Chapter 2
Values in Engineering and Technology

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2.1 Introduction

There is an intimate relation between technologies and values. Technologies sometimes endanger certain values, like health and safety, as in the case of the Fukushima nuclear disaster. Technologies may also foster certain values, like human well-being, democracy, or privacy. It has even been suggested that technology as such, rather than individual technologies, foster certain values, like efficiency, at the costs of others (e.g., Ellul 1964).

While there has been quite some attention for the relation between values and technology, less attention has been paid to role of values in engineering. I will understand engineering here as an activity that is aimed at understanding, creating, improving, maintaining and dismantling certain technologies. Since technologies are value-laden, it seems natural to expect that values also play, or at least should play, a role in engineering. However, engineering as an activity and as a practice is not only guided by what I will call external values, i.e., values deriving from the social impact of technology, but also by internal values. One might think of such values as technological enthusiasm, which is often a main motive for engineers to develop new technologies, and such values as effectiveness and efficiency, which are largely independent from specific technological applications.

This paper is organized as follows. I start with discussing some of the traditional distinctions that are made in moral philosophy between different kinds of values, especially between instrumental and final value and between intrinsic and extrinsic value. Next, I will discuss and criticize a thesis that is sometimes held with respect to value and technology, i.e., that technology is value-neutral. Thereafter, I will focus on the values in engineering. I will discuss some of the main internal and external values in engineering. I end with conclusions.

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2.2 Final Versus Instrumental and Intrinsic Versus Extrinsic Value

Often a distinction is made between intrinsic and instrumental values. Intrinsic values are those that are good in themselves or for their own sake, while instrumental values are valuable because they help to achieve other values. It should be noted that in this respect an object can be instrumentally valuable and intrinsically valuable at the same time. A car may, for example, be instrumentally valuable as a means of transportation to go from A to B, while at the same time being intrinsically valuable as a beautiful object.

Although the distinction between instrumental and intrinsic value may seem straightforward, it is not. Various philosophers have pointed out a number of terminological and substantive issues with respect to the distinction (for a discussion, see Zimmerman 2004). One issue is that the notion of intrinsic value is ambiguous. The notion is usually understood to refer to objects or states of affairs that are valuable in themselves. Intrinsic value is then value of a non-derivate kind. Intrinsic value may, however, also refer to things that are valuable due to their intrinsic natural, i.e., descriptive, properties. As Christine Korsgaard has pointed out, things that are valuable due to their intrinsic properties are unconditionally good (Korsgaard 1983). Their goodness does not depend on the relation with other objects or with people; otherwise their value would not be intrinsic to the object. However, according to Korsgaard, some things may be good in a non-derivate sense, even if they are not unconditionally good. An example is human happiness in a Kantian respect. According to Kant, human happiness is non-derivate goodness. Happiness is good in itself, and not because it is a means to another end or contributes to another value. Nevertheless, according to Kant, happiness is only conditionally good; it is only good insofar as it corresponds to good will, i.e., respect for the moral law.

To avoid the ambiguity to which Korsgaard refers, I propose to classify the values of objects in two independent ways. The first relates to whether values are relational or not. Values that are not relational will be called "intrinsic values" because these values depend only on intrinsic properties. Otherwise, values are called "extrinsic." The second way relates to whether the values of objects are values for their own sake or not. Values for their own sake will be referred to as 'final values'; otherwise values will be called "instrumental values."

2.3 The Neutrality Thesis

Sometimes the thesis of technology being value-neutral is defended (Florman 1987; Pitt 2000). The main argument usually given for this thesis is that technology is just a neutral means to an end which can be put to good or bad use. Value is thus created during use and is not located in technology. This also means that the objectionable effects of technology are to be blamed on the users and not on technological artifacts, or their designers. As the American Riffle Association has expressed it: "Guns do not kill people, people kill people."

What does claiming that technology is value-neutral exactly entail? One interpretation would be to say that it means that the value of technological artifacts only depends on their extrinsic properties. In this interpretation, the thesis that technology is value-neutral is clearly false. It can be seen as follows. Technological artifacts have a physical or material component, in other words they are also physical objects, even if they are not mere physical objects. The value of physical objects as a means to an end depends – partly at least – on their intrinsic properties. A stone can be used to split a nut thanks to its intrinsic physical properties. A tree leaf would have a much smaller or no instrumental value when it comes to splitting nuts. Since it is implausible that the instrumental value of physical objects merely depends on their extrinsic properties, the same may be said of technologies. So the value of technological artefacts does not only depend on their extrinsic properties.

