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Design Ethics: The Social Ethics Paradigm*

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Technology is human behavior that transforms society and transforms the environment. Design is the cornerstone of technology. It is how we solve our problems, fulfill our needs, shape our world, change the future, and create new problems. From extraction to disposal in the life-cycle of a product, the design process is where we make the most important decisions; the decisions that determine most of the final product cost, and the decisions that determine most of the ethical costs and benefits. It is quintessentially an ethical process. Ethics is not an appendage to design but an integral part of it, and we advocate using the moral imagination to draw out the ethical implications of a design [1]. We will stress and develop the social ethics paradigm, because design is an iterative social process for making technical and social decisions that may itself be designed at each stage with different people at the table, different information flows, different normative relationships, different authority structures, and different social and environmental considerations in mind [2]. Despite the considerable recent growth in the literature and teaching of engineering ethics, it is constrained unnecessarily by focusing primarily on individual ethics using virtue, deontological, and consequentialist ethical theories. In contrast, the social ethics method requires an examination of the social arrangements for making decisions that is particularly relevant to the iterative, decision-making, design process. Different social arrangements may be made for making any decision, each of which arrangement embodies different ethical considerations and implications. Dewey argued in much the same way for a scientific and experimental approach to ethics in general: 'What is needed is intelligent examination of the consequences that are actually effected by inherited institutions and customs, in order that there may be intelligent consideration of the ways in which they are to be intentionally modified in behalf of generation of different consequences.' [3]. The social ethics paradigm that we will unfold owes much to the pragmatist thought of John Dewey.

INTRODUCTION

IN INTRODUCING the idea of social ethics, it helps to distinguish it from other uses of this and similar terms. Also, although it is overly simplified to say so, traditional approaches to ethics [4] have focused on individuals, actions, and consequences [5]. Our approach is an examination of structure and process, and, as such, it involves social relations, their structure, and the norms and policies that characterize them. While we understand that traditional approaches in ethics are sometimes applied to organizations [6], for us it is an explicit focus to look at the functioning of collectivities.

We consider that our definition of social ethics is a clear method for examining the ethical dimensions of a crucial area of human behavior: the social arrangements for making decisions. This may easily be applied to how a family decides on a vacation, or a government or court system decides on the application of the death penalty. It may also be applied to how governments perform an increasingly critical task, the management of technology [7]. The rise and fall of the Office of Technology Assessment, which was dedicated to exploring the technical implications of policy, is a case study of interest here [8]. However, our focus is on decisions about technology and, in particular, on the way decisions are, and can be, made during the design process.

Some uses of the term 'social ethics' simply refer to the competing ethical perspectives on social issues such as abortion, pornography, and world hunger [9]. While the same subjects may be approached by the social ethics method we propose, that is not what these authors do. On abortion, for example, we focus on who decides and how, rather than what, they decide.

The idea of social responsibility is very common in engineering ethics literature [10–12] and it is described as a social movement in one of the best-known texts [13]. Other writers have absorbed the idea so thoroughly and disaggregated it in so many ways that it scarcely gets named [14]. Essentially, social responsibility in this context means bringing

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social and environmental issues into the ethical discourse about, and codes for, engineers and the use of technology. The environmental movement has been very influential in raising the salience of social responsibility in engineering ethics [15–17]. Using the social ethics paradigm differs from social responsibility approaches, since we would focus not on the (un)desirability of species generation, species extinction, safe water technology, resource depletion, renewable energy, CFCs, or PCBs, *per se*, but on who makes the decisions (and how) that control the extraction, refinement, production, use, and disposal stages in the product life-cycles and with what environmental implications and effects. Obviously, valuations of the technologies will appear throughout a social ethics analysis as trade-offs—to use the language of engineering design. In Fig. 1 we have tried to outline the distinctions that explain our position.

