapers) and do a life cycle analysis. Students develop criteria by which they decide which of the options is more environmentally friendly, and design a logo to represent this. One of the most exciting responses to this exercise from one of our classes was presented by our students at the Tenth Annual Technological Literacy Conference of the National Association of Science, Technology and

Society [Chen 1996]. Attachment 2 is the handout for this assignment from one of our courses.

II.2.3 Learning to Learn

The student citizens' education needs to evolve and continue to serve them in the face of change. For this, the course should also teach the "scientific and humanistic ways of thinking", including methods of structuring a new problem, and methods of recognizing commonalities and differences in classes of problems so that the transfer of learning to a new problem occurs as it develops. Gentner has shown that such translation of learning does not occur automatically [Gentner 1983]. So, it is necessary that generalizability and limitations be discussed explicitly in the course. Again the conceptual frameworks and tools aid in this development.

II.2.4 Confidence, Ownership and Autonomy

To be competent decision-makers students have to develop a problem-solving mentality that can enable them to feel confident and take "ownership" of adapting solutions to new problems. This means that the pedagogy of teaching has to place the students in situations not only of solving a specified problem, but in situations where they have to define the problem, collect data from diffuse, "real-world" situations and formulate strategy for solutions [Cassidy 1977]. Active problem-based learning through case studies is used routinely in our courses as a means of formulating, structuring and solving problems. These require students to represent the points of view of diverse stakeholders in the issue at hand. They also have to develop and present solutions founded on substantive knowledge and evidence.

Over the years, we have seen that a byproduct of this approach is the confidence and ownership that students develop towards their knowledge. They begin to gain the competence to go in search of the facts, analyze, synthesize and evaluate data, and examine the ethics of various decisions. During the semester we observe the students becoming increasingly autonomous and sensitive in their decision making.

II.3 Curriculum Materials

The materials to be produced will be the elaboration of the topics listed above in section II.2.1. For each of these topics, we will write the text material, problem and exercise sets and guidance on how to implement the problems, and we will discuss any relevant pedagogy. We will pay attention to the requirement that parts of these topic modules be stand-alone to meet the needs of those who wish to use only small segments. At the same time, we hope to maintain integrity and continuity for the course as a whole. We have had practice doing this in several cases, as we have used segments of our semester-long course as material for standalone workshops or as units injected into another course.

Attachment 3 includes several examples that demonstrate the nature of materials to be produced in this project. These are: Course plan from two of our courses, the outline of a case study on solid waste management, an outline from one of our workshops for high school students and a paper describing the high school workshops.

II.4 Expected Advantages of the Project

Various advantages of this approach can be enumerated. Among these are the following:

- This approach caters to diverse needs of student population.
- It provides an exciting way to teach an introductory course that aligns with NSF paradigm for engineering education at the undergraduate level, as well as environmental literacy for the general student population.
- The curriculum and its components focus on the complexity and contextual basis of environmental issues.
- It develops interdisciplinary skills, decision-making skills, group interaction skills, and communication skills. Ethics, group processes, and policy dimensions will be integrated into the curriculum.

II.5 Project Evaluation

The project will include the design of appropriate evaluation instruments to measure the learning outcomes of this course material, and to obtain a better understanding of how to measure environmental literacy.

II.5.1 Student Learning and Course Evaluation

Student learning will have to be measured in the following areas:

- substantive knowledge in the area of science, engineering and policy relevant to analysis and decision making in the area of environment;
- capability in problem structuring, formulation and solving;
- confidence and "comfort" in dealing with decision making in environmental problems
- communication and group interaction skills.

These attributes are not easily measurable. Quantitative and qualitative tests and measures will be designed for this evaluation. We will use the criteria of "utility, feasibility, propriety and accuracy" in the methods used [Patton 1987, page 27] and will adapt the methods as needed [Patton 1986; Rossi 1979; Shadish 1990].

(i) Quantitative Measures

We envision two types of quantitative measures of student performance, one to assess the knowledge of facts and applications and the other to assess how the student structures the problem. Knowledge of basic principles and their application to problems will be tested in the traditional manner. We will also construct instruments that involve student problem formulation from given open-ended situations. To evaluate these, we will design a protocol based on student constructions of a concept map to represent logic and formulation. We have used this method informally in our courses, and formally in research projects both on risk communication and on student perceptions of STS issues [Bostrom 1992]. Briefly, the method consists of using the students' representation and analyzing the results to evaluate the extent to which the student correctly represent concepts and links that are central to the problem.

