Design for Society – An Innovative Multidisciplinary Course for Engineering Technology

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ABSTRACT

This paper is an overview of an innovative multidisciplinary course that has been offered since the spring of 1996 at Penn State Harrisburg. In addition to reviewing the nature of the course as it is being taught in spring 1997, the paper follows the development of the course and the author's interest in the broad area of engineering for a better future. The course is innovative for a combination of factors:

- It goes beyond 'green engineering' to discuss ethics, diverse cultural critiques of technology, and the politics of technology.
- It is a technical elective and requires a significant group design project.
- It qualifies as a 'Diversity-Focused' course and considers three specific cultural groups and their attitudes toward technology: feminists, the Amish, and Native Americans.
- It makes use of collaborative groups throughout the course and requires considerable writing and speaking assignments.

BACKGROUND

The course evolved from several other courses taught by the author since 1984, including an *Introduction to Energy Technology* course which made use of Jeremy Rifkin's *Entropy*¹ and Fritjof Capra's *The Turning Point*². Although trained as an engineer, the author was becoming increasingly more aware of the connections between technology and society. Involvement in the solar energy field since 1977 also made it clear that engineering activities have direct and indirect effects on the environment, standard of living, and quality of life. In many ways, solar energy technologies represented a new way, an alternative way, of meeting the energy needs of modern society. New questions raised by workers in the alternative energy field were: "What do we really need as a society?," "Where do we want to go?," and "How do we get there?" A major concern was that technology was developing with very little concern about its impact on the environment and on people's lives. In lots of ways it appeared that technology was not controlled by people anymore, but had taken on its own *autonomy*, consistent with Jacques Ellul's landmark thesis³.

In 1990, Penn State Harrisburg (PSH) offered, in concert with the Pennsylvania Energy Office, an experimental course titled *Sustainability: Technology and Public Policy Dimensions*. This colloquium-style course brought together the technological expertise of the two organizations and brought in experts from all over the world.⁴ Around this time, PSH faculty were discussing

the need for diversity courses and the author realized that engineering technology students would benefit greatly from a course that looked at technology from various diverse viewpoints. But rather than being taught outside of the technology curriculum, the course would be developed and taught by engineering faculty. And it would by nature be inter- and/or multidisciplinary, a major challenge for the author or any traditional engineering faculty.

Some summer support was received by the author in 1994 to develop the course. This was used to do a comprehensive review of the literature with the assistance of a library research assistant and a Humanities faculty member. The quantity of related material was overwhelming and it took about a year to wade through all of the literature. A major challenge was to take the scholarly works and focus them into a three-credit course appropriate for senior engineering technology students.

As the course took shape, a question emerged to guide the content and objectives:

What are the responsibilities and challenges of engineers in designing for the needs and welfare of current and future societies, and for specific segments or groups within those societies?

This question was inspired by Victor Papanek's question: "How can people be brought into the design process?"⁵ Another question that had a major influence was asked by Langdon Winner: "How can we limit modern technology to match our best sense of who we are and the kind of world we would like to build?"⁶ These questions are similar to those that were mentioned earlier that grew out of the alternative energy field.

The course is innovative for a combination of factors:

- It goes beyond 'green engineering' to discuss ethics, diverse cultural critiques of technology, and the politics of technology.
- It is a technical elective and requires a significant group design project.
- It qualifies as a 'Diversity-Focused' course and considers three specific cultural groups and their attitudes toward technology: feminists, the Amish, and Native Americans.
- It makes use of collaborative groups throughout the course and requires considerable writing and speaking assignments.

Before reviewing the course content for the current semester in some detail, the next section goes into some experiences and lessons learned from the first semester.

EXPERIENCE FROM THE FIRST SEMESTER

The course first ran in spring semester 1996 with an enrollment of 31 students from Mechanical Engineering Technology, Structural Design and Construction Engineering Technology, Environmental Engineering Technology, and Computer Science. Many of the students took the class to meet the PSH Diversity requirement, which first had an effect in that semester.

