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Once upon a time at a large university, in a state far, far away, three senior engineering students were stretched out on lounge chairs in the student union building, digesting their lunches and enjoying the two-hour break between their 11 a.m. class and their 2 p.m. laboratory session. With his usual spontaneity, the most imaginative of the three broke the silence with a remark something like the following: "Have you ever stopped to think that a half dozen or so corporate executives, all in pin-striped, three-piece suits, sat around a conference table, in all seriousness, and finally decided to design, produce, market, and sell this . . . ?" And here the student held up a "gyroscopically controlled, dashboard hula dancer." The thought of grown men and women—"important" grown men and women—spending valuable time on a product of such *dubious* value sent the three students into a 10-minute fit of hysterical giggling. The next half hour, however, was spent in an intense discussion of the value of certain technological products and of what it would mean to be the engineer responsible for the developing of such products. Those products ranged from the silly, like the dashboard hula dancer, to the serious: products like napalm jelly and neutron bombs, products which had caused their parent corporations just a bit of trouble when they tried to recruit at various university campuses at that time.

While such a discussion certainly proved valuable to the students involved, in retrospect one can only regret that such discussions occurred—and today as well, occur—far too seldom, usually taking place, when they do, in student lounges and dorm rooms, but rarely in engineering classrooms.

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The Value-Ladenness of Technology

This paper attempts to argue the twofold thesis that (1) technology is never *neutral* or *value-free*, and (2) the products of technology intrinsically retain a portion of the values operative in the design process.

Technology is a human activity. That may seem obvious to most engineering educators. But the word *technology* too often implies that it is a *thing* or a *force* distinct from, and often in opposition to persons. Antitechnologists from Martin Heidegger[1] to Jacques Ellul[2] have viewed technology as a power that threatens human freedom. On the other hand, technophiles from Benjamin Franklin[3] to Ronald Reagan have thought technology could save the human race. In either case, technology is imagined as existing apart from people. A problem with this view is that it leads to the correlate view that technology exists apart from human values; in other words, it is neutral or value-free. That this view is officially renounced by the professional technological establishment is demonstrated by the codes of ethics published by organizations like the National Society of Professional Engineers (NSPE) and the Accreditation Board for Engineering and Technology (ABET). On the other hand, the fact that such codes very often function, if at all, as platitudes rather than day-to-day criteria for designing, suggests that even members of the profession, at least in a *de facto* sense, submit to the notion that technology is neutral.

To say that technology is a human activity is to say that it is a *normed* activity, i.e., there are right and wrong ways of doing technology. To speak of "right and wrong" is to speak of values. This, of course, is nothing new. As engineering educators we may avoid the words "right and wrong" because they suggest a kind of static artificiality of the sort that characterizes sophomore problem assignments: right and wrong answers. We often speak instead of "good" design or "bad" design; and we assign grades to senior design projects on the basis of our understanding of what constitutes good or bad design. Most often that has to do with such values as efficacy, reliability, and efficiency.

I want to argue that values beyond the pragmatic and economic are operating during every phase of designing—values which we can recognize in the specific designing process and in the final product.

To get some sense of these values, consider the following quotes. First, from the National Society of Professional Engineers *Fundamental Canons of the Code of Ethics for Engineers*:[4]

Engineers, in the fulfillment of their professional duties, shall

-hold paramount the safety, health and welfare of the public in the performance of their professional duties.

-perform services only in areas of their competence.

-issue public statements only in an objective and truthful manner.

-act in professional matters for each employer or client as faithful agents or trustees.

-avoid improper solicitation of professional employment.

In the chapter titled "Codes of Engineering Ethics" in his book *Controlling Technology: Ethics and the Responsible Engineer*, Stephen Unger distills the following basic principles or values from various engineering codes of ethics:[5]

-truth, honesty, trustworthiness

-respect for human life and welfare, including that of posterity

-fair play

-openness

-competence

The Accreditation Board for Engineering and Technology asserts the following as *Fundamental Principles of the Code of Ethics of Engineers*:[6]

Engineers uphold and advance the integrity, honor and dignity of the engineering profession by

-using their knowledge and skill for the enhancement of human welfare;

-being honest and impartial, and serving with fidelity the public, their employers and clients;

-striving to increase the competence and prestige of the engineering profession; and

-supporting the professional and technical societies of their disciplines.

