

From: rholland@nsf.gov  
To: Mike Gorman <meg3c@watt.seas.Virginia.EDU>  
Subject: Your Pending Proposal 9319983  
Date: 3 Mar 94 16:23 EST

Dear Mike,

Sorry it has taken me a while to respond, due to various factors including the need to coordinate the consideration of the proposal with the Education directorate. Here's the current status: The proposal has done relatively well in review. There are a number of questions and concerns that I will need your response to before making a final determination. Since I am late in getting to this point, the first question to ask is whether the project is still feasible, given that the semester for which you wanted support is rapidly becoming history. I imagine that a new timeline will need to be developed. The second question is whether a total of \$20,000 will suffice to do the project? That is the amount I can afford to recommend. If these questions are answered positively, then you can turn to the following concerns that arose in the review:


1. You have had substantial support from the Leadership in Science and Humanities program; before further support is granted, more information about results from that prior activity should be presented.
2. Plans for dissemination of results from this module need development and further specification. Could the results be distributed on anonymous ftp? Clarify how the module will be or might be used in engineering schools across the country. Have you disseminated results from the Leadership project or made particular contacts to do so? If so, can these contacts be used to distribute or test results from this module? If not, what contacts can you realistically expect to draw on? Do UVA engineering classes use any of the modules you have developed? Have your own engineering faculty been involved in developing or testing the materials? Can you get ABET involved or interested in the project and its results? Could you involve other local inventors and ethics people and engineering schools in looking at this result and developing similar materials?
3. Reviews indicate some concern that the discussion of ethical issues is vague and confused. Do you mean to imply that anything marketable is ethical? that creating new markets is by definition good? Some description or discussion of the kinds of ethical issues you expect to arise and elucidate in the module would help.
4. The role and use of the videotaping that is proposed is unclear.
5. Most engineers work in large organizations; do you think that the material you will develop can have or will have any

**THIS MATERIAL MAY BE  
PROTECTED BY  
COPYRIGHT LAW  
(TITLE 17, U.S. CODE)**

relevance to them?

I look forward to hearing from you on these matters and, once again, apologize for the time it has taken me to repond.

Sincerely, Rachelle D. Hollander

SCHOOL OF  
ENGINEERING   
& APPLIED SCIENCE

---

DIVISION OF TECHNOLOGY, CULTURE  
AND COMMUNICATION

University of Virginia  
Thornton Hall  
Charlottesville, VA 22903  
804 • 924 • 3425 FAX: 804 • 924 • 4306  
TDD: 804 • 982 • HEAR

31 March 1994

Rachelle Hollander, Program Officer  
Ethics and Values in Science and Technology  
National Science Foundation

Dear Rachelle:

The attached revision of proposal 9319983 is an attempt to respond to your e-mail message of 3/3/94. Pat Werhane and I have integrated the additional information into the proposal, using italics to highlight the relevant material. A revised budget and schedule are also attached.

The one concern I would like to address here is videotaping. Given the reduction in funding and the resultant necessity to focus the project more, we will have to rely on students notebooks as records of their processes. Videotaping group interactions is time-consuming and expensive; coding the tapes is even more time-consuming. We will still videotape group presentations in class, as indicated in the text of the revised proposal.

Thank you for giving us an opportunity to respond to your reviewers' concerns. I hope the result is a substantially stronger proposal.

Sincerely yours,



Michael E. Gorman

Attachment

## TABLE OF CONTENTS

PROJECT DESCRIPTION .....	1
Desired Outcomes .....	1
Background: A Course on Invention and Design .....	2
Structure of the Module .....	4
Implementation .....	7
Evaluation .....	8
Final End Products .....	9
Results from Prior NSF Support .....	11
BIBLIOGRAPHY .....	16
BIOGRAPHICAL SKETCHES .....	17
SUMMARY PROPOSAL BUDGET: YEAR ONE .....	18
Budget Notes .....	19
Budget Justification .....	20
Cost Share Letter .....	22

