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Ethics and Engineering Design

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Engineering ethics and science and technology studies (STS) have until now developed as separate enterprises. The authors argue that they can learn a lot from each other. STS insights can help make engineering ethics open the black box of technology and help discern ethical issues in engineering design. Engineering ethics, on the other hand, might help STS to overcome its normative sterility. The contributions in this special issue show in various ways how the gap between STS and engineering ethics might be overcome. In this editorial introduction, the authors discuss the various contributions briefly and delve into the way the various authors conceptualize the engineering design process and the consequences of those conceptualizations for what ethical issues become visible. They also discuss the implications for the responsibility of engineers for technological development.

Keywords: *STS; engineering ethics; engineering design; ethical issues; responsibility*

Science and Technology Studies (STS) and Engineering Ethics

Ethical issues in engineering have increasingly drawn attention in the past few years. In the United States, and recently also in Europe, this has resulted in a field of research and teaching that is now called “engineering ethics.”[1] Research in this field is mainly done by applied ethicists and by engineers.[2] Insights from STS are remarkably absent from research on engineering ethics, even though both fields could arguably benefit from each other.[3]

This lack of interaction between STS and engineering ethics might have several causes. First, engineering ethics has not shown much interest yet in opening the black box of technology. It has mainly focused on disaster cases, with the suggestion that such disasters could have been prevented by responsible behavior on the part of engineers or by whistle blowing. This has resulted in an externalist approach to technology, focusing on the outcomes of processes of technology development rather than on the internal dynamics of these processes. Another cause for the lack of interaction is that STS scholars have been shying away from explicit normative or ethical discussions. Even though they have often described the normative dimensions of technologies, they have hardly ever begun a normative discussion about them.

This special issue aims to meet the challenge of bridging the apparent gap between engineering ethics and STS. It does so by focusing on ethical issues in engineering design. Because of the externalist orientation of engineering ethics, ethical issues regarding the design of new technologies have received little attention until now. STS insights can be helpful to recognize, describe, and analyze ethical issues in engineering design, even if STS scholars have paid little attention to such ethical issues. Engineering design is one context in which ethical issues arise on a day-to-day basis and in which insights from STS and engineering ethics can be fruitfully combined.

The shifts of perspective that are required for linking both fields—from externalism toward a more internalist approach within engineering ethics and from description to normativity in STS—generate new theoretical challenges. As we will elaborate below, the process of technology design needs to be conceptualized in such a way that points of departure for ethical reflection become visible. For instance, different types of design and of organizational networks should be identified, which have an effect on the degree of ethical reflection that is possible or required in design. Also, the relationship between individual actions of designers and their institutional and social environment needs to be analyzed because such contexts enable and constrain the "moral behavior" of designers. One way to investigate this is to look at the relationship between external control and regulation on one hand and the actions and responsibilities of designers on the other. Third, ethical reflection during the design process requires anticipation of the future role of the technologies-in-design in their use context. For this anticipation, engineering ethics needs to open the black box not only of technology design but also of technology use: the mediating role of technologies in their use contexts.

Moreover, for a fruitful dialogue between STS and engineering design, another black box needs to be opened: that of ethics itself. The ethical questions to be addressed in engineering design should not simply be treated as new manifestations of the eternal questions philosophers have been trying to answer ever since Plato. They are meaningful only within the contexts out of which they emerge and can be studied and answered adequately only when they are explicitly related to these contexts. Ethical issues in and aspects of engineering design all have in common their normative rather than factual character, but when using notions such as "ethical reflection" or "moral behavior," the specific normative content of these forms of reflection and behavior should always be related to their sociotechnical context.

The articles in this special issue take up these theoretical challenges and many others, as we will elaborate below. The contributions come from many different disciplinary backgrounds: STS, sociology, engineering, philosophy, and engineering ethics. All articles move beyond the externalist perspective that is prevailing in engineering ethics and contribute to a more internalist and empirical perspective on technology development, which takes into account the dynamics of the design process itself and identifies the ethical aspects or questions arising in this context.

Mark Coeckelbergh investigates the relationship between engineering design and its sociotechnical context by focusing on codes and regulations. He analyzes two strategies used to direct the work of designers: exerting external control on one hand and leaving room for professional autonomy and responsibility on the other. Coeckelbergh argues that there does not need to exist a contradiction between the two, by elaborating the notion of "shared responsibility." This notion overcomes the dichotomy between external control, which suffocates individual responsibility, and individual responsibility, which leaves no room for external control. Responsibility for technology should not be assigned to the engineer only but also to the sociotechnical context. This brings him to conclude that institutional conditions should be created to enhance ethical decision making. In this way, regulation can stimulate the moral imagination of engineers and takes them seriously as autonomous agents, making ethics an integral part of engineering practice.