Finally, in the book *Responsible Technology*, Lambert Van Poolen neatly summarizes these values in a list he identifies as "Normative Principles of Design":[7]

-Cultural Appropriateness (which parallels E.F. Schumacher's concern for "appropriate technology"[8] and Victor Papanek's concern for "minimal design intervention"[9])

-Openness and Communication

-Stewardship (which includes economic viability as well as environmental consciousness and refuses to see them as adversarially related)

-Delightful Harmony (which, along with a concern for what today is referred to as *user-friendliness*, suggests a concern for the aesthetic dimension of design, e.g., excellence: the beauty in the form as well as the function)

-Justice

-Caring
-Trust

In summary, technology is a normed activity. That is to say, technology can be judged according to values, values other than those merely utilitarian, values which the engineering community has articulated fairly well and upon which it has agreed.

Foundations of the Western Dualist Worldview

The roots of western culture can be traced to ancient Greece. But our Greek (intellectual) forefathers have bequeathed to us a dualistic worldview. Plato's world was split in two: the world of matter on the one hand, and the world of ideas on the other. His student Aristotle, *the authority* among philosophers and scientists for almost two thousand years, institutionalized that dualistic worldview. In addition to distinguishing between the "noble" heavens and the "lowly" earth, he viewed humans as rational souls with material bodies. During the Middle Ages, as the Christian church studied the Scriptures through Aristotelian glasses, it blessed that dualistic view. Souls, eternal and immutable, were trapped in bodies until death released them to their eternal destiny. Bodies, along with the earth to which they returned, were seen as temporal and mutable. Theology was the "queen of the sciences," the arena wherein values were discussed. Science and the arts were seen at best as "neutral" or, more often than not, ignoble.

The Copernican revolution and the Enlightenment changed that to some extent. Science took on respectability. Theology was placed on a shelf—an exalted shelf, to be sure, but nonetheless a shelf—where its concerns became increasingly less relevant to the blossoming world of science, technology, and commerce. And this was completely consistent with the fundamental dualism which continued to characterize the Western worldview.

That dualism was strengthened by the evolution of what is perhaps the most powerful tool of modern science: abstraction. Abstraction is the mental process by which we isolate one aspect of reality from the whole so that we can study it in its isolation. It is what mathematicians do when they temporarily ignore physical, biotic, aesthetic, and historical questions and focus only on those abstract creatures we call numbers. It is what we all did as high school physics students when we first discovered that we could isolate the vertical and horizontal components of projectile motion, study them in their isolation—even assign equations to them—and then bring them back together, having gained a deeper insight into the nature of kinematics.

Like all useful tools, however, abstracting is dangerous if we misuse it. We may begin to mistake our abstractions for reality. Scientists (and engineers) who fall into this trap find themselves living in abstract worlds; or, to use the well-known euphemism, find themselves in "ivory towers." In these abstract worlds, they can neatly separate ethical concerns from economic concerns or from aesthetic concerns, and so on. Ultimately they begin to see the world of values as distinct and separate from the world of logic and of practical engineering.

The products of technology intrinsically retain a portion of the values operative in the design process.

To distinguish the tool of abstraction from the misuse of it, let us call the latter *abstractionism*, and let us define it as *the belief that our theoretical abstractions from reality are true representations of reality.*

When teaching Newton's second law any good high school physics teacher will point her students away from abstractionism by quickly reminding them that the real world includes friction and relativistic effects. The teacher hopes the student then sees Newton's law as a useful abstraction from reality and not a true representation of it. I suggest that we need to make that point on a broader scale and teach our students that physics is an abstraction from reality and that the world in which we live is an integral whole in which it is impossible, except in our minds, to separate the physical aspect from the economic, or from the ethical.

In the late sixties a little ditty popular among those opposed to the Vietnam war went like this:

> Once the rockets go up
> Who cares where they come down.
> That's not my department
> Says Werner Von Braun.[10]

This wasn't so much a criticism of Von Braun as it was a comic lamentation on abstractionism. The idea that an engineer could neatly separate his technical activities from the political and ethical consequences which are part and parcel of the context of those activities proved to be rich fertilizer for the soil in which the antitechnology movement of the late sixties grew.