Another clarification that helps to understand our position is that there is something of a split between approaches to engineering and other professional ethics and what we will refer to as the ethics of technology. Professional ethics has been well developed in the United States [18–19]. However, many scholars want to talk about technology more generally and certainly decisions in the design, development and use of technology go far beyond the scope of professional ethics and involve far more than engineers. One might make the distinction that professional ethics is concerned with the 'good' engineer, and ethicists of technology are concerned with 'good' technology. The scholars who practice these two approaches share many concerns, but they have chosen rather different paths. Some debate emerged between these two points of view at the Research in Ethics and Engineering conference at the Technological University of Delft in May 2002, which suggests that some co-existence issues are still unresolved.

We do not view ourselves as falling into either camp, since social ethics is of great use in professional ethics while obviously making good technology its goal. We hope that adopting the social ethics method will allow exponents of both views to have a common ground for analysis, thus promoting the development of a global approach to design ethics.

SOCIAL ETHICS BY EXAMPLE

The most vivid illustration of social ethics might be the case of abortion (a technology). The opponents of abortion take a deontological position and argue that abortion is taking a life and therefore wrong. The pro-choice proponents may not take a position on whether abortion is good or bad but rather take a position on who should decide.

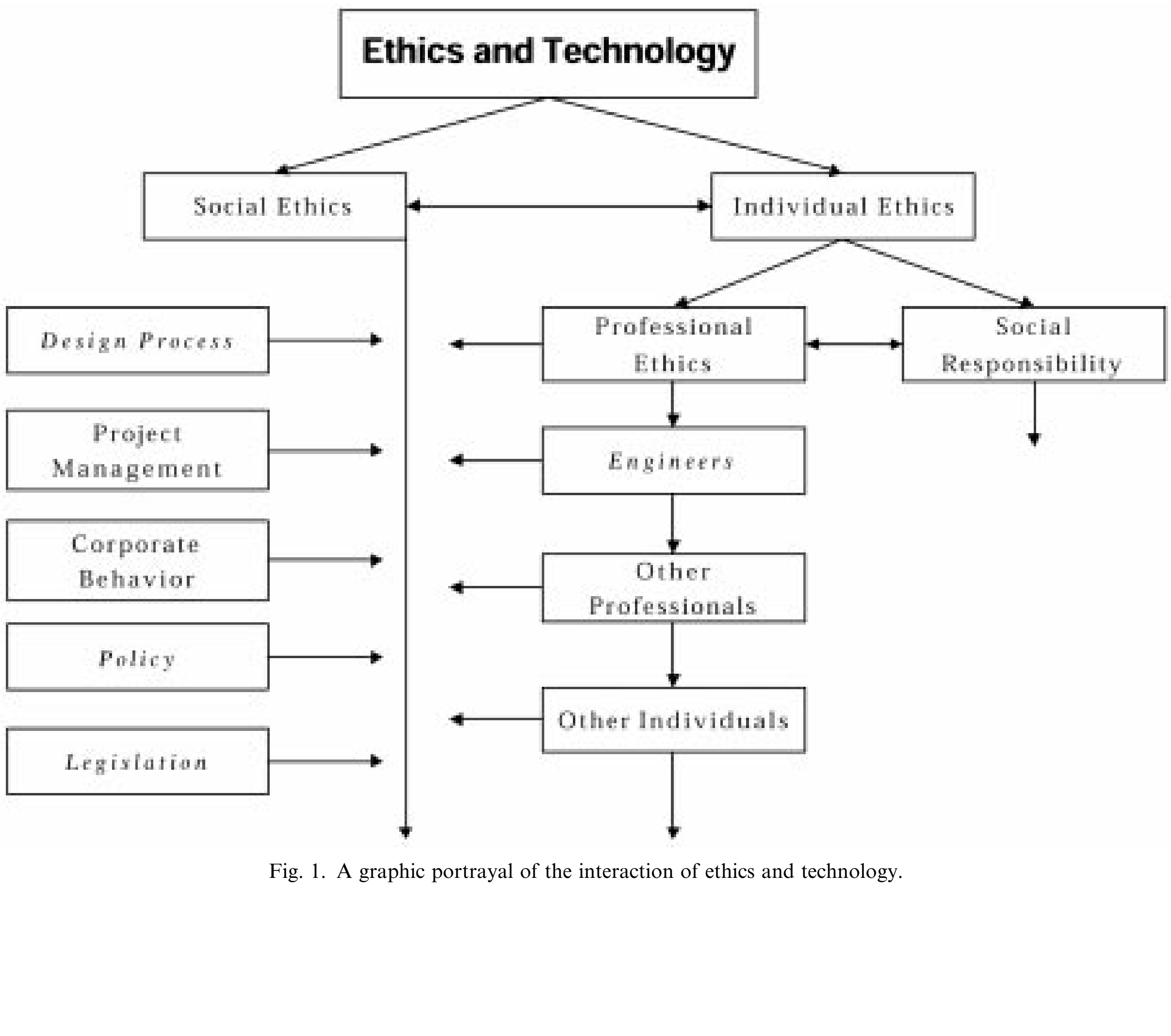

Fig. 1. A graphic portrayal of the interaction of ethics and technology.

They propose that the pregnant woman rather than male-dominated legislatures and churches should have the right to decide whether or not an abortion is the right choice for them. The pro-choice position would legalize abortion, of course, hence the debate. The pro-choice position, then, is based on what is termed here as social ethics, even though there is usually only a juxtaposition of two social arrangements in the case of abortion debates. Very clearly, different arrangements in the social arrangements for making a decision about technology (abortion in this case) can have very different ethical implications and hence should be a subject for conscious reflection and empirical inquiry in ethics.