The thesis that value is not intrinsic to technology may also be interpreted as implying that such value also partly depends on the extrinsic properties of a technology. To judge the plausibility of such a claim, it is crucial to define technology or technological artifacts because to a large extent that is what will determine what we consider to be the intrinsic and extrinsic properties of technological artifacts. If we define technology sufficiently broadly, we can always make values internal to technology. But what happens if we start off with a minimal definition of technology? I think that any plausible minimal account of technology needs to refer to the notion of function, and/or comparable notions like ends, purposes and intentions. The fact technologies have a function implies that they have instrumental value, i.e., that they can be used for some end.

On a minimal definition of technology, then, technology at least has instrumental value. This does not mean that such instrumental value is intrinsic to technological artifacts in the sense that it only depends on the intrinsic properties of technological artifacts. That, indeed, is not usually the case: the particular instrumental value of a particular hammer for driving nails into a piece of wood also depends, for example, on the physical abilities of users and such abilities are extrinsic to the hammer. So even if having instrumental value is part of what it means to be a technical artifact, that same instrumental value is not necessarily intrinsic to the technological artifact.

Van de Poel and Kroes (2014) have argued that technological artefacts cannot only embody instrumental value but also final value. One example they give is a sea dike. The technical function of a sea dike is to prevent the hinterland from flooding, which is instrumental to a moral value like the safety of the inhabitants of the hinterland, which might be considered a final value. The point is not that sea dikes can be used to achieve safety but that achieving safety is part of its *function*. They argue that dikes are *designed for safety*. This is different from, for example, a knife. The function of a knife is cutting; cutting of, for example, bread may be instrumental to a final value like health or survival or human-well-being. However, the attainment of such final values neither is part of the function of knifes nor have normal knifes been designed to achieve such final values. Whereas in the case of the knife, the function of the artifact and the final values that can be achieved by realizing the function are clearly separated this is not the case in the sea dike example. The instrumental function of sea dikes (protection from flooding) can hardly be distinguished from the final value for which they are designed (safety with regard to flooding). After all, the technical function of a dike may be described as providing safety with regard to flooding.

So far we have focused on the value-ladenness of technology; I now want to turn to the value-laden character of engineering. Partly, values in engineering derive from the values realized by technology. Such values are, for example, incorporated in the engineering design process (Van de Poel 2009). Engineering is, however, also value-laden because it is a professional practice (Davis 1998; Pritchard 2009). Michael Davis, for example, has argued that engineering is a profession today. He defines a profession as "a number of individuals in the same occupation voluntarily organized to earn a living by openly serving a certain moral ideal in a morally-permissible way beyond what law, market, and morality would otherwise require" (Davis 1998, p. 417). Engineering as a profession is, in his view, thus by definition value-laden.

The statement that engineering is value-laden is not uncontroversial. Samuel Florman, has, for example suggested that it is not the task of engineers to determine the broader social goals for which technology is to be used or to be optimized (Florman 1983). Somewhat similarly, Steven L. Goldman talks about the social captivity of engineering. According to him engineering practice is "captive to social determinants of technological action that selectively exploit engineering expertise, define the problems engineers are to address as the terms of acceptable solution …" (Goldman 1991, p. 121).

Heinz Luegenbiehl has explicitly addressed the question whether a definition of engineering should "emphasize the requirement of engineering activity to benefit humanity" (Luegenbiehl 2010, p. 153) or should choose a more value-neutral approach. He opts for the latter option and defines engineering as "the transformation of the natural world, using scientific principles and mathematics, in order to achieve some desired practical end" (Luegenbiehl 2010, p. 153). He maintains nevertheless that "some value element is unavoidable, in that I assume that engineering activity should leave the world no less well off and that disbenefits created by engineering not be catastrophic in nature" (Luegenbiehl 2010, p. 153).

In what follows, my aim is to further explore the values that play a role in engineering. In doing so, I will distinguish between what I will call internal and external values.