Perhaps the ecological crisis we now face is the most striking example of the fruits of abstractionism. Lynn White, Jr., in his classic paper, "The Historical Roots of Our Ecologic Crisis," pointed an accusing finger at Christianity for its rejection of pagan animism and its doctrine that "nature has no reason for existence save to serve man."[11] While agreeing with White, I would argue that this anthropocentric and nature-devaluing doctrine derives more from synthesizing the Greek dualistic worldview and Christian theology. We must first see nature as neutral and truly separate from humanity before we can see it as having value only in terms of its service to humanity.

But that is precisely what the engineering community has done over the last century. While discovering that our atmosphere, as well as our rivers and streams, have enormous capacity for dealing with our refuse, we failed to consider seriously the implications for the biosphere until those implications stood up and stared us in the face. While designing a transportation system around the single family car, we failed to consider the sociological implications of the accompanying highway support system or the long range economic implications of the system's dependency on our nonrenewable fossil fuel resources.

The Value-Ladenness of Technological Artifacts

The second point of this paper's thesis asserts that technology is not only a normed activity which is never neutral or value-free, but that the products of technology—the artifacts of our technological culture—have values embedded in them. The implications of this are at least two-fold.

First, the values inherent in such artifacts will necessarily influence the persons who utilize them. Thus the consumer is responsible for considering what his or her consuming of a product means for self and for community. A simple but deadly example is drugs. Cocaine is a technological product with not only physical and biotic properties, but also economic, legal, and ethical values. To purchase and use cocaine is to act economically, legally, and ethically according to a very specific value system—a value system which is *transmitted by the cocaine*.

Second, the designers, manufacturers, and marketers of technological artifacts are responsible not only for the physical or biotic properties of such artifacts, but also for the values that, inherent in the design process, are transmitted by those products. Thus, computer programmers designing recreational software for the mass market must consider the psychological, pedagogical, and sociological implications of their products, especially when they aim the product at that part of the population least able to discern them.

Before looking at a few specific examples, we should consider that all technological products have properties by which they can be described. Many of those properties are carefully designed into the products. But some of those properties are designed in by default (for example, the environmentally polluting properties of leaded gasoline were not designed into it in any deliberate sense). What is important to realize is that each product has a spectrum of properties. That spectrum includes not only spatial, physical, and biotic properties, but also properties which we might categorize as ergonomic, economic, aesthetic, legal, and ethical. None of these properties are any less real than any of the others, although they certainly may be less obvious or less open to clear-cut analysis. And none of these properties can be neatly separated from the product or from the spectrum of properties that describe it.

Consider the very ordinary eyeglasses that many of us wear. Neil Postman suggests that

> The invention of eyeglasses in the twelfth century not only made it possible to improve defective vision but suggested the idea that human beings need not accept as final either the endowments of nature or the ravages of time. Eyeglasses refuted the belief that anatomy is destiny by putting forward the idea that our bodies as well as our minds are improvable.[12]

A value such as this—the potential perfectibility of our bodies—is not one that is consciously designed into the artifact, but it is there nonetheless. And it has enormously influenced the technology of the West, leading directly to the heart transplants and gene splitting of our own age.

The clock is another technological artifact that is not without its share of cultural value baggage. In his book *Technics and Civilization*, Lewis Mumford concludes that the clock

> "is a piece of power machinery whose 'product' is seconds and minutes." In manufacturing such a product, the clock has the effect of disassociating time from human events and thus nourishes the belief in an independent world of mathematically measurable sequences.[13]

This way of looking at time has, among other things, made our initial understanding of special and general relativity much more difficult than it might have been otherwise.

Perhaps communications technology gives the best example of not only how values are embedded in technological products, but also how those products can then profoundly shape the culture that embraces them. Consider the stages of that technology as represented respectively by the following communications media: oral, print, telegraphy, and television.