## Project Description

*We propose to develop a course module that can be used in a wide variety of classes to illustrate how environmental ethics can be integrated into the invention and design process. The module will begin with a case-study of an inventor of solar heating systems who is motivated both by environmental and market concerns. Students will then be given a chance to design their own technology that meets the criteria of environmentally sustainable development; they will have to evaluate their design both for its ecological soundness and from a practical economic perspective, demonstrating how their technology could be marketed. Afterwards, students will analyze and compare their own design processes, focusing especially on the role of ethical concerns in making design decisions. To determine its effectiveness, this module will be piloted and evaluated in a special course on invention and design intended for students from both engineering and the liberal arts. It will then be prepared for dissemination to instructors nationwide.*

### **I. Desired Outcomes**

*In many courses, ethical issues are presented as dilemmas which arise from questionable motives, decisions or actions. Encouraging students to create a technology that will meet stringent environmental requirements allows them to see that trying to "do the right thing" is not simple. Adding the requirement that the resulting technology must be marketable helps students understand other ethical dilemmas faced by engineers who want to build a better world: the practical goal of economic feasibility often dictates creativity and invention.*

From this module, students should learn the following:

*(1) An understanding of the complexities involved in ecologically sustainable development and familiarity with some of the environmental issues facing the world today.*

(2) *How an environmental agenda can shape the invention process. As Melvin Kranzberg has noted, "Technology is neither good nor bad-nor is it neutral." By building in environmental concerns from the start of the creative process, one can create technologies that are more likely to be beneficial.*

(3) That accepting ethical constraints on design does not limit one's imagination. The desire to create a sophisticated new technology is often as great a motive for an inventor as fame and fortune (Pacey, 1989). Adding the constraint that this technology be environmentally appropriate creates new opportunities for innovative thinking.

(4) Skills for analyzing and reflecting on ethical issues in design: Ethical decision-making does not come 'naturally'; indeed, ethical problems are frequently hard to recognize until it is too late and one has made a chain of decisions that are hard to unravel (cf. Pritchard). *By beginning with an environmentally friendly design, students may be lured into thinking that they have solved all the ethical issues. Yet they will then have to defend their design against criteria for sustainable development, e.g., does it use renewable energy, are its materials biodegradable, does it pollute, does it help to clean up or preserve the environment, etc? When they think about how to market this technology, students will be faced with other ethical issues, that may force design compromises. (For a good overview of issues concerning 'green' design and associated economic trade-offs, see see Office of Technology Assessment, 1992).*

## **II. Background: A Course on Invention and Design<sup>1</sup>**

This case will be introduced into a course on invention and design which sets-up a collaborative learning environment; students and faculty from a variety of disciplines explore issues in design together. Standard university curricula tend to compartmentalize engineering, humanities and social sciences. But real world

---

<sup>1</sup>Development of this course was supported by the Leadership in Science and Humanities program of the NSF, NEH and FIPSE.

engineering decisions defy such compartmentalization, as students discover when they take this course.

Currently, we use three modules in the course--the invention of the telephone, the computer and the design of a medical diagnostic system. All cases involve ethical considerations and these are discussed in the course. For example, the medical case involves students in developing an expert system to diagnose cases of sexual assault. Students have to make sure that their system is capable of keeping all client information confidential. They also have to deal with the politics of providing diagnoses for insurance purposes. Is it ethical to label a client in accordance with an insurance code, simply in order to obtain payment? Could an expert system eventually be used to make diagnosis and treatment more 'efficient', thereby robbing abuse victims of the necessary human contact and empathy?

The ethical issues in these other cases have more to do with the impact of the technology than its design. The module we propose focuses specifically on the role of environmental concerns in invention and design.<sup>2</sup> Ethical concerns are often seen as implications or results of designs. We want students to see that sound ethical decisions can be embedded in the way in which one approaches the process of inventing. In this module, our example is the extent to which one can invent and market an ecologically sound technology, one that could potentially produce global benefits.

The goal is not just to develop a module for use in this course, however. The course is itself a kind of laboratory for testing ideas which can be used in other classes across the curriculum. All the modules used currently are being prepared for wide dissemination; this one would be no exception. (See Final End Products, below).

*In addition, the module proposed here will be used in a fourth-year course required of all graduating engineering students at*

---

<sup>2</sup>Cases have been used to teach engineering ethics at a number of institutions, including the Center for the Study of Ethics in Society at Western Michigan and the Center for the Study of Ethics in the Professions at the Illinois Institute of Technology.