Consider also the question of informed consent in the case of the Challenger. The launch decision was made in the light of a new and considerable risk, of which the crew was kept ignorant. (Think also of the criteria Collingridge (1980, pp. 32–42) proposes for the design process in order to deal with partial ignorance in the design process and to avoid a lock-in into an undesirable design with all accompanying risks: (1) corrigibility of decisions, (2) choose systems that are easy to control, (3) flexibility of the decision, (4) insensitivity of the decision to error.) In a personal dialogue with one of the present authors (Devon), Boisjoly, the best-known participant critic, insisted that the commander of the Challenger would never knowingly have taken such a risk. Informed consent, absent here, is a well-known and well-used idea and it represents part of a social arrangement for making a decision (we return to the Challenger case later in this paper). Analysis is now underway for the recent Columbia tragedy. At present, it seems likely that new arrangements will be made for decision-making for the shuttle flights, and these may include having inspections of the tiles at least from ground telescopes prior to return flights from the International Space Station (http://www.caib.us/news/press_releases/pr030417.html). In hindsight, there is again evidence that the cause of the problem was clearly discussed without adequate resolution prior to the return of the Columbia. In examining the social arrangements for decision-making, the flow of information to the stakeholders is very important. In both these cases, the crews were not included in some critical information flows. It may be that excluding the crews in this manner is, on balance, defensible, and maybe they would have chosen to fly anyway, but this is an example of an option that would be carefully examined using a social ethics approach.

The skywalk of the Hyatt Regency failed because of a design change that was both bad and unchecked [20] (see, http://ethics.tamu.edu/ethics/hyatt/hyatt1.htm). A bad decision is inevitable, sooner or later, so an unchecked decision means that the social arrangements for decision-making were inadequate. The original design was also bad (very hard to build) and this was largely because the construction engineers were not consulted at the outset—a bad social arrangement for making decisions. It may be compared to the concurrent engineering reforms in manufacturing that uses product design and development teams to ensure input from both design and manufacturing engineers, among others.