A copy of the course syllabus for this semester is included as an Appendix to this paper. The only significant differences last year were the books required^{7,8,9} and a few of the current topics were not in the outline, specifically green engineering (although it was covered) and ISO standards. The book that provided the focus of the course last year was Papanek's *Design for the Real World*.⁷ Although it is an excellent source of novel and creative ideas that respond to the question of designer responsibility, the students were turned off by Papanek's self-righteous attitude. The book is also somewhat out of date. The other two books were dropped because only a few articles were used from them. The same articles were used this year via library reserve. Because of time constraints, we also did not get to the unit on housing. But other than the cited differences, the course content followed the current syllabus.

Most of the classes were conducted as either a large discussion or smaller group discussions. There were only a few instances where a lecture format was used, and never for the entire class. Students prepared for the discussions by reading from the texts, handouts, or library assignments. Most of the time, a majority of the students came prepared to participate. This was encouraged both by the small group work and by assigning 15% of the grade to class participation.

There was typically one, two-page, individual paper required each week. These papers generally presented a summary of the readings with student interpretation and personal insights. About every other week, a group paper was required that was completed in one class using collaborative group techniques with elements of guided design. These group papers also formed the basis for entire class discussions. Sometimes, groups would report their results orally.

By far the most significant effort was the group term project. Several exercises were used to aid the students in selecting a project, and the general project goals were:

- Applies much of what we have learned in this class.
- Applies additional technical skills from other classes or experience.
- Results in a working, full-scale prototype utilizing readily available, low-cost materials.
- Challenges the group's abilities and requires library research.
- Designed for a group that has traditionally been neglected by the design community.

The seven groups (four or five students each) finally decided to design solar cookers or solar water purifiers (solar stills). To focus their efforts to a particular region and culture, a province in Zimbabwe was chosen as the target. This was a result of conversations with Solar Cookers International. The Internet proved to be a valuable source of information about the native peoples and one group found a Master's paper of a student who helped evaluate a solar cooking project in Zimbabwe. Near the end of class, the groups set up their projects outside and cooked beans and rice or purified tap water that had been contaminated with salt. Most of the cookers worked well, but only one of the four stills produced more than a few drops of clean water. The groups also were responsible for preparing a poster presentation about their projects.

The group projects were successful in challenging the students to design a basic product using simple materials for a specific group of people. Much was learned about the people in

Zimbabwe and their sometimes unexpected experiences with solar cookers. The importance of understanding the culture and listening to the users of technology was a valuable lesson.

Student feedback at the end of the course indicated that they would have liked more freedom to choose other projects, and to be able to choose their partners. This semester, each student is proposing a project, and then in groups of 3-4 students, each group will decide on the project for their group. But the instructor is still choosing the group members to help ensure diversity of majors in each group so that students get accustomed to working with others outside their specific majors.

One instructional development from the group efforts was an effective group grading process. The instructor grades the group projects as a whole and assigns a grade. This grade is then adjusted on an individual basis using individual grades assigned by each student in the group. Each student's individual grade average (as evaluated by themselves and their partners) is compared with the global average based on the students' evaluations. This variation from the global average is then used to adjust the instructor's group grade for each student. For example, suppose the instructor assigns a grade of B (85%) to the group project. Based on the students' evaluations, the global average for the group is 90%. If student Y's individual average is 80%, this variation of -10% (80%-90%) is applied to the group grade of 85%, and student Y receives a grade of 75%. This method allows for individual differences to be accounted for, but relies on the instructor's experience as a basis for the grade.

OVERVIEW OF THE CURRENT COURSE

The last year has led to a few new developments related to the course. One is that two excellent books were found that are much more relevant to the overall course. One is *Design for Society* by Nigel Whiteley.¹⁰ Whiteley's book is not only more current, it has chapters on feminist critiques, green design, and designer's ethics and responsibilities. Another plus is that it is written from a British perspective which adds to the diversity of perspectives. The second book that students purchase is *Green Products by Design* which was developed by the now-defunct U.S. Office of Technology Assessment.¹¹ This book is used by Richard Devon in green engineering courses at Penn State's University Park campus. It is an excellent overview of green design from a resource management perspective.