Internal values are values that are perceived by engineers as internal to engineering practice and that do not, or at least seemingly do not, refer to broader social goals and values. Internal values are typically context-independent, in the sense that they are relevant in various contexts of use. A typical example is efficiency; efficiency is an important value in engineering independent from the exact technology or the exact context of usage. Similarly, a value like technological enthusiasm is more or less independent from the technology developed. Internal values are often, although not necessarily always, perceived as final by engineers, i.e., as values that are strived for their own sake. However, as we will see below from a moral point of view internal values are usually not final values.

External values are values that are related to effects of technology on other practices. Typical examples are safety, health and sustainability. They typically refer to broader human, social, environmental, and political goals. External values may be final in a moral sense, and they often are as we will see, but this is not necessarily the case. Although external values find their origin outside engineering practice, they may be internalized, for example through technical codes and standards. This has typically happened with a value as safety, as will see in more detail below and is increasingly happening with sustainability.

2.4 Internal Values

2.4.1 Technological Enthusiasm

Technological enthusiasm pertains to the ideal of wanting to develop new technological possibilities and take up technological challenges. This is an ideal that motivates many engineers. It is fitting that Samuel Florman (1994/1976) refers to this as "the existential pleasures of engineering." One good example of technological enthusiasm is the development of Google Earth, a programme with which, via the Internet, it is possible to zoom in on the earth's surface. It is a beautiful concept but it gives rise to all kinds of moral questions, for instance in the area of privacy (you can study the opposite neighbour's garden in great detail) and in the field of security (terrorists could use it to plan attacks). In a recent documentary on the subject of Google Earth one of the programme developers admitted that these are important questions.[1] Nevertheless, when developing the programme these were matters that the developers had failed to consider because they were so driven by the challenge of making it technologically possible for everyone to be able to study the earth from behind his or her PC.

Technological enthusiasm in itself is not morally improper; it is in fact positive for engineers to be intrinsically motivated as far as their work is concerned. The inherent danger of technological enthusiasm lies in the possible negative effects of technology and the relevant social constraints being easily overlooked. This has been exemplified by the Google Earth example. It is exemplified to an extreme extent by the example of Wernher von Braun.

Wernher von Braun is famous for being the creator of the space programme that made it possible to put the first person on the moon on 20th July 1969. von Braun grew up in Germany. From an early age he was fascinated by rocket technology. In the 1930s von Braun was involved in developing rockets for the German army. In 1937 he joined Hitler's National Socialist Party and in 1940 he became a member of

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[1] "Google: Achter het scherm" (i.e. "Google: Behind the Screen"), *Tegenlicht*, broadcast on May 7, 2006.

the SS. There is much to indicate that von Braun's main reason for wanting to join the SS was carefully calculated: in that way he would be able to continue his important work in the field of rocket technology. During the Second World War von Braun played a major role in the development of the V2-rocket which was deployed from 1944 onwards to bomb, amongst other targets, the city of London. When, in 1945, von Braun realised that the Germans were going to lose the war he arranged for his team to be handed over to the Americans. In the United States von Braun originally worked on the development of rockets for military purposes but later he fulfilled a key role in the space travel programme, a programme that was ultimately to culminate in man's first steps on the moon. Von Braun's big dream did therefore ultimately come true.

Von Braun was reconciled to the subordinate role of engineers but perpetually sought ways of pursuing his technological ideals and, in so doing, displayed a degree of indifference to the social consequences of the application of his work and to the immoral intentions of those who had commissioned the task. His creed must have been: "In times of war, a man has to stand up for his country, as a combat soldier as a scientist or as an engineer, regardless of whether or not he agrees with the policy his government is pursuing" (Stuhlinger and Ordway 1994, p. xiii). It is a role that might alternatively be described as being that of a "hired gun." The dangerous side of this role can perhaps best be summed up in the words of the song text of the British satirist Tom Lehrer[2]:

> Once the rockets go up
> Who cares where they come down
> 'that's not my department'
> said Wernher von Braun.