The introduction of print technology during the Middle Ages resulted in no less than a cultural revolution. It might be argued that both the Protestant Reformation and the Copernican Revolution owe a large part of their impetus to Gutenberg's invention. Oral communication lacks permanence. Print is characterized by permanence. The oral tradition, while necessarily communal, favored the gifted few while print made learning available to anyone who could be taught to read. Thus print favored democracy and the individual. According to Neil Postman, the chief characteristic of the printed word is that it has *content*, a semantic, paraphrasable, and propositional content.[14] To sense what Postman means, simply compare how a technical paper in a technical journal communicates with how a 30-second television commercial communicates.

The introduction of telegraphy during the middle of the nineteenth century caused another radical change in our culture in general, and specifically in the way we think. Telegraphy brought with it the *new idea* that transportation and communication could be disengaged from one another and made possible the idea of context-free information. "Knowing the facts" took on a different meaning. Prior to telegraphy the field from which facts could be selected was highly limited and defined by a context—the immediate environment. Telegraphy made possible the "knowing" of facts that were irrelevant to one's immediate set of concerns and very much taken out of context. For example, we may come to know that Prince Charles and Princess Diana are expecting another child almost as soon as they know. But knowing that fact, that torn-loose bit of information, very likely has no significance to our lives. The game *Trivial Pursuit* would stand very little chance of arising in a culture whose communications media were limited to the oral and typographic.

The most recent change in our communications media is that of television, which adds to that of telegraphy the idea of context-free visual images.

> ***Physics is a useful abstraction from reality, but not a true representation of it.***

In fact, the technology of television is at its technical best when it is communicating these bite-sized chunks of visual information. This technical characteristic of television imbues it with what Postman calls an *amusement bias*. For example, "the news" has to be set in a series of unrelated bite-sized and relatively entertaining stories to be effective television. *The McNeil-Lehrer News-hour* may be better journalism than *The Nightly News*, but technically it is second rate television—and that is why so relatively few people watch it.

This aim of television to amuse has critical implications for education. Children raised on "technically good" television require an equally entertaining school curriculum or else they find it "boring." It may be argued that the degree to which schools have yielded to that requirement represents the degree to which our young people have fallen behind their contemporaries in other parts of the world in their understanding of mathematics and science.

Turning to another example, we can see that the automobile has also shaped modern culture. But designed into the automobile are values that reflect our culture and direct it as we move into the future. Modern America values individualism, so we think each family (if not each person) ought to have its own car. Consequently, we need a complex highway system and won't use mass transportation except where it was a technical necessity (air transport) or an obvious convenience (city bus systems).

Another value which the automobile reflects is environmental stewardship—or worse, the lack of it. Consider how often many of us accelerate and decelerate 3000 pounds of steel to a speed of 25 mph, twice, simply to acquire and transport a gallon of milk one to two miles.

Finally, the values built into BMW's, Corvettes, and Rolls Royces are obvious to anyone who thinks about them, whether they embrace or reject them.

Computers offer us one more example for the non-neutrality of technological artifacts. At first glance computers seem to be the epitome of *mere tools*, dependent completely on the programmer or the user. But consider the following quote by George Grant:

> Abstracting facts so that they may be stored as "information" is achieved by classification, and it is the very nature of any classifying to homogenize what may be heterogeneous. Where classification rules, identities and differences can only appear in its terms. [This means] that the "ways" that computers can be used for storing "information" can only be ways that increase the tempo of the homogenizing process in society, [and that computers'] very capabilities entail that the ways they can be used are never neutral. They can only be used in homogenizing ways.[15]

Grant is saying that to store information, computers must receive it in a form they can use. That requires classification which, by its nature, reduces the unique to the ordinary. Using a computer, then, is never neutral, for whatever reduces the unique to the ordinary naturally favors the status quo notions of what is ordinary. The computer thus accelerates values, promoting the values inherent in the classification scheme with which it works.