In a way, the course has shifted a little from a more philosophical stance to a more practice-oriented one. However, the underlying basis for the course is still to look at how technology affects society and how to fashion technology to make the best possible future for all of the world. The reader will get a better sense of the course with a summary of the major course topics. Please refer to the syllabus in the Appendix.

The course starts with a student-centered review of professional codes of ethics. In small groups, students review the codes and creeds and search for common features. An important common bond that is found is the responsibility of engineers and scientists to improve human welfare. Though clearly anthropocentric, this common ethical standard forms the foundation for the course. The conversation is then broadened to consider whether there are common moral values

of peoples from all over the world, as suggested by Rushworth Kidder.¹² Before presenting Kidder's list of eight shared values, the students develop a list on the board. In both classes, the students' lists were remarkably similar to each others and to Kidder's list of eight moral values: love, truthfulness, fairness, freedom, unity, tolerance, responsibility, and respect for life. One point that this demonstrates is that there are shared values that can provide the grounds for developing shared goals and guidelines for technological development and critique.

This leads into the next section which is an investigation of the meaning of sustainability and appropriate technology. A definition of sustainability is "providing for the needs of the present without compromising the ability of future generations to meet their needs." There are at least two important aspects of this term. One is the consideration of future generations; this is not clearly stated in any of the current professional codes of ethics. Another significant aspect is the meaning of 'needs', in particular how this might be defined differently by different cultures and people. It also becomes clear in reading the Whiteley book that the consumer cultures of most western societies have far exceeded 'needs', and in so doing threaten the ability of even present generations.

Two films are used to supplement this section. One is *The Future*¹³, a 20-minute movie that depicts three visions of the future. First is a high-technology scenario featuring weather control, space colonies, genetic engineering, euthanasia, and just about every other conceivable technology. The second scenario is technology-out-of-control featuring dead rivers, unbreathable air, overpopulation, food shortages, "natural" disasters, and nuclear war. The final scenario is a new world view with emphasis on people, cooperation, appropriate technology, and ecology. Students respond to the film with a short paper interpreting the film and presenting their vision of the future.

The second film is *The Other Way*¹⁴, a film about British fuel economist E.F. Schumaker. Schumaker helped bring attention to the need for "intermediate technology" in developing countries. Several good examples are described with key points being that bigger is not always better, and technological development must consider the people's needs; it must have a human face.

Several articles are read about appropriate technology, but the most important one is *Four Philosophies of Technology*¹⁵. Drengson argues that technological development goes through four progressive stages: technological anarchy, technophilia, technophobia, and finally, appropriate technology. While characteristics of all four are evident in the U.S., we seem poised to move into the fourth phase where technologies are designed with the following requirements:

1. They should preserve diversity.
2. They should promote benign interactions between humans, their machines, and the biosphere.
3. They should be thermodynamically sound (efficient) in the generation and use of energy.
4. They should dynamically balance all costs.
5. They should promote human development.

And perhaps most importantly, “appropriate technology requires that we reflect on our ends and values, before we commit ourselves to the development of new technologies, or even to the continuation and use of certain old ones.” Drengson sees the “transformation of the technological process into an art” where “technology is designed to enhance individual persons, ecological integrity, and cultural health.”