A faulty, unchecked design decision by a single engineer at a construction company was also the cause of the lift slab failure during the construction of Ambience Plaza (Poston, Scribner). A steel angle that conveyed the force to raise the slabs was under-designed. The consulting engineer only verified the safety of the building after it had been built. In this case, workers were killed who were violating procedures by being in the building during lifting operations. This, again, suggests a poor management arrangement, including poor code enforcement.

It is possible to look at most of the popular case studies in engineering texts from a social ethics perspective and improve the analysis and the recommendations. (There are many on-line case studies; for a good meta-site on engineering ethics, see http://www4.ncsu.edu/~jherkert/ethicind.html.) Consider a fictional video case study, *Gilbane Gold* (see http://ethics.tamu.edu/ethics/gilbane/gilban1.htm), which was produced by the National Society of Professional Engineers (NSPE). In it, an engineer, 'David,' is confronted by a 'gray' decision, where legally produced data that show that waste is safe is being confronted by better data from a new technology that suggest there are illegal toxicity levels after all. One engineering text reviews this [21] and, following the NSPE approach, suggests eight things that David could do, such as creating a technical solution, confronting his boss, or blowing the whistle to the local press. Many of these may be viewed as social actions, but none entails permanently changing any social arrangements, not even establishing conflict resolution procedures, and there are no analyses of how the social arrangement for making this decision could be changed in various ways with various trade-offs. The focus never leaves the ethical dilemma of the individual. This is fine if exploring individual ethics, but decisions are almost always social, with many stakeholders, and it may be ethically suspect to reduce such problems only to individual dilemmas.

In the case of the DC-10, so well studied by John Fielder *et al.*, one of the critical technical problems that led to the crash of several DC-10s was raised in the design stage [6]. The problem was having all the electrical and hydraulic controls systems run under the floor of the passenger compartment, which was above the luggage bay. If pressure were lost in the cargo bay (a faulty cargo door design achieved this in the Paris crash in 1974), then the floor would collapse and the plane would lose its control systems and inevitably crash. The issue of a poor cargo door design, and the sequence that could follow its failure, was raised very explicitly in 1972 by an engineer, Dan Applegate, at Convair, a subcontractor [6]. Under the contract between McDonnell Douglas and Convair, Convair was not allowed to contact the FAA directly. A social ethics approach would not focus on the ethical dilemmas faced by the engineers with the subcontractor, or those at McDonnell Douglas, who dismissed the concern. Rather, it would examine the alternatives to the contractual structure and the authority of the FAA (who did learn of the cargo door problem through test results). Legal responsibilities are based in part on the required flow of information. Thus, establishing appropriate information flows is very important.

The final characteristic that must be stressed is that, following Dewey, social ethics is empirical, and it may also be experimental where feasible and permissible. Using the social ethics paradigm means exploring many alternatives for the social arrangements for making decisions and, wherever possible, weighing the known, or at least the most likely, trade-offs. To abandon one arrangement in favor of one other by weighing trade-offs only for the two possibilities is a primitive use of social ethics. As with design, the more ideas for alternative solutions, the better. And, as with conflict resolution, creativity is a plus.

In teaching design, we have the opportunity for trial-and-error approaches to what we do. For example, in teaching design to engineering students through project experiences, all faculty will see frequent examples of dominating personalities who tend to throttle information flows and narrow ideas to their own. Even without this happening, groups of students can quite democratically adopt just one solution concept almost immediately and develop it—and only add some other ideas at the end of the project to keep the professor happy. This means the design process is poorly done, which will have negative outcomes for all the stakeholders. The situation, including the ethical trade-offs, may be improved. The design process and the team have to be structured so that the early stages of design are done properly, through an early design review or by other means.

Or consider the make-up of design teams. Leifer at Stanford has found, experimentally, that structuring diversity into a team enhances the team's performance when managed properly [22]. This provides a material (corporate) reason for doing something that many people value for other reasons—namely, celebrating diversity. By extension, it even has connotations for the admissions policy of a university. Thus, when weighing trade-offs for this arrangement, there are benefits that appeal broadly to many stakeholders, from corporate managers to university administrations. There are, however, many ways to design such diversity and so the experimental nature of social ethics is necessary.