Kathryn Henderson analyzes an interesting example of "morality in action" by discussing the role of building codes in the currently reviving technique of straw bale building. Such codes appear to play an important role in the moral struggle around straw bale building between ecology-oriented values on one hand and health and safety values on the other. Henderson analyzes how building codes result from values that are articulated by the professionals with whom approval of straw bale building has been sought, from the kind of data about straw bale building that are found significant, and from the degree of persuasion with which that data have been presented. Her investigation shows how values are embedded and constructed in the everyday practices of technological innovators and societal officials and sheds light on the role of normative judgments in the development and introduction of new technologies.

Matthew Mehalik and Michael Gorman investigate possibilities to design technologies that embody positive ethics. By analyzing a case study concerning the discovery of permethrin in products from a Swiss textile dye and weaving manufacturing facility, they elaborate several strategic concepts for assessing the sociotechnical networks in which engineering design takes place and for developing appropriate moral reasoning strategies. With the help of concepts such as "chains of failure" (Chiles 2001), "structural secrecy," and "normalization of deviance" (Vaughan 1996), the authors analyze how sociotechnical networks can become susceptible to insecure situations. The concept of "moral imagination" (Werhane 1999), encompassing among others critical reflection by actors on their own role and the creative envisioning of new possibilities for action, opens a way for designers to prevent such situations. To help structure the ability to use moral imagination, Mehalik and Gorman develop a three-state framework for describing to which extent actors share a common representation of the mental models that are operational in a specific context and to which extent they are able to influence this context.

Tsjalling Swierstra and Jaap Jelsma investigate in what sense the concept of moral responsibility is applicable to the work of designing engineers. By analyzing empirical material concerning an experimental impact assessment project at a university, they show that the conditions for moral responsibility, which have been developed in moral philosophy, are seldom met in the practice of technology design. According to these standards, only in rare cases of individual whistle blowing do technology designers bear responsibility. From this, however, Swierstra and Jelsma do not conclude that the concept of individual moral responsibility is not applicable in the complex sociotechnical context of engineering design. Rather, they rethink the scope and content of moral responsibility. They maintain that normative reflection on technology development needs a concept of individual responsibility: only human actors can act responsibly and networks cannot. Their empirical analysis further shows that there is a lack of incentives for moral behavior in engineering, which is to a large degree the consequence of the specific way technology-in-the-making is organized.

Ibo van de Poel and Anke van Gorp introduce an internalist perspective on engineering ethics by investigating the relation between the need for ethical reflection in design processes and the type of design process. They take Vincenti's (1992) distinction between normal design and radical design as a dimension for classifying types of engineering design, as well as his concept of "design hierarchy," ranging from high-level conceptual design to the low-level design of parts of products. These dimensions allow them to investigate the room and need for ethical reflection in four types of design, each illustrated by a case study: radical high-level design (the Dutch-EVO lightweight car), radical low-level design (refrigerants), normal high-level design (housing systems for laying hens), and normal low-level design (piping and equipment design). Van de Poel and Van Gorp argue that ill-structured design problems (i.e., processes that are on the radical and high-level side of the spectrum) require more ethical reflection than well-structured problems, as they impose only few constraints to the activities of designers. But they also argue that the presence of such constraints in well-structured design processes does not take away the necessity of moral reflection since the availability of an adequate normative framework for making moral decisions cannot be considered self-evident.

Peter-Paul Verbeek connects STS analyses of the influence of technologies on their environment with moral decision making during the design process. He shows that by revealing the influence of technologies on human actions—"scripts"—STS has actually charged technologies with morality. Technologies appear to give material answers to the ethical question of how to act. Designers appear to be doing "ethics by other means": they materialize morality. Therefore, the notion of scripts could help engineering ethics to overcome its externalist orientation and to direct itself more directly to engineering design processes. Integrating concepts such as scripts in engineering ethics is a complex task, however. First, the ambition to design technologies with the explicit aim to influence human actions raises moral questions itself. Second, there is no direct connection between the activities of designers and the scripts of the artifacts they are designing: when technologies are in design, their scripts are not entirely predictable. Therefore, Verbeek discusses two methods for anticipating the role of technologies in their use context: anticipation by imagination in the form of a mediation analysis and an augmented version of constructive technology assessment.