Feminist perspectives on technology is the next section of the course and is probably the most controversial at first because of prejudice and bias that the students bring with them to this topic. Many of the students think of bra-burning, man-hating, femi-Nazis; but this semester were surprised by a guest “feminist” that does not match most of the stereotypes. Sherry Bartush, an Honors student in Humanities and Women’s Studies and a grandmother and business owner, agreed to help the author with two class sessions at the beginning of this section. Students prepared by reading the “Feminist Perspectives” chapter in *Design for Society*, three articles from *Machina Ex Dea*⁸, and a short story by Mrs. Bartush. With her help, the students developed an understanding of the meaning and importance of perspective. One important message was that most design is done by men, usually without adequate consideration of the perspective of the intended users, especially if the users are women. Students were asked to conceive of a product for a group with a different perspective than their own. Other messages are that designers too often stereotype women in a sexist way, and that many products are not well designed for use by women. Mrs. Bartush pointed out that in postmodern feminism, the concern is not just for women, but for inclusiveness for all people.

There is a potential pitfall in just looking at redesigning products to be better suited for women users, and that is it tends to ignore the underlying power structures of western society that are essentially patriarchal. True progress will have to occur in examining the foundations of our world views and our perspectives and working toward a more egalitarian culture and society, clearly a political and social agenda foremost. That is not a call for eliminating the differences between men and women, but for eliminating the unequal distribution of power and balancing the patriarchal emphasis on domination and control.

The next section of the course goes into “green design,” starting with the chapter by that name in Whiteley and then the entire *Green Products by Design* book. Small group worksheets are used to assist the students in summarizing the readings and exploring the meaning and challenges of being a “green designer.” In *Green Products by Design*, green design is “an extension of traditional design to include the goals of waste prevention and better materials management.” This somewhat conservative formulation was chosen in order to be able to suggest concrete actions available to the designer. One of the most potentially useful tools is that of Life-Cycle Analysis (LCA) that attempts to measure the “cradle-to-grave” impact of a product on the ecosystem. In practice, LCA should consist of three steps: an inventory of resource inputs and waste outputs, an assessment of the risks associated with these inputs and outputs, and an assessment of possible options for improvement. Though straightforward conceptually, the second step is extremely difficult to do because of the limited reliable information available on risks. Doing a thorough analysis of a product and its options is also a formidable task and one must draw the analytical boundaries somewhere. Nonetheless, LCA is one metric that can help

inform the green designers decisions. Other important topics covered include design for disassembly, remanufacturing, energy efficiency, system-oriented design, and product renting.

Whiteley takes a broader perspective on green design with an emphasis on the effect of consumer lifestyle. He describes green attitudes ranging from “pale green” to deep ecology (although he doesn’t use the latter term). At the deep ecology end, citizens question the very foundations of the consumer lifestyle and the societal dedication to economic growth. On the practical side, he presents a list of “Ten questions for the Green Designer.” He also goes into the processes of production with consideration of worker health and job satisfaction.

Because the area of green engineering has received increasing attention in the last several years, students are given a group project to develop a bibliography of resources from the last five years. Each group submits a bibliography of all the sources they found, with a few summaries of those resources that they felt were outstanding. A spokesperson for each group also gives a five-minute oral presentation. The bibliographies are then combined and a complete list is returned to the students for their future reference.

Another group exercise at this point in the semester is to develop a group project proposal. Students begin by proposing a project that they are interested in, both in a written memo, and orally to the class. Then groups of three to four students discuss the ideas and submit a proposal for the group. This semester, projects include gardening tools for the elderly, a cooker that can use solar heat or fuel, a cooker/heater that can be built from trash and uses paper for fuel, cardboard furniture, and a solar water purifier. Each group will build and demonstrate working prototypes and prepare a written report.

The next topic is the Amish. This group was chosen for two main reasons. One is that they are known for carefully reviewing the potential benefits and harm in using a technology and two is that the local Lancaster county area is home to a thriving Amish community. A video, *The Amish: Between Two Worlds*¹⁶ is used to introduce the topic. Students read sections of *The Riddle of Amish Culture*¹⁷ and an article from *Technology Review* called “Technology Amish Style”¹⁸. A guest speaker, Dr. Richard Ammon, a faculty member in Education who is familiar with the Amish culture and knows some Amish people, comes to the class to answer students’ questions and provide his personal insights.