A detailed and valid method of analysis of these instruments will be developed as part of the project. The tests will be given at the beginning of the course and after the course is completed to see if there is an observable difference in the student's approach to problems. Details have to be thought through and validated.

(ii) Qualitative Measures

Many facets of the course and of student learning can be evaluated only through a qualitative approach [Guba 1981; Marshall 1989]. We will start with an array of approaches and refine these as we proceed to arrive at a system of methods for evaluation.

As parts of developing accountability in the student, it should be useful to expect them to participate in a meaningful and responsible course and self-assessment. We will design systematic and routine situations for students to participate in ongoing formative evaluation of the material as well as of their learning. In our classes, we have asked students to keep course journals in which they discuss the perceived usefulness of the material as well as their understanding. We have used these to revise course material, but these could also be used to assess student learning.

Another method we are considering is of quality circles to elicit students' observations about the course. Rossi has suggested using participants in a program in a preliminary assessment of program impact [Rossi 1979]. We will explore several methods of structured group meetings for evaluation as part of the project to obtain methods that yield useful results but are not overly cumbersome and tedious to conduct. We have some experience of using student peer evaluations in group projects for the purposes of feedback and evaluation.

II.6 Faculty Enhancement Workshop (Pilot)

The products of the project are: materials for environmental education; pedagogical strategies and methods; evaluation strategies and tools. We believe that a series of faculty workshops can be an important means for initial dissemination of the project material. While we plan to obtain funding under the Faculty Enhancement Program of the DUE for a series of workshops starting in 1998, we look to this project to fund a pilot workshop in 1997. This would enable us to plan a solid series, based on this pilot.

The pilot workshop to be held at CMU would be for 10 or less participants, selected from an opportunity sample of primarily local participants. These participants would be faculty who intend to use the material in their Fall 1997 or Spring 1998 courses. They would be required to identify courses in which they would use specific material. Material developed up to that point will be sent to these faculty.

The workshop will have two components: The PIs and selected experts will conduct a series of general presentations and discussions about the overarching elements of the curriculum, including the basic principles as appropriate; non-technical subjects such as environmental ethics, risk assessment, and policy issues; methods of evaluation; and, pedagogical elements such as development and use of concept maps, and conducting group projects.

Participants will work individually or in groups preparing and presenting to the others focused material and methods tailored for their class use in the following academic year. They will also select methods of evaluation and work out details for their own evaluations.

We request funding in the present project for this as well. We will follow these participant's implementation and evaluation during the following academic year, and invite them to contribute their material for our curriculum.

As feasible, we will bring these participants back as "master teachers" for the larger workshops to be funded under alternate programs.

II.7 Project Execution and Management

II.7.1 Project Personnel

The PIs, Indira Nair at CMU and Sharon Jones at RHIT, have jointly and individually developed and taught a number of courses and workshops for a diverse set of students at CMU and RHIT. These courses and workshops have led to the material that will form prototypes to be refined and tested during the project. Because we will both be teaching this course during the entire duration of the project, we have a built-in opportunity to refine, test and revise the material in our classes at two different institutions. In addition, we will encourage students from Chatham College, a women's college near CMU to take these course through cross-registration. By keeping detailed track of these students' learning we will test the evaluation instruments as well.

Indira Nair is Associate Professor in the Department of Engineering and Public Policy at CMU. She has designed and taught numerous interdisciplinary courses at CMU as well as in local high schools. Design of educational materials and teaching are two of her primary interests in research and in practice. Her research work in teaching includes a study on the mental models of engineering and humanities students, using disassembly of a device to teach science to young children, and communicating scientific uncertainty to public audiences. [Atman 1996; Nair 1996]. Her other research interests include: health effects of ionizing radiation, biological effects of low frequency fields, risk assessment and risk communication, and green design. Courses designed and regularly taught by Nair at Carnegie Mellon include: Introduction to Engineering and Public Policy, Science and Technology for the Environment, Radiation, Health and Policy, Green Design and Science, Technology and Ethics.

Nair was the Chair of the review panel of the study that resulted in the report, "Green Products by Design" of the U.S. Congress Office of Technology Assessment in 1990. She serves on the National Council of Radiation Protection Committees, on the EVS Panel of NSF, on the Board of Directors of Student Pugwash USA, an organization dedicated to promoting student discussions of the social responsibility of science and technology and on the Executive Committee of the Pittsburgh Regional Center for Science Teachers (PRCST). She has co-organized and chaired the annual STS symposia for science teachers conducted by PRCST. She was awarded the Doherty Prize by CMU for "outstanding contributions to excellence in education" and the Leadership in Education of the Greater Pittsburgh YWCA in 1991, and the Special Presidential Advising Award of CMU in 1992.