In the sections below, we would like to focus on two themes that stand out when confronting STS and engineering design. First, we will discuss in what ways the various conceptualizations of the design process elaborated in the articles help to reveal specific ethical issues regarding engineering design. After this, we will investigate what the insights gained could imply for understanding the moral responsibility of designing engineers.

Ethical Issues and Conceptualizations of the Design Process

By cross-fertilizing engineering ethics and STS, this special issue aims to accomplish two things: to augment engineering ethics with a more internal approach to technology and to augment STS with a normative perspective. The articles in this issue make clear that studying ethical issues in engineering design requires insights in the process and dynamics of engineering design. All articles build on such insights, which, in most cases, are informed by approaches and empirical research from STS. STS appears to be able to enhance ethical reflection by its empirically informed conceptualization of the design process, which lays bare many points of application for moral reflection, in close connection to the specific sociotechnical context in which ethical issues arise and are recognized as such.

Two types of conceptualizations of the design process play a role in the articles. First, several authors conceptualize engineering design in terms of its relations to the wider sociotechnical environment. Both Henderson and Mehalik and Gorman use STS insights to analyze engineering design in terms of sociotechnical networks, that is, networks of actors in which technology is developed.[4] Henderson follows actor-network theory in seeing designing not only as an activity that takes place within sociotechnical networks but also as one that involves the creation of new sociotechnical networks. Designers should be conceived as "heterogeneous engineers"; the success with which they build new networks determines the success of their designs. At the same time, Henderson stresses the situated character of design. Design is grounded in particular social practices and local contingent relationships that (partly) determine the outcome of design processes. She shows that local and contingent differences between Arizona and New Mexico resulted in different perceptions of ethical values with respect to straw bale building and eventually in different decision making with respect to building standards and codes.

Mehalik and Gorman also conceptualize design as an activity that plays itself out in sociotechnical networks. They argue that the specific configuration of the network in which design takes place influences the degree of moral imagination of engineers. This implies that, apart from the specific moral issues engineers encounter, there is an important ethical question about how to shape the organizations or networks in which engineers do their job.

Coeckelbergh conceptualizes design, or more generally engineering, in relation to its wider social environment. He is especially interested in the role of the context, for example, in the form of regulation, in encouraging or discouraging moral behavior. Like Mehalik and Gorman, he is interested in ways to organize the context in such a way that the responsibility and moral imagination of engineers are enhanced.

A second conceptualization of the design process that plays a role in the articles does not concern so much the context of the design process but its cognitive structure and its relation to the role its products will play in their future use contexts. Following Akrich (1992) and Latour (1992), Verbeek conceives of design as a process of inscription: designers implicitly or explicitly inscribe certain modes of use and interaction into their products. In this way, designers can and do build moral prescriptions into their products. Verbeek's conceptualization of design leads to a whole new array of ethical questions pertaining to technical design, including questions about the right of the designers to moralize users through design.

Van de Poel and Van Gorp conceive of design problems as cognitively ill-structured problems. Nevertheless, design problems may get better structured in the course of time, both as a result of a better understanding of the design problem at hand and as a result of the sociotechnical dynamics of technological development. They argue that well-structured and ill-structured design problems give rise to different types of ethical issues and require different forms of ethical reflection on the part of designers.

By looking more carefully at the dynamics and character of design processes themselves, therefore, many insights are gained that are significant for engineering ethics. The articles show that empirical analyses of the engineering design process are not only relevant for understanding how engineers actually deal with ethical issues but also useful to discern the relevant ethical issues themselves in the first place. In fact, the articles suggest somewhat different approaches here. Whereas Henderson's article suggests an approach that looks for ethical issues by studying local practices because it is in such practices that values and ethical considerations are embedded, Verbeek's approach suggests looking into the materiality of the designed artifact itself. The articles by Mehalik and Gorman and Coeckelbergh suggest looking at the wider contexts and sociotechnical networks in which design takes place and its influence on the moral responsibility and imagination of engineers, whereas Van de Poel and Van Gorp place more emphasis on the cognitive structuring of the design process and on such issues as the formulation and operationalization of design requirements and the making of trade-offs among them.

These approaches do not exclude each other. Seeing design in terms of inscription, for example, does not exclude a view of the design process as being embedded in larger sociotechnical networks. The various contributions together, then, offer not only a conceptualization of the design process that shows points of application for ethical reflection but also a diversity of approaches to ethical issues in engineering design.