A key characteristic of Amish culture is that the Amish community is of utmost importance, and the individual discovers their fulfillment in the community. Work is central to Amish life and the life of the community. Hard physical work is considered a calling from God; it is sacred. This is in direct contrast to modern society’s mind/body dualism that places physical labor well below mental exercise. Many tasks on the farm are performed by a family group or a large community group, for example barn raising.

Perhaps the most well-known technology that the Amish have avoided is the automobile, opting for horse-drawn carriages instead. Cars are a direct threat to the close-knit community because they facilitate individual autonomy and would pull the community apart, literally and figuratively. Car ownership would lead to people showing off their wealth, status, power, and

pride, all characteristics that the Amish abhor. In the words of Donald Kraybill, “for a stable, simple, local people who cherished community dependency and separation from the world, the car was a peril.” The Amish do allow the hiring of non-Amish neighbors to drive them in certain situations, but ownership is a taboo. Part of the reason for this concession is the dismantling of mass transportation systems, particularly the trolley.

This leads into the first technology that is explored in more detail, the automobile. Students read a chapter, “Clean Motion,” from the excellent book *How Much is Enough?*¹⁹ Durning argues that the consumer class does most of the world’s driving, contributing a very unequal share to the world’s resource depletion, pollution, and sprawl. Rather than an optional tool for easy mobility and freedom, the American car has become an apparent necessity that locks the average American into nine hours behind the wheel per week. His solution is to reverse urban sprawl and shift the consumer class away from cars and airplanes toward bicycles, buses, and trains. This type of movement is already occurring in selected cities around the world, evidence that it is possible to make the shift suggested.

In a more pro-automobile vein, the Lovins²⁰ argue that cars can be made today that are ten times more efficient (300 miles per gallon). These “hypercars” make use of ultralight composite materials, superb aerodynamics, and recovery of braking energy. They would utilize a hybrid electric drive, combining a small fuel-powered engine, electric drive motors, and batteries or flywheels for energy storage. To spur their marketing appeal, “feebates” would be used with a fee paid for the purchase of inefficient cars, and a rebate for efficient ones. The Lovins do warn that for all their advantages, other efficient forms of transportation and rebuilding of communities to reduce the need for mobility are important global needs.

Last year, students spent a class period driving a Solectria Force electric vehicle and pedaling 1970’s era pedal-cars around the campus. Their assignment was to consider the bicycle as an alternative form of transportation to the automobile, list the advantages and disadvantages, suggest design changes that are needed, and to consider how to overcome other disadvantages that don’t have technical fix.

The other unit that much time was spent on last year was solar cooking. The author has used solar cookers at home and in several solar energy classes as class projects. They make a good topic for this class because the “market” for them is in poor countries where fuel for cooking is scarce. Thus students must learn about the countries and the people in these countries to understand the technical situation as well as social and political considerations. Furthermore, the cookers require a good understanding of heat transfer, thermodynamics, and solar dynamics. An additional challenge is to design with readily available materials and know-how.

This year an additional unit on indigenous architecture and Native American peoples of the American southwest is planned. Emphasis will be on the history of adobe architecture and pueblos, and the connection between the native peoples and the earth. One of the sources of information will be *Living the Sky*²¹ which is about the archaeoastronomy of these people and how their dwellings and communities were in concert with their cosmological beliefs. The

translation of some of these principles into modern passive solar buildings will be explored. Students will design a house using passive solar techniques.

CONCLUSIONS

This course serves to introduce engineering technology and science students to the larger context of engineering and design. It hopefully broadens their perspectives on the potential for technology to serve human ends and to be seen as a useful set of tools to help society get to where they want to be. At the same time, it shows the limitations to the viability of modern consumerist society and the need to rethink common beliefs and values. It provides some practical examples of how designers can take responsible actions for the betterment of society, both now and in the future.

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BIOGRAPHICAL DATA

ANDREW S. LAU is an Associate Professor of Engineering at Penn State Harrisburg and is currently Program Chair of Mechanical Engineering Technology. He received his B.S. in Mechanical Engineering, summa cum laude, from

Penn State in 1977, and his M.S.M.E. from the University of Wisconsin-Madison in 1983. A registered Professional Engineer, he consults in the solar energy and energy conservation fields.