*the University of Virginia after it has been piloted and revised in the Invention and Design course. The second semester of this fourth-year course includes lengthy units on ethics and design; as this module combines elements of both, it would be a perfect addition to this course. Our eventual goal is to have every engineering graduate of the University of Virginia exposed to these materials.. This exposure will, in turn, allow us to refine the module for the widest possible dissemination.*

### III. Structure of the Module

The module we have selected involves three components:

- (1) A case-study of a modern inventor of solar heating systems.

A.C. Rich decided to work in the solar energy field because he saw it as one solution to problems like global warming. During his college years, he became active in the environmental movement, organizing and participating in senior seminars and conferences.

After graduating in 1979, he worked as a district manager for a solar company that went out of business when the tax-credit for alternate energy was repealed. In order to stay in the solar industry, he became a one-person sales and servicing company, working with the existing technology. Constant interaction with consumers made him increasingly aware of the shortcomings of existing designs; from these perceived shortcomings, he developed a set of constraints which guided the development of a new solar water heater.

Why a water heater? Because Rich thought that the way water was heated in homes was monumentally inefficient, from an environmental standpoint. Why generate power from a distant source that generated pollution and acid rain when the sun could heat water right at the remote location? Obviously, standard technology would have to be used as a back-up, but the amount of power consumed could be drastically reduced.

Rich went on to develop a design that was a radical departure from current practices in the solar industry, involving two patents

and wholesale substitution of materials--for example, instead of glass he used plastic and instead of copper pipe, polypropylene. His goal was to develop a low maintenance, low cost system that would last for twenty or more years and could be installed and operated in virtually any climate zone within the United States.

This case complements the emphasis on technological creativity that is the main theme of the course while adding an important ethical component. It also incorporates some of the business and management aspects of inventing. Rich had to survive a severe recession in the solar industry; his company is still struggling, held together in part by his Utopian dreams of a day when millions of people are using the sun to heat their water. *Therefore, his case allows us to raise the issue of ecologically sustainable development in the context of creative design and economic feasibility.*

Rich was invited to speak to the Invention and Design class this last semester, and also interacted with an undergraduate research team studying inventors. Therefore, we have video-taped him discussing his process and acquired copies of his research materials, patents and business plans. He has agreed to be an active collaborator in this project.

*By the end of the module, students will have learned that there is an important ethical component to invention and design. An inventor can be driven by a desire to improve the world, and this desire has practical consequences in terms of her or his design process, the resulting technology, and the practical constraints of the economy as she or he struggles to create a market for sustainable technologies.*

## (2) Background Readings and Discussion

To put this issue into broader context, we would use articles such as like Michael Davis' "Explaining Wrongdoing" and "Thinking Like an Engineer: The Place of a Code of Ethics in the Practice of a Profession" and selections from Martin & Schinzinger's (1989) *Ethics*

*in Engineering, Pritchard's Teaching Engineering Ethics: A Case Study Approach., Schmidheiny's (1992) Changing Course and Kennedy's (1993) Preparing for the Twentieth Century.*

### (3) Design Component

Every case in this course has a design component, in which the students work in groups on an invention problem consonant with the goals of the unit. In this unit, we would ask students to come up with a design that promoted sustainable development in an area of their own choosing. Groups would have to begin with problem definition: what major environmental problem could they begin to alleviate with a feasible design? Their goal would be to 'sell' their idea to a panel of judges that would include faculty with expertise in energy, resources and the environment. They would have to both describe how their design would benefit the global environment and how it could be marketed without relying on heavy subsidies from governments. They could use Rich's process as an example--and even try to improve on his invention--but they could not simply imitate an existing invention.