Design Processes and the Responsibility of Designing Engineers

What do the insights that were gained in the contributions to this special issue imply for understanding the responsibility of engineers? To what extent are engineers to assume responsibility and to be held responsible for the technologies they are designing and their eventual (sociotechnical) effects? Generally speaking, the responsibility of engineers depends on such factors as the latitude available for behaving in morally responsible ways and the degree to which they can actually influence the outcome of design processes and the eventual social consequences of the technology they are designing. The articles in this special issue help to better understand this latitude and influence.

To understand the role of both factors in the responsibility of engineers, it is useful to distinguish between active and passive responsibility. Passive responsibility is "responsibility after the fact" (Bovens 1998, 28). It refers to accountability for something that has occurred in the past. Whether someone can be held responsible in this sense depends on such factors as to whether there exists a causal relation between someone's actions and the outcome for which someone is to be held accountable, whether a norm has been violated in the action, and whether the person can be (morally) blamed for the action (Bovens 1998, 28-30). The causal connection requirement and the requirement of blameworthiness imply that someone's passive responsibility depends on the degree to which he or she was able to control the course of action.

Active responsibility refers to responsibility as a virtue (Bovens 1998, 32). Whereas passive responsibility is allocated after the fact, active responsibility is assumed beforehand, most often because someone feels responsible. Like passive responsibility, active responsibility is related to the degree of control someone has, but in a more complicated way. For one thing, the degree of active responsibility a designing engineer can and will assume depends on his or her freedom in acting and on the degree to which he or she can influence the outcomes of the design process. As Coeckelbergh stresses in his contribution, for people to assume moral responsibility, a certain (moral) autonomy is needed. They need to be given the opportunity to take responsibility. On the other hand, someone feeling responsible will look for the means to make a difference. In other words, the degree of control people have is not always given but often can, at least partly, be influenced by the actor him or herself.

The articles in this special issue all draw attention to specific contextual factors that determine to which extent active and passive responsibility can play a role in the actions of designers. We will discuss four of these factors. Three of these can be seen as external factors, which determine the freedom of action of designers: the technical norms and codes that designers are to follow in the design process, the division of labor and responsibilities between the designers and other actors, and the type of organization of the sociotechnical network, which determines the latitude available for designers. A fourth factor is the predictability of the consequences of the actions of designers.

Van de Poel and Van Gorp argue that in cases in which there are many external constraints—especially in what they call low-level normal design—there are fewer ethical issues that are explicitly dealt with by the designing engineers themselves. A main reason for this is that in such cases, an important part of the relevant decisions has already been made outside the design process, for example, in drafting technical norms and codes. Those engineers responsible for formulating such norms and codes, therefore, bear part of the responsibility for the technologies designed.

This, however, does not imply that no ethical reflection is needed from the designing engineers themselves in situations of normal (low-level) design. Designers should at least reflect on the question whether it is ethically acceptable to follow the normative framework that was (implicitly) set out for them. In fact, as Van de Poel's and Van Gorp's cases show, engineers sometimes deliberately choose to engage in radical designs that call into question the (ethical) assumptions of existing normal designs. An example is the designers of the lightweight car DutchEVO who call into question existing moral conceptions of car safety and sustainability. We see something similar in the case of the straw-building pioneers in Henderson's article. On the basis of ecological considerations, they choose for a radically new—though at the same time old—building technique. In both cases concerned, we can say that the designers acted out of an experience of responsibility. They looked for radical designs because they felt actively responsible.[5]

Another factor determining the responsibility of designers is the division of labor and responsibilities between the actors involved in technology development. We have already mentioned the role of engineers in drafting technical codes and norms. Interestingly, as shown in the articles by Coeckelbergh and by Henderson, the way regulations and technical codes are formulated also has an effect on this division of labor and the distribution of responsibilities. It is relevant to make a distinction between prescriptive regulation and performance or goal-setting regulation here. Whereas the former prescribes specific characteristics of a design at a detailed hardware level, the latter leaves the designers more freedom. The idea of performance or goal-setting regulation is that the regulator sets the goal or performance standard to be achieved and that the designer is free to achieve those goals as he or she thinks best.[6] As Coeckelbergh argues, goal-setting regulation leaves more autonomy on the part of the engineers and therefore tends to enhance not only the accountability (passive responsibility) of engineers but also their sense of responsibility (active responsibility).[7] In fact, goal-setting regulation also leaves more room for what Van de Poel and Van Gorp call radical design, since it does not freeze a certain configuration or specific details at the hardware level.