2.4.2 *Effectiveness and Efficiency*

Engineers tend to strive for effectiveness and efficiency. Effectiveness can be defined as the degree to which an artifact fulfils its function. Efficiency could be defined as the ratio between the degree to which an artifact fulfils its function and the effort required to achieve that effect. Efficiency in the modern sense is usually construed as an output/input ratio (Alexander 2009). The energetic efficiency of a coal plant may thus be defined as the ratio between the energy contained in the power produced and the thermal energy contained in the unburnt coal.

Effectiveness and efficiency are different values that may well conflict. The design that most effectively fulfils its intended function may not necessarily be the most efficient one. A very effective vacuum cleaner that removes more dust than a less effective one may nevertheless be less energy-efficient, that is to say, it may use

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[2] Text from the number "Wernher von Braun" by Tom Lehrer that featured in his album *That was the year that was* of 1965.

more energy per unit of dust removed than the less effective vacuum cleaner. So, we may be faced with a conflict between effectiveness and efficiency.

The drive to strive towards effectiveness and efficiency is an attractive value for engineers because it is – apparently – so neutral and objective. It does not seem to involve any political or moral choices, which is something that many engineers experience as subjective and therefore wish to avoid. Efficiency is also something that in contrast, for example, to human welfare can be defined by engineers and is also often quantifiable. Engineers are, for example, able to define the efficiency of the energy production in an electrical power station and they can also measure and compare that efficiency.

Efficiency is an ideal that endows engineers with authority because it is something that – at least at first sight – one can hardly oppose and that can seemingly be measured objectively. From a moral point of view, however, effectiveness and efficiency are not always worth pursuing. That is because effectiveness and efficiency suppose an external goal in relation to which they are measured. That external goal can be to consume a minimum amount of non-renewable natural resources to generate energy, but also war or even genocide. It was no coincidence that Nazi bureaucrats like Eichmann were proud of the efficient way in which they were able to contribute to the so-called ‘resolving of the Jewish question’ in Europe which was to lead to the murdering of six million Jews and other groups that were considered inferior by the Nazis like Gypsies and mental patients (Arendt 1965). The matter of whether effectiveness or efficiency is morally worth pursuing therefore depends very much on the ends for which they are employed. So, although some engineers have maintained the opposite, the measurement of the effectiveness and efficiency of a technology is value-laden. It proposes a certain goal for which the technology is to be employed and that goal can be value-laden. Moreover, to measure efficiency one need to calculate the ratio between the output (the external goal) and the input, and also the choice of the input may be value-laden. A technology may for example be efficient in terms of costs but not in terms of energy consumption.

2.4.3 Other Internal Engineering Values

There are a range of other internal values to engineering. I mention some:

- *Reliability*, which might be understood as “the ability of a product to perform its function adequately over a period of time without failing” (cf. Kuo et al. 2001, p. 252).
- *Robustness,* which may be defined as the “ability of a product to perform its function adequately in new or unforeseen circumstances” (cf. Vermaas et al. 2011, p. 113).
- *Maintainability* which might be understood as “the probability that a failed system can be repaired in a specific interval of downtime against reasonable cost” (cf. Kuo et al. 2001, p. 251).

- *Compatibility* which might be understood as "the ability of a product to adequately perform its function in conjunction with other apparatus and infrastructure."
- *Quality*. Quality might be understood in a variety of ways. Sometimes it is used to refer to such values as reliability, robustness and compatibility. It is also used in the sense of "robust in meeting the requirements (within certain acceptable limits) despite variations in the production process" (cf. Holt and Barnes 2010, p. 125). It might also be understood in terms of "meeting or even exceeding user requirements" or in terms of "user satisfaction."[3] In the latter case, it seems to refer to an external value because user requirements and user satisfaction refer to values outside engineering practice.
- *Rationality.* Rationally does not so seem to refer to a value that is realized in the products developed in engineering but rather to engineering as a process. It relates to how this process is organized, how decisions are made and how knowledge is developed. Rationality in engineering can be understood in a range of different ways; for a good discussion see Kroes et al. (2009).

Most of these values are internal values in the sense that engineers value them independent from the exact technology they develop and independent from particular applications. While engineers may perceive these values as final, just like they value technological enthusiasm and effectiveness and efficiency as final, from a moral point of view they are instrumental values, with the possible exception of rationality.