### (4) Reflection and analysis:

*For a design exercise to be effective, it must be followed by analysis: students need to reflect on and compare their design processes. In this module, this reflection will include a detailed consideration of ethical issues involved in ecology, the use of environmental requirements as part of one's design, and an evaluation of the design and its marketing possibilities. How did groups deal with the environmental components of this design? What guidelines or strategies could other 'green' designers follow? How could one create an economically viable market for an environmentally-beneficial technology?*

*To promote this sort of reflection, each group will be asked to prepare a narrative of its design process and present it to the class. Then groups will be encouraged to compare their different*

*approaches to environmentally-conscious inventions. As a result , students should be more capable of recognizing environmental issues and analyzing ethical aspects of invention and design--in particular, reconciling the ideal of sustainable development with the practical aspects of the market. Ideally, engineers and other inventors who go into organizations will be better able to develop environmentally appropriate technologies whose practicability can be defended as well.*

#### **IV. Implementation**

This module will be developed and tested in three environments:

(1) In the summer of 1994, we propose to pilot features of this module in a secondary course for gifted students run by the Summer Enrichment Program at the University of Virginia. Students from a wide variety of backgrounds will be sought. In this intense, three-week seminar, students will be exposed to the telephone module before the one listed here. Development and implementation of this summer course was supported by a grant to the PI by the Geraldine R. Dodge Foundation (see Current and Pending Support). The foundation has not supported the development of this module, only costs associated with implementation of the course. This module would make an excellent addition to that course; it would require no additional resources from the NSF to incorporate it. The secondary students will serve as a useful pilot audience for potential use of this module in first-year courses at the university level.

(2) *In the spring of 1995[\*?], we propose to introduce this module into a university course on Invention and Design offered to majors from any discipline at the three or four hundred level. In practice, this means the course is taken mostly by third or fourth year students, though we have had first and second year students in it.*

(3) *At the same time, we propose to introduce this module into at least one section of a 400-level course taught to all graduating*

*engineering students. This course already includes lengthy units on ethics and on design; this module offers a way of connecting these hitherto disconnected components of the course. The eventual goal is to have this module become a standard part of this course.*

## V. Evaluation

The original grant for the Invention and Design course funded an extensive and thorough evaluation of this course. This proposal includes funding for a similar evaluation of this specific case that would include three major components:

(1) A survey administered at the beginning and the end of this case. Students would be asked questions about whether and to what extent they thought inventors factored ethical concerns into their designs, and whether ethics ought to play an important role in the earliest stages of the invention process, or enter later when the questions of use and marketing come into play. The goal of this measure is to assess whether students think differently about ethical and environmental considerations in design as a result of taking this course. Questions could be adapted from existing surveys and scales that measure development in ethical thinking (see Rest et al., 1986, for an overview).

(2) Focused interviews: Selected students would be interviewed to look for issues that were missed in the surveys and questionnaires. In particular, we would be trying to find out more about the process of change in views of design and ethics across the unit. This would mean doing several interviews with the same students, a strategy often used to track ethical and intellectual development over longer time periods (cf. Perry, 1970).

(3) *Video-taping: Group presentations of their design process and the resultant class discussion would be videotaped .*

(4) Design notebooks: Every student would be required to keep an inventor's notebook, in which she recorded her ideas and experiments during the design component. These notebooks would

be one of our most important records of students' problem-solving processes. Students are taught how to keep such records as part of the course; such documentation is extremely important in invention and discovery.

(5) Student papers: Each group would prepare a proposal that described its design, the environmental benefits that would accrue if it were adopted, and a strategy for marketing it. Individual students would be required to submit papers in which they compared their groups' processes to A.C. Rich's and to those of other groups. (Again, this parallels assignments done for the other modules in the course).

This combination of measures will allow us to assess whether students have attained the desired outcomes noted in the first section.

## VI. Final End Products

One end-product would be a module that could be used in a wide variety of courses, following the Ethics Across the Curriculum model used at the Illinois Institute of Technology.<sup>3</sup> For example, all first-year engineering students are required to take a course on engineering design. Every fourth-year engineering student takes a course that incorporates both design and ethics. We intend to write-up this module so it can be adapted for use in both of these courses.

But it could also be used in a variety of other courses outside of engineering, e.g., in business and science-technology studies. We will keep these other audiences in mind as we prepare the module for dissemination.

The module would include the following:

---

<sup>3</sup>See Michael Davis, "Integrating Ethics into Technical Courses: IIT's Experiment in its Second Year", paper presented at the 1992 Frontiers in Education Conference.

- (1) A document for students that gives them background material on A.C. Rich and his invention process and sets-up the students' design problem.
- (2) A teaching note that gives instructors advice on how to run this module, including goals, information on assignments and additional background information and reading.
- (3) A set of supplementary lectures and a syllabus from a course on Invention and Design that would allow instructors to see how this module could fit into a number of contexts. These materials would include notes on the invention and design process, using other inventors as examples.