These last illustrations serve as an introduction to the next section, where we examine ethics in the design process.

APPLYING SOCIAL ETHICS: THE DESIGN PROCESS

In addressing the embedded nature of ethics in the design process, we will assume a generic set of stages to the process. However, the process is rarely defined in exactly the same way by authors. Even the idea of a design process that is applicable across most, if not all, engineering disciplines is not that old and owes much to the work of Pahl and Beitz, whose simplest scheme is provided here [23]:

- Product planning and clarifying the task
- Conceptual design
- Embodiment design
- Detail design

We will provide one example of a variation in the way the process is used. A site visit in 2003 to a consumer product plant of the ABB Group in Spain by one of the authors found that the design and development process was used as a prominent wall chart in the offices of product design and development engineers. In their operation, the first stage of design is a group process that leads to the embodiment design for a new product. The next stage is the detail design, which is done by an individual engineer but ends with a group process for the manufacturing and quality control plans for production. This stage leads to the manufacturing stage, and then the marketing stage. Each stage has a separate manager, although inter-manager communication takes place throughout the process.

Applying the social ethics approach to design means focusing on the design *process*, and not so much on individual designers or designed products. Of course, improving the design process will eventually lead to better products; at least, that is what we believe. Moreover, a good design process will be a design process in which, among other things, individual designers can flourish, both with respect to their technical skills and with respect to exercising their social responsibility. They may also feel good about disagreements if they think that differences of opinion are handled well through open and respectful discussions [2]. That is, individual behavior is in part a function of the social arrangements in which it occurs.

An important notion for the social ethics approach is that design results from human choices. The design process is a humanly organized process. This view should not be mistaken for implying that the 'organization' of the design process is the result of deliberate human choices here and now. Clearly, the structure of the design process at least partly results from inherited customs and institutions. As Dewey maintains, a social ethics approach does not take such customs and institutions for granted, but reflects on how they function and whether they can be intentionally improved.

Below we will examine a number of issues that cut across the different phases of design, independently of how these phases are exactly defined. These issues are:

- the way the design task is organized and divided up between different design teams or team members;
- the way decision-making with respect to the design is set up; and
- the inclusion (or exclusion) of stakeholders in the design process and the way in which they are included (or excluded).

For each aspect, we will first briefly discuss why it is relevant from a social ethics perspective and, second, what this perspective implies for this aspect of the design process.

DIVIDING UP THE DESIGN TASK AND RESPONSIBILITY

Design is usually not carried out by a single individual; typically, it is a collective effort. Not every designer has the same role during the design process. Some people will design a specific part, others will integrate partial designs into an overall design, and still others will mainly be involved in project management.

The way the design task is divided up between different teams and individuals is ethically relevant, because it will in most cases have consequences for the products that are eventually designed. Moreover, it will affect the responsibility of the people involved. With respect to the latter, a distinction could be made between two types of responsibility: active and passive responsibility [24].

Active responsibility refers to a person feeling responsible for certain things. Active responsibility can be seen as a disposition or a virtue that implies, for example, taking one's tasks and obligations seriously, caring about the consequences of one's actions, and being aware of the potential violation of moral norms or of harm to others by one's actions [24]. It is known that whether people assume active responsibility depends not only on their personal character, but also on the institutional setting [24–25]. Some institutional settings stimulate active responsibility, while others inhibit it. Institutional setting may also invoke specific types of active responsibility. Large bureaucratic organizations, for example, may stimulate individuals to take their specific task seriously, but may inhibit such virtues as looking for and caring about the consequences of the organization's actions [26–27].