A number of approaches have been developed to design for the mentioned internal values. Such approaches are now known under the heading: design for X or DFX (Holt and Barnes 2010; Kuo et al. 2001). In DFX approaches, X can stand for a certain virtue or value or for a life phase. Table 2.1 lists a number of $\mathrm{DFX}_{\mathrm{virtue}}$ and $\mathrm{DFX}_{\mathrm{lifephase}}$ approaches that are distinguished in a recent overview article by Holt and Barnes (2010).

2.5 External Values

2.5.1 Safety and Health

Safety and health are without doubt among the main external values in engineering. Most US codes of ethics declare these values to be paramount in engineering. So, the NSPE Code of conduct states that "Engineers shall hold paramount the safety, health, and welfare of the public." Likewise, the code of ethics of the FEANI, the overarching European association of engineering societies, states that "Engineers

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[3] If it is used in terms of "user satisfaction," quality seems to refer to the value of human well-being of a desire-satisfaction account of well-being is adopted. Cf. the discussion below.

Table 2.1 DFX approaches (Holt and Barnes 2010)

$\text{DFX}_{\text{virtue}}$	$\text{DFX}_{\text{lifephase}}$
Design for environment	Design for manufacture and assembly
Design for quality	Design for end-of-life
Design for maintainability	Design for disassembly
Design for reliability	Design for recycling
Design for cost	Design for supply chain
Affective design	
Inclusive design	

shall carry out their tasks so as to prevent avoidable danger to health and safety, and prevent avoidable adverse impact on the environment."

Safety is sometimes defined as the absence of risk and hazards. However, risk reduction is not always feasible or desirable. It is sometimes not feasible, because there are no absolutely safe products and technologies. But even if risk reduction is feasible it may not be desirable from a moral point of view. Reducing risk often comes at a cost. Safer products may be more difficult to use, more expensive or less sustainable. So sooner or later, one is confronted with the question: what is safe enough? What makes a risk (un)acceptable? The ethical literature on risk has established that the moral acceptability of risks does not only depend on their magnitude but also on considerations like voluntariness, the balance and distribution of benefits and risks, and the availability of alternatives (Asveld and Roeser 2009; Hansson 2003; Shrader-Frechette 1991; Hansson 2009; Harris et al. 2008). So conceived, safety refers to the situation in which the risks have been reduced in as far that is reasonably feasible and desirable.

Health is defined by the World Health Organisation (WHO) as "state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (World Health Organization 2006). This definition refers to the broader value of human well-being that I will discuss below. In engineering, the focus is usually on avoiding negative influences on human health. It is not obvious that there is a requirement for engineering to contribute positively to human health, with the exception perhaps of some specific domains like health technologies. The possibilities of new technologies, like biotechnology and nanotechnology, have also led to a debate on whether technology should only aim at curing illness and perhaps improving health or should also contribute to improving humans and their achievements (Savulescu and Bostrom 2009). The latter is known as human enhancement. The positions on human enhancement range from the belief that it is not only desirable but even morally required to the conviction that it is utterly undesirable and immoral.

Health and safety are often seen as final values from a moral point of view. It might also be argued that these values are not really valuable in themselves bur rather contribute to the good life or human well-being. Their contribution is, however, not merely causal, but rather they are, as values, constitutive for the overarching value of human well-being. Safety and health may thus also be seen as constitutive values for the final value of human well-being.

In regular engineering practice, however, the focus is usually on avoiding negatively influencing human health. In such cases, the focus is often on potential health risks that are to be minimized. The approach may then be similar to that of safety risks that I discussed above with an important role for the notion of acceptable risks. For example, for potential toxic substances, acceptable health risks are often formulated in terms of acceptable daily intake (Covello and Merkhofer 1993).

Although health and safety are external values, in the sense that they refer to the effects of technology outside engineering practice, they have been internalised in engineering practice over time. In the case of safety this has even led to the academic treatment of the principles of safety engineering, although safety engineering is fragmented over different technological areas (Hansson 2009). Health has not yet led to a specific area in engineering, although in the late nineteenth and in the twentieth century attempts have been made to establish sanitary engineering and later public health engineering as distinct disciplines (Van de Poel 2008, pp. 614–615, footnote 9).