### *Dissemination of Modules*

*We have submitted the telephone module from the Invention and Design course to American Society for Engineering Education's case library and have also sent copies of it to a half-dozen scholars at other universities who requested copies; we have asked them to report on their results when they try it out. In addition, we have shared these materials with the National Inventor's Hall of Fame, and the Lemelson National Program in Invention, Innovation and Creativity at Hampshire College. We plan on making contact with ABET after the case has been made available through the ASEE's case library.*

*It is our understanding that this library uses anonymous ftp for internet distribution of cases. We have a more ambitious plan--to create and distribute a hypertext version of this case on the World Wide Web. This would allow us to include visual images as well as text. For example, we could incorporate a detailed chart depicting Al Rich's invention process; this chart would contain buttons one could toggle to go to sketches from his patent, pictures of installed systems and photographs of the inventor. In order to accomplish this goal, we would work with the Institute for Advanced Technology in the Humanities on this campus, which is actively disseminating scholarly materials over the web. (Gorman is an Associate Fellow at the Institute).*

*In addition, we plan on making the module available through the Darden Business School, which has an extensive catalogue of cases that can be purchased by schools and students. Our goal in these multiple dissemination efforts is to make sure anyone who wanted to use the module could access it.*

### **Presentations and Publications**

*We have presented or made arrangements to present this course and its intellectual foundations at a number of conferences, including Innovative Approaches to Engineering Education, an NSF-sponsored conference held in Florida in June of 1993, and the annual meeting of the American Society of Engineering Educators to be held in Edmonton, June 26-9, 1994. A brief article describing the course appeared in the September, 1993 issue of the American Society for Engineering Education's Prism magazine--this article has produced a half-dozen requests for more information.*

*A longer article describing the course will appear in New Literary History; an interdisciplinary journal, and as a chapter in a book entitled Critical Creative Processes, edited by Mark A. Runco. We also plan on publishing results and a description of the modules in the Journal of Engineering Education and in Science, Technology and Human Values, including a detailed account of this new module.*

## **VII. Results from Prior NSF Support**

The principal investigator, Michael E. Gorman, has been awarded three NSF grants, in collaboration with W. Bernard Carlson. "The Cognitive Style of American Inventors: A Comparative Study of the Telephone, 1870-1880" (No. DIR-8722002) was awarded by the program in History and Philosophy of Science and Technology for the period 1 September 1988 to 31 August 1991. This grant permitted the PIs to establish a framework and methodology for studying invention and design and assemble original, archival materials for applying these tools to a comparison of early telephone inventors. We also began at that time, to assemble a multi-disciplinary undergraduate research team to assist us.

A second NSF grant, "Technological Innovation as a Cognitive Process: A Comparative Study of Telephone Inventors" (DIR-9012311), also from HPST, permitted us to implement a computerized system that charts or maps an inventor's path to her or his invention.

A third NSF grant, "Mapping the Invention Process: An Integration of Cognitive and Social Approaches to the Invention of the Telephone, 1870-1880" (DIR-9100424) allowed Drs. Carlson and Gorman to begin writing a book on the telephone.

This project has facilitated a number of publications, including:

Gorman, M.E. and Carlson, W.B. (1990). "Interpreting invention as a cognitive process: The case of Thomas Edison, Alexander Graham Bell and the Telephone." *Science, Technology and Human Values*, Vol. 15: 131-164.

W. Bernard Carlson and Michael E. Gorman, "Understanding Invention as a Cognitive Process: The Case of Thomas Edison and Early Motion Pictures, 1888-1891," *Social Studies of Science*, 1990, Vol. 20, pp. 387-430.

Gorman, M.E. (1992) *Simulating Science: Heuristics, Mental Models and Technoscientific Thinking*. Bloomington: Indiana U. Press.

Gorman, M.E., Mehalik, M.M., Carlson, W.B. & Oblon, M. (1993). Alexander Graham Bell, Elisha Gray and the speaking telegraph: A cognitive comparison. *History of Technology*., Vol. 15, pp. 1-56.