Passive responsibility refers to accountability or liability after something (undesirable) has occurred. This type of responsibility is important for people not directly involved in the design process—like managers in the corporation, users and stakeholders—in order to have an addressee that can be held accountable or even liable. Whether someone can be held accountable depends on such factors as whether that person had an influence on the decision or choice made, whether a norm has been violated and whether they can be blamed for their actions [24]. This implies that the way the design task is divided up among different people has an effect on who can be held accountable or liable. What is also important is that the fact that people can be held accountable afterwards will give them an additional motive to act in a responsible way beforehand (active responsibility).

The reason why the design task is split up into smaller parts is not only that design is usually too much work for one individual to do, but also because good design requires a variety of skills, expertise, knowledge and other qualities rarely found in one individual. Obviously, organizing and managing the design process means allocating tasks to individuals and design teams in such a way that everyone's qualities are used as well as possible and so that cooperation is stimulated.

However, carrying out the partial tasks or phases in the design process adequately is no guarantee of a design that is good, or even satisfactory, overall. Some considerations need to be addressed at a collective level and cannot simply be allocated to an individual or team responsible for only a part of the design. Examples of such considerations are:

- the integration of the different parts of the design or sub-assemblies into an overall design; and
- considerations of certain social or ethical concerns (like safety, environmental friendliness and the like) that concern the entire design.

The responsibility for this type of issue could be organized in different ways. One way would be to make someone explicitly responsible for such aspects. This has the advantage that taking care of these 'collective' concerns is someone's task and that that person may be held accountable afterwards. However, the danger of such an approach is that others may not feel a responsibility for issues like safety, while their attention may be crucial to achieve a safe design. Moreover, much depends on the person doing the integration in this approach. Even if this person is of good will, the important question is whether she/he will be able to gather and understand all the relevant information in order to make the 'right' decision.

As an alternative, dealing with the mentioned collective issues could be made a group effort. This may create more involvement and input from the different group members, but, especially in large groups, the effect may also be that nobody in particular feels responsible. Moreover, it may well be that relevant information and knowledge is not integrated. In that case, it may be better to have someone in particular who takes care of or pushes the issue.

Of course, there are middle ways between the two approaches mentioned above. Our goal here is, however, not to offer a recipe for how to deal with such issues. What is the best way of dealing with such 'collective' responsibilities may well depend on contingent factors like: the type of design task, the number of people involved, their specific skills and qualities, the type of collective considerations to be addressed, etc. Our point is that a social ethics approach requires attention to issues like the formation of the design team, the splitting up of design tasks and project management that relates to the allocation of tasks. While a social ethics approach does not imply a substantive position with respect to, for example, the levels of safety to be achieved in design, it implies that the information flows with respect to, and the responsibility for, issues like safety are to be adequately organized, in order to avoid diffusion of responsibility and of relevant information [25].

This may all sound rather obvious. However, it is remarkable how many social processes are organized with no one (in particular) feeling or being responsible for possible consequences, especially if these consequences are undesirable and not foreseen. Ulrich Beck speaks in this respect of the 'organized irresponsibility' in technological development [11]. According to Beck, we have 'organized' technological development in our society in such a way that no one in particular is responsible for negative 'side-effects', especially not for such effects that are 'unforeseen.' Given the large number of people involved and given the partial ignorance with respect to the effects of technological development, almost everyone has an excuse for not being responsible. If Beck is right with respect to technological development at large, it seems likely that in many individual design processes we face similar problems. A social ethics approach would focus attention on such inadequacies in inherited institutions, instead of (only) addressing the need for individual engineers to feel more responsible.

DECISION-MAKING IN DESIGN

During the design process, a lot of choices are made. Some of the choices are ethically relevant, like the choice of what design requirements and criteria to formulate, what trade-offs between design criteria are acceptable, the choice between different conceptual designs, and the choice of what risks and secondary effects of a design to accept [28].

Sometimes decisions in design are made explicitly, sometimes they are made implicitly. In setting up the design process, project managers often build in explicit decision moments. Such explicit decisions can be made in a variety of ways. They can be made by the project leader, by the design team, by the client or by a combination of those people. In the next section we will argue that a social ethics approach requires an inclusive approach; that is, an approach in which a wide range of relevant issues and possibly also of stakeholders are included.