Safety and health are also internalized in engineering through technical codes and standards. Technical codes are legal requirements that are enforced by a governmental body to protect safety, health and other relevant values. Technical standards are usually recommendations rather than legal requirements that are written by engineering experts in standardization committees. Codes and standards have two main functions (Hunter 1997). The first is standardization and the promotion of compatibility. The second aim of codes and standards is guaranteeing a certain quality or protecting external values. Though external values usually are not explicitly stated in codes and standards, considerations in safety and health often are the foundation for the content of codes and standards.

2.5.2 Human Well-Being

Several engineering codes of ethics state that "engineers shall use their knowledge and skill for the enhancement of human welfare" (Code of ethics American Society of Civil Engineers and Code of Ethics American Society for Mechanical Engineering.) Also in other engineering texts and methods, one find references to external values like human welfare, happiness, quality of life, human flourishing, the good life, and well-being. I will here use the term "human well-being" to refer to the value that is at stake in all these cases. I take it that well-being not only refers to feeling well here and now but that it tells something about how somebody's life is going *for* that person.

In moral philosophy, human well-being is generally seen as a final value, that is worthwhile for its own sake, rather than to achieve something else. In philosophy, three main theories about how to understand the value of well-being have been developed (Crisp 2008):

- Hedonism conceives of human well-being as pleasurable experience.
- Desire satisfaction accounts conceives well-being as the fulfillment of the (actual) desires that people have
- Objective list accounts assume that well-being can be understood in terms of a list of general prudential values

I will first briefly discuss some of the philosophical objections that have been raised in philosophy against each of these theories and will then discuss how each of these philosophical positions may be put to work in the context of engineering, particularly in engineering design.

A main objection against experience accounts has been raised by Nozick (1974), who invites us to imagine an *Experience Machine* that can give us any possible, positive experience we desire, while we actually float in tank and do nothing. Would you plug in to this *Experience Machine*? While most of us would probably appreciate the pleasure and joy that the machine can create for us, it seems likely that many people would not plug in. The reason is that what we not just value experiences but also value *to be* somebody and *to do* certain things. We do not just want the experience of friendship, we want friendship; we do not just want the impression of being in control of our own life but we want to be in control (at least to some extent). We can thus conclude that what make positive experiences good or desirable are the *values* on which they are based. Sometimes the value lies in the experience itself (as with the value of joy and pleasure); in other cases the values lies outside the experience itself (as with values like accomplishment, friendship and autonomy).

Desire-satisfaction accounts also have a number of problems (Crisp 2008; Griffin 1986). One problem is that people might well desire things that do not contribute to their well-being. I may have a longing desire to eat an entire pie every day, but on closer reflection, it is likely that I will come to the conclusion that that is not contributing to my well-being. Well-being then is not so much about satisfying the desires I have here and now but rather about how my life overall and over a longer period of time is going. Another problem of desire-satisfaction accounts is a phenomenon known as adaptive preferences (Nussbaum 2000, pp. 136–142). When people are for a long time deprived of basic rights or needs, they might very well loose a desire for such rights or for fulfilling those needs. It would however be wrong to conclude that fulfilling those rights and needs then no longer contributes to their well-being. In fact most people would start appreciating those rights and the fulfillment of those needs again once they are no longer deprived of them.

Objective list accounts assume that it is possible to list a number of values (or other items such as capabilities) that together constitute well-being. Objective list accounts also have their problems. First, it seems rather obscure how we can come to a list of objective prudential values and how we know when it is complete. Second, such accounts seem to ignore reasonable differences between people in what constitutes well-being for them. After all, my well-being is to an important extent dependent on my ability to set my own goals in life and to accomplish these (Raz 1986). One possible way to try to avoid these problems is by basing the list not only on certain features of human nature but also in part on so-called informed desires (see Griffin 1986, p. 70; Nussbaum 2000, p. 76). These are basically the desires that people were to have if they were fully (or at least sufficiently) informed and took a reflective attitude towards their own life. In addition it could be argued that even if the resulting list would consist in the basic components of human-well-being, that the specific content these abstract values get in the life of individual people and their relative importance may well reasonably differ from person to person (and maybe also between cultures).