APPENDIX

ET 420 - Design for Society COURSE SYLLABUS - SPRING 1997

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Catalog Description: An interdisciplinary study of the engineering design process and the influence of society and culture on design.

Objectives:

This course seeks to examine engineering design from a societal perspective by asking the question: What are the responsibilities and challenges of technologists in designing for the needs and welfare of current and future societies, and for specific segments or groups within those societies? Students will be exposed to a diverse range of perspectives on technology, and will consider and apply these perspectives in actual design projects and case studies.

Some specific educational goals are to:

- Explore and compare what is meant by "appropriate technology," "sustainability, and "green engineering;" and understand how these terms can take on significantly different meaning in different cultures.
- Examine and describe connections between technology and society.
- Examine some different perspectives and attitudes toward technology.
- Explore a few specific technologies and envision alternatives.
- Learn and apply the engineering design process in a societal and cultural context.

Texts:

1. *Design for Society*, Nigel Whiteley, Reaktion Books, London, 1993.
2. *Green Products by Design, Choices for a Cleaner Environment*, Office of Technology Assessment, U.S. Congress, OTA-E-541, October 1992.

Several other textbooks and readings will be handed out or put on reserve to support this course.

Scope:

This course has at least two ambitious goals. One is to get engineering technology students to appreciate and begin to understand the complexity of the design process, particularly considering the diverse users of their designs. And two is to have them take responsibility for their designs during the process, with a fuller understanding of the impact of technology on society. This inherently involves an interdisciplinary approach, with readings in the fields of sociology, psychology, philosophy, ecology, history, science, and engineering.

Against this broad backdrop, specific design problems will be undertaken by the students working in cooperative groups. We will focus on some specific technologies under specific cultural circumstances. A comprehensive group project is required that will involve the design and construction of a working prototype.

The course will involve lectures, cooperative groups, guest speakers, field trips, videos, and hands-on projects.

Requirements:

Readings: There will be a substantial amount of reading required from the texts and from supporting materials in the library and in handouts. Study guides will be used for some of the readings. Effective class discussion will depend on an understanding of the assigned readings.

Short reports: Individual short reports (2-3 pages) will be required, based on reading assignments and class and group discussions.

Group reports: Short written and oral reports will be required to summarize the results of classroom cooperative group assignments.

Term project: Each group will be assigned a design project that will involve two major results, a design report and an actual prototype of the design. The design will require library and product research and application of principles learned in class. Each group will present their project to the class.

Grading:

Each student's grade will be based on a combination of grades received on the requirements listed above. Group project grades will be determined by the teacher and by input from group members. There will also be a class participation grade. Weighting toward the final grade is:

Class participation	15 %
Short reports	25 %
Group reports	25 %
Term project	35 %

COURSE OUTLINE

1. Introduction
 - 1.1 Course overview
 - 1.2 Engineer's creed, ethics
 - 1.3 Basic human moral values and needs
2. Terminology
 - 2.1 What is technology? appropriate technology? sustainability? human scale? green engineering?
 - 2.2 How does culture affect the definition and application of these terms?
3. Feminist perspectives on technology
4. Green engineering
5. Transportation technology
 - 5.1 The Amish and technology
 - 5.2 The Amish and personal transport
 - 5.3 Clean motion
 - 5.4 The hypercar
 - 5.5 Design of a personal transportation vehicle
6. Housing
 - 6.1 Vernacular architecture
 - 6.2 Pueblo Indian culture and villages
 - 6.3 Sustainability and housing - design project
7. Cooking
 - 7.1 History, U.S., India, desertified African countries
 - 7.2 Solar cooking, design of a multi-fuel cooker for fuel-scarce countries
8. Technology in the future, outlook for developed and developing countries
9. Project presentations and discussion