The last of these is co-authored with two undergraduate engineering students, both of whom are doing undergraduate theses related to our work. We are currently working on another major paper in which an undergraduate biology major will play a major role. Therefore, our prior NSF support has had a direct effect on the

education of several undergraduates, transforming them from consumers into producers of knowledge.

*Description of results from prior work supported by the Leadership in Science and Humanities Program:*

*The NSF has also funded the PI of the current proposal to develop a course which is based on this research. "Using Case Studies to Teach Invention and Design" (DUE-9252587) was funded by the Leadership in Science and Humanities program, which includes NEH and FIPSE as well as NSF. This course includes a module based on the telephone, taught by the PI, as well as modules on the computer and on a medical diagnostic system, taught by three of his engineering colleagues who are CO-PIs on the grant.*

*The first iteration of the Invention and Design course worked better than expected. In general, the course evoked a strong positive response from most of the students, despite the fact that it was an enormous amount of work and consumed more of their time than most three-credit courses. When asked to rate how well the course achieved its objectives compared with other, similar courses, students gave it a 4.3 (where one is well below and five is well above average). All agreed that it was worth continuing. As one chemical engineering student noted in his final paper:*

*"The class ranks up there with ... the only classes I've enjoyed in my three year collegiate career. I learned about some great inventors of our time, worked with some terrific students and faculty, learned about driving simulators and other aspects of computer technology, and worked indirectly with the diagnosing and treatment of victims of sexual assault. This is an excellent class as far as learning is concerned and I think more students will become interested in it in the future."*

*One of the course goals was to give students a deeper understanding of the invention and design process. The course certainly succeeded, as measured by comments on questionnaires, in final papers, and in a focused interview held at the end of the*

course.<sup>4</sup> As one engineering student noted, "From this course, my understanding of invention and design has changed. At first I thought that invention was something some inventor pulled out of his hat. I now understand that throughout each invention and design project, you must reflect on what you have done. Invention and design are a step-by-step process, constantly being reevaluated at every turn. There will be failures and successes, each stimulating thought and leading to new ideas."

A cognitive science major also learned about the process: "My conception of invention and design has changed in some important ways. I have come to appreciate the deliberateness that is necessary to successfully invent or design something. I came into the class thinking that many inventions were simply accidental discoveries, a la Fleming and penicillin. The truth is that most of invention and design is careful, deliberate, slow progress towards a goal that may be unclear, but is still aimed for. ... This is not to say that luck has nothing to do with the process. ... But there is a difference between blind, stupid luck and making the most of an unexpected opportunity."

Other students gained similar insights. While we feel we gave students a deeper understanding of the design process, we felt we could have done better at showing how ethical considerations can play a major role throughout the invention process, from selection of a problem to implementation, manufacturing and marketing. Our one example of this was A.C. Rich, whose lecture to our first iteration of the Invention and Design course was one of the high points of the semester. But a lecture is not sufficient to make this point--students need to experience the role of ethics in design through the same kind of activities that were so successful in other modules. Hence, this proposal.

It is well to remember that the course was intended as a laboratory for exploring new ways of teaching inventions and design. Therefore, the primary focus of this new EVST proposal is not just improving a single course--it is the development of a module that suggests a new way of showing how ethical considerations can affect the design process.

---

<sup>4</sup>We have prepared a lengthy summary of the evaluation of the first iteration of this course, including detailed comments on the individual modules--we would be happy to supply a copy upon request.

To summarize, the current proposal is a natural outgrowth of the PI's prior support from NSF. Three grants have allowed the PI to gain an intimate understanding of the invention process; a fourth has allowed him to develop a course based on this understanding. This proposal will permit him and his colleagues to build a strong environmental component into this course, and to explore the role of ethical concerns in the design process.

## VIII. Bibliography

Davis, Michael (1989) "Explaining Wrongdoing." *Journal of Social Philosophy*, Vol. 20, 74-90.

Davis, Michael (1991). "Thinking Like an Engineer: The Place of a Code of Ethics in the Practice of a Profession." *Philosophy and Public Affairs*, Vol. 20, 150-167.

Kennedy, Paul (1993) *Preparing for the Twenty-First Century*. New York: Random House.

Martin, M.W. & Schinzinger, R. (1989). *Ethics in Engineering*. (2nd Edition). New York: McGraw-Hill.