Sharon Jones is an Assistant Professor in the Department of Civil Engineering at Rose-Hulman Institute of Technology. At Rose-Hulman, she is responsible for teaching several environmental engineering courses, as well as developing a new interdisciplinary graduate program in environmental engineering. At Rose-Hulman, Sharon has designed and taught project-based courses in environmental issues, and solid waste engineering. She has worked with Indira Nair on several project-based courses at both the college and pre-college level at CMU. And, she has taught a project-based courses "Characterization and Assessment of Environmental Problems" at Allegheny College, Meadville, Pennsylvania.

Jones is completing her Ph.D. in Engineering and Public Policy at CMU. Her research focuses on developing a framework by which global change scientists can assess the value of their research for long-term policy and decision-making. Jones is a licensed Professional Engineer who has worked on environmental issues in solid and hazardous waste management for both government and private consulting. She has an undergraduate Civil Engineering degree, and Masters degrees in both Civil Engineering and Public Administration.

II.7.2 Suitability of Institutions

CMU and RHIT provide two different types of institutions to test, evaluate and revise the material. The courses using the prototypes of the material to be developed in this project have been taught both at CMU and RHIT. As these are part of the existing curricula, institutional support from both institutions is already present. Attachments 4 are letters from both schools. As a research university at the forefront of both design and environmental engineering, CMU provides a rich background in faculty and material that could be of use in the project including a variety of emerging research topics such as green design to be translated into course material. RHIT is a widely recognized leader in undergraduate science and engineering education. Faculty at RHIT are continually evaluating better methods of teaching, and include experts in multi-media education, computers in the classroom, and integrated curricula. In addition, students from Chatham, a women's college renowned for environmental science and education, generally cross-register at CMU. During the project, we will make concerted efforts to evaluate some of the material from the perspectives of these students as well.

The Engineering and Public Policy Department has an interdisciplinary core course, Technology/Policy Project which has existed since 1970. Both of the PI's have vast experience in the project-based learning environment. Nair has written a Project Handbook for internal use. [Nair 1987]

II.8 Dissemination of Results

There are several routes and components for dissemination. Dissemination efforts will consist of:

1. faculty workshops and follow-ups,
2. publication of the course materials both as a text and over the internet ,
3. preparation of a course manual with the pedagogy and classroom techniques for project-based teaching and
4. presentations at conferences.

The pilot faculty workshop is an important venue for dissemination and validation of the curriculum. We plan to hold a pilot workshop of 10 faculty from the nearby region for two weeks in the Summer of 1998. These workshops will be used for summative evaluation and for the use and validation of material on other campuses. We will use these pilot workshops to plan national dissemination workshops and to test the course material and manual.

We plan to contact publishers towards the end of the project so that the materials produced will be published both in a complete text and in modular form. From the early days of the project, we plan to make the syllabus available over the internet and make available any part of the subject and evaluation materials and details of pedagogical techniques to those

interested. We will also present the lessons learnt at national conferences such as the Annual ASEE Meeting and the Conference on Environmental Education.

II.9 Proposed Schedule for Project:

We seek funding for:

- Development and testing of the materials described
- Development of evaluation instruments
- Development and piloting of a faculty enhancement component
- Follow-up evaluations of students who have graduated from program components (stand alone courses or units introduced into other courses)

The schedule of work for the proposed project is given below. Because of our teaching commitments, we will start work on the project before the onset of the support requested. Sharon Jones will be teaching "Environmental Issues" in the winter quarter 1996. Indira Nair will teach "Science, Technology and the Environment" in the Spring of 1997. We hope that the project funds will be available for use from January 1997 on, or by late Spring 1997.

We also hope to synergize this materials development project with a concurrent faculty enhancement project that will figure centrally in our dissemination plan. To this end, we are asking funding under this project for a pilot faculty workshop. We will apply to the NSF Faculty Enhancement Project for a formal set of workshops in the Summer of 1998.

Summer, Fall 1996- Refinement of materials used over the last 2 years in similar courses into a package to be used in academic year 1996/1997. Development of course evaluation tool (pre and post) for students at the 2 institutions.