Although explicit choices and decisions in design are important, much of the decision-making is also implicit and incremental. Many choices are made in designing that are not explicitly recognized as choices or decisions at all. They are simply seen as the way to deal with this problem, the best way to go on, etc. Of course, implicit decisions are not always bad decisions. One potential problem, however, is that a range of incremental and implicit choices may result in a situation that nobody would have wanted had it been the result of an explicit one-shot choice. In fact, many moral problems in design seem to stem not so much from a deliberate immoral decision, but from a range of decisions that in themselves are morally dubious [29].

A nice example in this respect is also the Challenger disaster, as described by Vaughan [30]. The Challenger disaster is a classical case study in the literature on engineering ethics. In this literature, the case is often interpreted in terms of managers versus engineers [18]. Whereas the engineers were concerned about the safety of the Challenger, and especially the O-ring, the managers are portrayed as having made a deliberate decision to take the risk of disaster in the light of other interests in terms of money and prestige. Vaughan maintains that this is a wrong interpretation of what actually occurred. In her view, the decision to launch the Challenger should be seen in the light of a pattern of earlier, partly implicit, decisions in which the interpretation of what was technically occurring when O-rings eroded on earlier flights and what was still an 'acceptable risk' had shifted. The decision to launch the Challenger on the night before the fatal disaster fitted into this pattern, although once again it was a reinterpretation, and broadening, of what was still an acceptable risk. In Vaughan's reading, both the managers and engineers involved thought of the O-rings as an acceptable risk on the night of the launch decision (and some of the managers still believed they made the right decision after the fact).

The way Vaughan describes the Challenger launch decision can be seen as an illustration of a phenomenon known as 'organizational deviance': norms that are seen as deviant or unethical outside the organization are seen within the organization as normal and legitimate [30]. In fact, many outside the organization believed with hindsight that the Challenger never should have been launched, while the decision to do so fitted many of the implicit norms and rules that had evolved within the organization. The interesting point is that Vaughan's description also makes clear how this organizational deviance comes about. The reason was not that NASA did not care about safety; in fact, safety concerns are important within the organization, and NASA have tried to create a range of organizational procedures to safeguard safety. The deviance rather came about as the result of a pattern of incremental and partly implicit decisions with respect to the O-rings; it was this range of decisions that led to what Vaughan calls the 'normalization of deviance.' A similar conclusion is already being drawn about the Columbia tragedy in 2003. ''I'm hearing a little bit of an echo here,' said former astronaut Sally Ride, a member of both investigation boards (http://www.washingtonpost.com/wp-dyn/articles/A63290–2003May31.html).

This is reminiscent of the work of another sociologist. In his 1984 book, *Normal Accidents*, Perrow extends a detailed account of the accident at the Three Mile Island nuclear plant near Harrisburg, Pennsylvania, to other technologies [31]. He argues that all technology fails: accidents are normal. Therefore, he argues, we must look at issues such as the extent to which technologies are coupled (tight coupling means undesirable chain reactions, while loose coupling may mean more localized outcomes) and unacceptable hazards, even if infrequent. In Perrow's view, nuclear energy involves unacceptable risks.

Vaughan's analysis of the Challenger disaster also illustrates a more general point: decisions—including incremental and implicit ones—tend to commit us to certain courses of action and frame subsequent decisions [25]. We find it very hard to revise a decision, even if we know it was a wrong decision. While this is true for individual decisions, it is usually even more difficult to revise collective decisions.

Empirical research on designing suggests that designers also tend to adhere to their initial choices and design solutions [32–35]. This may sometimes be rational, because developing a possible solution to a design problem may be a way to better understand an ill-defined design problem [36]. Nevertheless, commitment to an initial solution can become irrational or even unethical if it implies that better solutions are forgotten or, what is worse, for example, safety requirements are watered down in order to make the initially chosen design feasible.