The three philosophical approaches to well-being can also be found in engineering, particularly in engineering design. Several authors have argued that user value, and in particular human well-being, is created through experience and they have developed approaches to measure the experiences created by technical products and to design for certain experiences (e.g. Koskinen et al. 2003; Desmet and Hekkert 2007). Desire-satisfaction accounts are perhaps the most influential in engineering, as they fit well with economic theory and therefore with approaches that focus on adding economic value. An example is demand modeling (Cook and Wu 2001). Also approaches that focus on quality management, in particular quality function deployment (QFD) are based on a desire-satisfaction account of well-being. QFD aims at systematically taking into account user satisfaction in the engineering process by systematically translating customer demands in engineering characteristics and setting priorities amongst them (Akao 1990; Hauser and Clausing 1988). Although the method is beset with some methodological problems (Van de Poel 2007), it is a main example of how well-being conceived in desire-satisfaction terms can be taken into account in engineering.

Objective list accounts have until yet not been very influential in engineering and design. However, a number of authors have sketched how an approach based on an objective list account of well-being may guide engineering design. Van de Poel (2012) provides a general discussion on how we might design for well-being if we adopt an objective list account. Another approach may to understand the values in an objective list account in terms of human capabilities, an approach that has been especially advocated by Sen and by Nussbaum (Sen 1985; Nussbaum 2000). They developed the capability approach as an alternative to economic approaches to well-being. Oosterlaken (2009) gives some ideas about how one might design for capabilities.

2.5.3 Sustainability

Although environmental values play a role in engineering for quite some time, the last decade this has been increasingly understood in terms of the broader value of sustainability. Thus the Code of conduct of the US NSPE (National Society of Professional Engineers) states that "Engineers are encouraged to adhere to the principles of sustainable development in order to protect the environment for future generations." It is interesting that this is formulated in terms of a recommendation rather than a requirement to hold paramount as in the case of safety, health and human well-being. This suggests that sustainability is still a less generally accepted value in engineering that the aforementioned ones, although this may now be changing. As we will see below, this may be partly due to the contested character of sustainability.

The most influential definition of sustainable development has been provided by the Brundlandt commission:

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:

- the concept of 'needs', in particular the essential needs of the world's poor, to which over-riding priority should be given; and
- the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs" (WCED 1987).

It can be argued that this definition of sustainable development refers to two types of justice, i.e., intergenerational justice, as testified in the phrase "without compromising the ability of future generations to meet their own needs" and intragenerational justice, as testified in the phrase "the essential needs of the world's poor, to which over-riding priority should be given" (Brumsen 2011). It should be noted that both types of justice might conflict in particular cases. A typical example is biofuels. Biofuels are attractive in terms of intergenerational justice because they make energy resources available to future generations and they may help to abate greenhouse warming. At the same time, they compete with food crops, so contributing to increasing food prices, which may lead to an increase in malnutrition and hunger, especially amongst the world poor. From the viewpoint of intragenerational justice, biofuels therefore do not (yet) seem very attractive.

Another issue with respect to sustainability is whether should be understood in anthropocentric or in biocentric terms (Brumsen 2011). If sustainability is understood in anthropocentric terms, sustaining nature and the environment are strived for the sake of human well-being; on a bio-centric view, nature is attributed final value, i.e., value independent from human goals and human well-being. It appears to me that a plausible understanding of sustainability should somehow take into account both the sustenance of human well-being, and nature as finally valuable.

It might then be argued that sustainability is an overarching value that refers to, at least, four constitutive values: intragenerational justice, intergenerational justice, human well-being and its sustenance and nature as a final value and its sustenance. Even if one accepts that all these values are somehow constitutive for sustainability, one might disagree about the exact understanding of each of these values, as we already saw for human well-being above, and about their relative importance. Sustainability might then be understood as a "contested value" (Jacobs 1999).

Typical for contested concepts, according to Jacobs (1999), is that while there is agreement that they are valuable there is disagreement about their exact meaning and content. Engineers often seem to dislike the contested character of sustainability; it also seems to have been a reason for some engineering societies not to include it in their codes of ethics or to make it only a recommended rather than a required value as we saw in the case of the NSPE code.