Engineering Curriculum

The 1987 *National Action Agenda for Engineering Education*, published by ASEE (American Society for Engineering Education) recommends that engineering curricula be revised to include

> Integration of the humanities and social science content into the overall engineering curriculum. The objective should be to provide students with the social and cultural context of engineering, including ethical issues and values.[16]

The two-fold thesis of this paper, that technology and technological artifacts are not value-neutral, lends urgency to this recommendation from the National Action Agenda. Engineering students need to be convinced that their work has not only narrow technical and economic implications, but also highly significant legal, ethical, political, social, aesthetic, cultural, and other non-technical implications as well. This can be accomplished only if the curriculum is structured as a kind of tapestry, where the threads representing the various aspects of life in our complex world run through it in an interwoven fashion. Literature and economics, just to mention two courses, must not be perceived as "humanities and social science requirements" apart from the engineering core. Students must see that studying machine design without studying literature, or linear algebra without history, makes them only partly educated, and that partly educated persons, particularly technically trained but partly educated persons, can be very easily enslaved by a system of values which they may otherwise reject.

To accomplish this kind of holistic education, engineering educators must emphasize at least two things. First, the overall curriculum, as suggested by ABET and by the National Action Agenda, must contain course work in the humanities, course work which, as mentioned above, must be perceived by the student as an integral part of his or her engineering education. Second, each individual course, whether technical or in the humanities, must be taught in a way that counters the tendency toward abstractionism. The discipline of fluid mechanics may be an abstract one at times, perhaps even most of the time. But the course in which that discipline is studied is a part of life—and life is complex. Therefore the fluid mechanics course must convey that complexity to the student. Last, each engineering educator ought to be sensitive to the values which he or she teaches. The teaching of values will occur whether we like it or not. So the question then is not whether we shall teach values, but rather, what values are we teaching?

Conclusion

On a weekday in December of 1988 Patrick Purdy walked into the Cleveland elementary school playground in Stockton, California, carrying an AK-47 assault rifle. He opened fire on the children playing during recess, killing some, wounding others, and sent a horrified nation back to the debate table to wrestle with the issue of gun control.

Amidst the echoing rhetoric one frequently hears the well-known cry of the National Rifle Association, "Guns don't kill people, people kill people." I suggest that such reasoning can be formulated only from within a society which has fallen victim to abstractionism, a society which adheres to the Aristotelian dualism of mind and matter and views matter as neutral.

The assault rifle is a technological product with values designed into it. One of those values is a contempt for human life. It is not designed for hunting food, for protecting oneself against wild animals, or for any other legitimate activity. It is specifically designed to destroy people. Yet Patrick Purdy purchased it easily at a gun shop for $350.

The engineer who designed, the businessman who marketed, and the politician who failed to regulate the assault rifle must be held in part responsible for the use to which it is put. And perhaps the engineering educator who failed to teach his students that technology and the products of technology are value-laden, and that engineers play a major role in determining what those values are, perhaps he too must share a part of the responsibility.

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3 Merle Curti, *The Growth of American Thought* (New York: Harper & Row, 1943), 166-167.

4 Mike Martin and Roland Schinzinger. *Ethics in Engineering* 2nd Ed. (New York: McGraw-Hill, 1989), 352.

5 Stephen H. Unger, *Controlling Technology* (New York: Holt, Rinehart and Winston, 1982), 34.

6 Martin & Schinzinger, 342.

7 Stephen V. Monsma, Ed., *Responsible Technology* (Grand Rapids, MI: William B. Eerdmans, 1986), 170-177. Van Poolen has written two of the chapters in this book.

8 E.F. Schumacher, *Small Is Beautiful* (New York: Harper & Row, 1973). See, in particular, Part II Chapter 5 and Part III Chapter 2.

9 See Victor Papanek's *Design for the Real World* (New York: Random House, 1972) and his *Design for Human Scale* (New York: Van Nostrand Reinhold, 1983).

10 Recited by Tom Lehrer, political satirist of the early 1970s, at a number of his "performances."

11 Lynn White, "The Historical Roots of Our Ecological Crisis," *Science*, Vol.155, No.3767 (March 10, 1967): 1207.

12 Neil Postman, *Amusing Ourselves to Death* (New York: Viking Penguin, 1985), 14.

13 Postman, 11.

14 Postman, 49. This discussion regarding communications technology borrows heavily from Neil Postman who borrows from Marshall McLuhan.

15 George Grant, "The Computer Does Not Impose on Us the Ways It Should Be Used," in *Beyond Industrial Growth*, ed. A. Rotstein, and quoted in Monsma.

16 *A National Action Agenda for Engineering Education*, published by American Society for Engineering Education, 1987. See page 10.