Office of Technology Assessment (1992). *Green Products by Design: Choices for a Cleaner Environment*. OTA-E-541 (Washington, D.C.: U.S. Government Printing Office).

Pacey, Arnold (1989). *The Culture of Technology*. Cambridge, MA: 1989.

Perry, William. (1970) *The Forms of Intellectual and Ethical Development in the College Years; A Scheme*. New York: Holt, Rinehart and Winston.

Pritchard, Michael S. (Editor). *Teaching Engineering Ethics: A Case Study Approach*. Center for the Study of Ethics in Society, Western Michigan University.

Rest, J., Barnett, R., Bebeau, M., Deemer, D., Getz, I., Moon, Y., Spickelmeier, J., Thoma, S., and Volker, J. (1986). *Moral Development: Advances in Research and Theory*. New York: Praeger Press.

Schmidheiny, Stephan (1992). *Changing Course: A Global Business Perspective on Development and the Environment*. Cambridge: MIT Press.

## IX. Biographical Sketches

*Michael E. Gorman* has spent five years developing a cognitive framework and applying it to the invention of the telephone, in collaboration with W. Bernard Carlson and a team of undergraduates. He has just published a book, *Simulating Science*, on technoscientific thinking. He has taught a wide range of interdisciplinary courses, including courses on scientific and technological creativity. In the last year, with support from the NSF, FIPSE and NEH, he designed a new course on invention and design, coordinating a team of engineering colleagues. (See attached vita for more details).

*A.C. Rich* invented and patented the solar "SKYLITE"<sup>tm</sup> water heater and is the founder and president of AMERICAN SOLAR NETWORK, Ltd., a corporation now based in Sacramento. He has received numerous grants and awards for his socially-responsible innovations.

*Patricia H. Werhane* is the Ruffin Chair in Business Ethics in the Darden School at the University of Virginia. She is an internationally recognized expert on business ethics who has authored or co-authored eight books on this topic, is on the editorial board of five journals, and is a founding member and past President of the Society for Business Ethics. (See attached CV for more details).

**X. SUMMARY  
PROPOSAL BUDGET**

ORGANIZATION		FOR NSF USE ONLY			
		PROPOSAL NO.		DURATION (MONTHS)	
University of Virginia		AWARD NO.		Proposed	Granted
				PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR	
SENIOR PERSONNEL: PI/PI, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)		NSF Funded Person-mos.		Funds Requested By Proposer	Funds Granted by NSF (If Different)
		CAL	ACAD	SUMR	
1. M. E. Gorman, P.I.				1.15	\$ 5,734
2. P. H. Werhane, Faculty Participant				.50	5,384
3. ( ) OTHERS(LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
4. ( 2 ) TOTAL SENIOR PERSONNEL (1-6)				1.65	11,118
OTHER PERSONNEL(SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL-CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES(A + B)					11,118
FRINGE BENEFITS(IF CHARGED AS DIRECT COSTS)					888
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)					12,006
PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING \$1,000.)					
TOTAL PERMANENT EQUIPMENT					
TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)					
2. FOREIGN					
PARTICIPANT SUPPORT COSTS					
1. STIPENDS \$ _____					
2. TRAVEL _____					
3. SUBSISTENCE _____					
4. OTHER _____					
5. ( ) TOTAL PARTICIPANT COSTS					
OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES					
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES - A. C. RICH					1,080
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS					1,080
TOTAL DIRECT COSTS (A THROUGH G)					13,086
INDIRECT COSTS (SPECIFY RATE AND BASE) 6 Modified Total Direct Costs to 6/30/95, 52% effective 7/1/95					
TOTAL INDIRECT COSTS					8,914
TOTAL DIRECT AND INDIRECT COSTS (H + I)					20,000
RESIDUAL FUNDS(IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPM 252 AND 253)					
AMOUNT OF THIS REQUEST (J) OR (J MINUS K)					\$20,000
COST SHARING: PROPOSED LEVEL \$3,640		AGREED LEVEL IF DIFFERENT \$			
1. TYPED NAME & SIGNATURE* M. E. Gorman		DATE	FOR NSF USE ONLY		
2. REP. TYPED NAME & SIGNATURE* Wayne Jennings		DATE	INDIRECT COST RATE VERIFICATION		
			Date Checked	Date of Rate Sheet	Initials-ORG