What can we learn from the observations made above? One important lesson is that adequately organizing decision-making during the design process is essential to good design. From a social ethics point of view, more important than which decisions are made, procedural (ethical) criteria like explicitness, inclusiveness (a topic to which we will turn next) and the possibility to revise a decision (as far as possible) are important.

One potential way to improve decision-making during the design process according to such criteria might be to apply some of the formal, prescriptive design models and methods that have been developed in the literature. Such models and methods usually promote a more structured approach, taking into account different options and making explicit decisions at a number of relevant points in the design process [36–37]. Nevertheless, such models and methods are not a panacea to all problems in design. In fact, such methods will be built on ethical presuppositions that may turn out be problematic (or not). And what looks like a good design and decision-making process on paper may not be one in reality.

INCLUSION OF STAKEHOLDERS AND RELEVANT GROUPS

Design implies not only a transformation of the physical world but also of society. Design impacts on other people than those directly involved in shaping it. Moreover, this impact is often not exactly known beforehand. Engineering design is a form of social experimentation, as Martin and Schinzinger call it [13]. It is carried out in partial ignorance and the final social outcomes and effects are generally unknown. Moreover, design does not end after products have left the factory. Products are designed and redesigned on the basis of knowledge about how they work, and what kind of effects they have in practice.

Designing engineers, however, lack the kind of experimental control that is regular in normal scientific experiments. The potential negative consequences of engineering design may be more disastrous and difficult to control than in the case of normal experiments. Martin and Schinzinger plead for introducing the criterion of informed consent for engineering as social experimentation. By this, they mean that the people who may be affected by a technology should be informed as well as possible about the potential risks and effects involved and should give their voluntary consent in order for the project to be carried out.

From a social ethics paradigm, informed consent could be seen as a *procedural* criterion or norm for good engineering. This norm would imply a set of additional criteria and norms for the design process. An important norm would be the inclusion of a diversity of viewpoints and stakeholders in the design process [2]. This norm could be achieved in design processes in a variety of ways. One way would be to broaden the range of design requirements and criteria posed in the design process. Also, some of the recently developed methods and approaches in design, like concurrent engineering, quality function deployment and design for X, where X stands for such issues as manufacturing, users, the environment, recycling and life-cycle, might be useful here. It would be interesting to evaluate whether such approaches and tools have the potential to improve engineering design from an ethical point of view.

Another possibility is also to try to involve different stakeholders in the process of design and technological development. One interesting approach is what is known as 'constructive technology assessment' (CTA) [38]. CTA aims at anticipating the potential effects of technology and feeding them back to the process of technology development and design. CTA is broader and more procedural than traditional technology assessment (TA), which aims to (objectively) predict the consequences of technology in order to improve technologies. Proponents of CTA want to make technological development more reflexive, and want it to contribute to learning. Reflexivity implies that the people involved are aware of, and reflect upon, the social nature of the process of technological development and their role in it, and the role of other actors. Learning relates to better knowing the possible consequences of the technology, developing new options and the like. In addition to such first-order learning, second-order learning is important [38]. This is learning about values, including moral values. It is this type of second-order learning that Dewey would probably have particularly appreciated, because it emphasizes the role of inquiry in ethics. After all, engineering design is a kind of inquiring, not only into the physical world but also into society and ethics.

CONCLUDING REMARKS

The social ethics approach and individual ethics approach do not exclude each other. However, individual ethics without social ethics is powerless. This is not to deny that reforms in social arrangements are to be achieved by individuals, but to stress that they will realize their morality within malleable social arrangements that will definitively constrain and shape what they do. Therefore, these social arrangements must be designed to create the ethical environments in which morality may be best exercised. The design of such social decision-making arrangements, like any engineering design, should be subjected to a process that involves studying many alternatives, includes many stakeholders, and weighs empirical evidence very strongly.

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