One might try to overcome the contested character of sustainability, by trying to reach consensus on a generally accepted definition of sustainability. Such an approach seems me, however, illusionary as disagreements about sustainability are often disagreements about the kind of society we want to live in, and such disagreements are ineradicable in the pluralist society we live in. This does not mean, however, that we cannot take into account sustainability in engineering and design. Often engineering solutions will mainly be aimed at taking away existing unsustainability or avoiding adding new unsustainability. In many cases, agreement about what is unsustainable is much easier to achieve than agreement about what is sustainable.

As a value, sustainability is increasingly internalized in engineering practice in a number of ways. First, it plays a role in engineering trough laws and regulations, and through technical codes and standards. One might for example think of requirements for energy efficiency of devices, or requirements for heat isolation. There is also an increasing attention for what might be called design for sustainability (Bhamra and Lofthouse 2007; Birkeland 2002). Such approaches may state general design principles for sustainability, provide tools to design for sustainability, and suggest certain technical features or design concepts. There are also an increasing number of tools for sustainability in engineering, one might in particular think of various tools for life cycle analysis of products.

2.5.4 Other External Values

In addition to the aforementioned values, other external values are relevant for engineering. Some of these external values are generally relevant for engineering. Examples are justice and democracy, and inclusiveness. For such values, also approaches have been developed to give them a larger role in engineering practice. Sclove (1995) for example has formulated design principles for democratic technologies. For inclusive design, a whole range of approaches has been developed, that aim at making accessible technological products that all users, with special attention for the underprivileged, like for example handicapped people (Clarkson 2003; Erlandson 2008).

In addition to such more general external values, one might distinguish external values that are more domain-specific. A typical example is aesthetics in architecture. Friedman et al. (2006) have distinguished 12 values that are especially important in the domain of information and communication technologies (ICTs): human welfare, ownership and property, privacy, freedom from bias, universal usability, trust, autonomy, informed consent, accountability, identity, calmness and environmental sustainability.

She and her colleagues have also developed an approach for integrating such values in design: value sensitive design (VSD). Friedman and Kahn (2003) distinguish three kinds of investigations that are relevant to VSD: empirical, conceptual and technical. Empirical investigations “involve social scientific research on the understanding, contexts, and experiences of the people affected by technological designs" (Friedman and Kahn 2003, p. 1187). It is not hard to see why this is relevant: people's experiences, contexts and understanding are certainly important when it comes to appreciating precisely what values are at stake and how these values are affected by different designs. Conceptual investigations aim at clarifying the values at stake, and at making trade-offs between the various values. Technical investigations "involve analyzing current technical mechanisms and designs to assess how well they support particular values, and, conversely, identifying values, and then identifying and/or developing technical mechanisms and designs that can support those values" (Friedman and Kahn 2003, p. 1187). The second part of this assertion is especially interesting and relevant because it provides the opportunity to develop new technical options that more adequately meet the values of ethical importance than do current options.

2.6 Conclusions

My main aim in this contribution was to explore some of the main internal and external values in engineering. The treatment of these values has necessarily been somewhat cursory. Nevertheless, I think that the overview given contains some general lessons with respect to internal and external values in engineering and their relation. Internal values like technological enthusiasm and efficiency are often perceived by engineers as final. However, in a moral sense, they are usually instrumental values; they are means to achieve final values that are usually external to engineering practice. This is not to say that internal values are morally improper, but that their moral appropriateness depends on the broader, final values for which they are put to work for.

Most of the external values I discussed are final values or they are constitutive values, i.e., values that are constitutive for some final value, for example by being a part of the overarching final value, rather than by just being a means to the final value. External values seem relevant for engineering practice in at least two ways. First, they may provide part of the explanation and justification why certain internal values like efficiency are strived for in particular engineering projects. Second they may be more directly relevant in engineering practice. As we have seen they may be internalized, for example through technical codes and standards or specific engineering approaches, like Quality Function Deployment or Design for X approaches.

It is important to be aware that if external values are to play out in engineering they have to be internalized, at least to some extent, in engineering. Obviously, this process of internalization has been taken place in most engineering domains with respect to the values of safety and health; it is now also increasingly occurring for human well-being and sustainability. Domain specific values like aesthetics and privacy have also to a large extend been internalized in the relevant domains. With respect to other values and other domains, this process of internalization is often just starting.

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