## BUDGET NOTES

- \* Faculty - Appointments are generally effective calendar year (CY) beginning July 1 or Academic Year (AY) beginning September 1. M. E. Gorman, 1.15 mos. effort summer 1995; P. H. Werhane, .50 mos. effort summer 1995, plus increases.
- \* Salary Increases - A 2% salary increase is applied to a majority of SEAS proposals, effective 7/1/94 or 9/1/94, and is accumulated annually from these dates. Faculty increases are based on contributions in academic and research areas and are approved by the State of Virginia Budget Office. Staff increases are based on State of Virginia proficiency guidelines. New salaries are given as soon as they are available.
- \* Fringe Benefits - The University of Virginia's fixed fringe benefits rates, as they apply to sponsored programs, have been approved by DHHS as follows: from 7/1/93 to 6/30/94 rates are 22% for faculty and senior professional staff, 27.5% for classified staff, and 8% for wage employees and for summer effort by faculty with AY appointments; from 7/1/94 to 6/30/95 rates are 24.5% for faculty and professional staff, 32.5% for classified staff, and 8% for wage employees and summer effort by faculty. Although not yet approved by DHHS, the University estimates future rates for 7/1/95 to 6/30/96 as 25%, 33.5% and 8% respectively. Fringe benefits do not apply to graduate and undergraduate research assistants.
- \* Consultant - A. C. Rich, travel and services.
- \* Indirect Costs - The University of Virginia's negotiated MTDC Indirect Cost rates with DHHS per agreement of 3/3/94 are 52% of the Modified Total Direct Costs for "on campus" and 23.5% "off campus" for 7/1/92 through 6/30/94; 7/1/94 - 6/30/95, rates are 53% and 23.5%; 7/1/95 -6/30/96, 52% and 23.5%; 7/1/96 - 6/30/97 and until further amended, 51% and 22.5%. (Note: The MTDC base consists of total direct costs less individual equipment items in excess of \$500, all subcontracts and subgrants, alterations and renovations, patient care costs, stipends, tuition remission and rental costs of off-campus facilities.)
- \* Cost Sharing - Support for a half-time graduate teaching assistant for spring semester 1995, wages and tuition remission, total value of \$3,640.

## Budget Justification

Support for the PI: *To evaluate the module and write it up for dissemination, the PI will need a month of summer support.*

Consultants: A.C. Rich has already agreed to serve as a consultant on this unit. We would like to fly him out from California to conduct an extended seminar with the students. They would have studied materials regarding his case in advance, and would be able to ask him focused questions about his invention process and the politics of marketing environmentally-appropriate technology.

Faculty Participants: Patricia Werhane is on the faculty of the Darden Business School, is a nationally-recognized expert on business ethics; she was Henry J. Wirtenberger Professor of Business Ethics at Loyola University of Chicago. She has also done significant work with programs that specialize in engineering ethics, particularly at the Illinois Institute of Technology, where she conducted faculty workshops. She will help the PI draft module materials that force students to reflect on and analyze ethical issues. She has agreed to sit-in on portions of the course as the module is being taught, playing an active role in class discussions. She will also assist in preparation of materials for dissemination, and will be offered the opportunity to be a co-author on publications describing the module and its impact.

Graduate Student: To conduct the evaluation under the PI's close supervision, a graduate student is necessary. The PI cannot, for obvious reasons, conduct confidential interviews, distribute surveys and videotape groups in a course he is coordinating. A graduate student in Systems Engineering has spearheaded the evaluation of the initial phase of this course; this student or another could be hired *as a graduate teaching assistant* for a semester to complete a thorough evaluation of the environmental ethics unit. An additional benefit is that this engineering graduate student will receive training in ethics. The School of Engineering and Applied Science has agreed

to support a graduate teaching assistant to help specifically with this module in the Spring of 1995.

Schedule:

The module will be implemented in the Invention and Design course *and in a fourth-year engineering course with an ethics component* in the spring of 1995. *The PI and Professor Werhane will devote a month of the summer of 1995 to writing-up the results of the first iteration of the module as a case suitable for publication by the Darden School's case service. The result will be materials that will be ready for use in a wide range of courses across the curriculum where the role of ethics in design ought to be considered.*