Project Duration: January 1997 - December 1999
Start of Project (formal) January 1997

Spring 1997	Use package in courses at the two institutions. Conduct pre and post evaluations of students in self-contained course. Develop faculty enhancement workshop pilot materials. Develop evaluation tool of faculty use of material.
{{May 1997	Apply for Faculty Enhancement Workshop funding}}
Summer 1997	<ul style="list-style-type: none"> • Conduct pilot faculty enhancement workshop. (funding requested in this project). Participants for pilot workshop will come from the home institutions and any others whose interest we can elicit, and will include faculty who are already interested in such material. • Use results of workshop and course evaluations to update package of material to use in academic year 1997/1998.
Academic year 1997/1998	<ul style="list-style-type: none"> • Use revised package in courses at 2 (or 3) institutions. Conduct pre and post evaluations of students in self-contained course. Conduct evaluations of students in course with integrated modules. • Begin formalizing materials into text and faculty instructional materials. • Use results of Summer 1997 faculty workshop to prepare for Summer 1998 workshop. Solicit much wider participation from faculty across US.
Summer 1998	<ul style="list-style-type: none"> • Develop evaluations for graduates of curriculum that includes the "environmental issues" course and/or modules. These will be conducted over the next 2 to 5 years. {{ Under separate funding if obtained: Conduct faculty enhancement workshops for national audience. Use results of workshop and course evaluations to finalize text and faculty instructional materials.}} • Present results at ASEE Annual meeting.
Academic year 1998/1999 Summer 1999	•Develop materials into preliminary revisions of multimedia tool to be distributed across internet or similar technology that allows for wide dissemination.
Fall 1999	•Presentations at Conferences

II.10 Results from Prior NSF Support

One of us (I.N.) has been a co-PI on three recent projects supported by NSF. One was a research project, Grant No. DIR 9012421, from the Ethics and Values Studies Program of the Division of Social, Behavioral and Economic Research with Professor Cynthia Atman of the University of Pittsburgh as co-P.I. The work (1991 - 1994) was an empirical comparison of the knowledge and attitudes about STS issues of freshmen in engineering and those in non-engineering majors. The essential finding, particularly relevant to this proposal is that: (a) engineering and non-engineering freshmen consider environmental issues of central importance; (b) that they have limited understanding of the complexities of environmental problems; (c) while engineering freshmen have more confident knowledge about some technical issues, both groups have about the same level of general understanding and the same misconceptions about selected environmental issues. All these imply that a general course should be valuable for both these populations. The results of this work have been published in 4 papers. [Nair 1993; Atman 1992, 1994]

The second project was under the Young Scholars Program of the Division of Elementary, Secondary and Informal Education, Grant No. ESI-9353846 to bring to CMU 52 bright high school students for six weeks of each summer to involve them in a program consisting of workshops in STS and in technical communication and a research experience in one of the three NSF Centers of excellence at CMU. This program received excellent evaluations from its alumni over its six years, but did not receive NSF funding when we applied for renewal in 1996. A variety of material developed for the STS workshops uses some of the techniques described in this proposal and we are currently developing a secondary school teacher inservice program using some of these. Sharon Jones developed a case study and taught in these workshops for two of the summers.

Currently, Indira Nair is the PI for an Information Dissemination Award grant from the Program for Women & Girls under the Division of Human Resources (Grant No. DIR 9012421) for a book of biographical narratives of women currently working in science and engineering. The book is to be completed at the end of 1996, and will be published by Temple University Press.

II.11 Budget Narrative

The main items in the budget are significant amounts of time for the co-PIs to be able to develop, teach and evaluate the material and conduct the faculty workshops. Student assistance and concerted effort by the PI'S are the mainstay of the preparation of this material. Despite her large commitment of time (3 months per academic year, 2 months of summer), Sharon Jones' academic year support is provided completely by RHIT. Two months per year of Indira Nair's time will also be cost-shared by CMU.

Travel for the PIs for planning, for the participants of the Pilot Faculty workshops in Summer of 1998, and to conferences for dissemination are the other major items. Sharon Jones will spend 3 weeks in the summer in Pittsburgh. As her summer month salary is charged to the project, only travel and \$100 per day to defray lodging costs is charged for this time.

We will hire an evaluation consultant to design and conduct the project evaluation. This consultant's time is charged at 15 days per year at \$400 per day.

The pilot faculty workshop is our main dissemination venue, and this is seen as the justification for that expense. The workshops also help in summative evaluation and for the use and validation of material on other campuses. The two-week workshops are budgeted at \$200 per day for 12 days and travel of \$400 per person for ten participants. We will use these pilot workshops to plan national dissemination workshops.

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