A third contextual factor that influences the passive and active responsibility of engineers, as the articles show, is the type of organizations or sociotechnical networks in which engineering work is embedded. This is an important issue in the article by Mehalik and Gorman. They distinguish between three types of network states: state 1 networks are strictly hierarchically organized, state 2 networks are characterized by competing perspectives mediated through common rules and regulations, and in state 3 networks, participants share mental models but have a large degree of autonomy. These three network states differ with respect to the latitude they leave to engineers and therefore also with respect to the accountability (passive responsibility) that can be attributed to engineers. Another difference between the network states, as Mehalik and Gorman argue, consists in the degree to which they foster moral imagination and therefore active responsibility on the part of engineers.

A final issue is the predictability of the consequences of the activities of designers. As Verbeek elaborates, not only designers but also users and even the technologies themselves help to determine the eventual effects and impact of technological designs. Users can employ technologies in unforeseen ways and technologies-in-use often have an unexpected influence on the perceptions and behavior of users. In such cases of unforeseen use, one might wonder whether designers bear a responsibility for unforeseen social effects, and if they do so, to what degree they do.

What is especially interesting about Verbeek's contribution is that he sees a role not only for users but also for the technologies themselves in the attribution of responsibility. The example of the seat belt can illustrate this. In general, seat belts—and comparable systems such as air bags—make drivers feel safer and may therefore well erode their sense of active responsibility for safety (both of themselves and of other people). Seat belts also influence the allocation of accountability (passive responsibility) if an accident occurs. In fact, part of the accountability is taken over by the technical system (the seat belt) and thus eventually by the designers or producers of the system because the system in itself cannot be held morally responsible neither legally liable. This means that the responsibility of designers depends not only on the social contexts in which they work but also on the products they design.

In conclusion, both the passive responsibility that can be ascribed to engineers and the active responsibility they will assume appear to depend on such factors as the external constraints and the type of regulation with which engineers are confronted, the type of organizations and networks they work in, and the type of products they design. It is, however, important to realize that none of these factors in themselves is a simple given. Engineers can decide to design a different product than originally intended, or try to remove the external constraints they face (for example by choosing for radical design). Society can strive for different types of organizations and networks in which engineers do their work. Governments and engineers can strive for different types of regulation.

Conclusion

The articles in this special issue show that engineering ethics and science and technology studies can substantially reinforce and benefit from each other.

First, it became clear that research in engineering ethics should go hand in hand with empirically informed analyses of the process of engineering design. STS research reveals myriad points of application for moral reflection with regard to the design process. The social organization of this process, the way in which design problems are structured, the input it receives from its sociotechnical context, the artifacts it produces, and the users of these artifacts all play a role in the eventual social effects of the work of engineers and in the space available for active and passive responsibility. If engineering ethics is to provide adequate answers to the moral questions raised by technological developments, it will substantially benefit from STS analyses that help to get a closer understanding of the dynamics of these developments.

Conversely, engineering ethics can help STS to broaden its focus from describing technological developments and their moral aspects to actually engaging in moral discussions. To paraphrase Kant, if engineering ethics without STS is blind, STS without engineering ethics is empty. A widespread idea within STS is that each description is in fact a normative account of reality. Seeking closer contact to discussions in engineering ethics, therefore, would allow STS to take its own normativity more seriously and to put it explicitly into practice. It would also lead to a more reflective form of normativity, instead of a normative stance that is based only on gut feeling or (implicit) tradition.

When STS scholars would engage more explicitly in ethical discussions, their contribution could be especially interesting when they would use STS insights not only to identify points of application for moral reflection but also to contextualize the ethical questions, and their answers, themselves. The STS perspective makes it possible to perform a context-sensitive form of ethics, in which normative questions are seen as intrinsically connected to the context out of which they emerge. This would, in fact, well resonate with developments in modern moral philosophy that stress the importance of contextual factors in coming to moral judgments.[8]

By investigating how specific aspects of the technology-in-design acquire moral relevance, STS can help both to formulate adequate moral questions and to find a way of answering them that does justice to the concrete setting from which these questions emerged. Synergy between engineering ethics and STS along these lines could result in an empirical and reflexive research, which is empirically informed and critically contextualizes the moral questions it is asking but at the same time does not shy away from the effort to actually answer them.

Notes

1. See, for example, Harris, Pritchard, and Rabbins (1995); Martin and Schinzinger (1996); Whitbeck (1998); and Davis (1998).

2. For a recent overview of research in engineering ethics, see Brumsen and van de Poel (2001).

3. See, however, Lynch and Kline (2000) and Goujon and Hériard Dubreil (2001).

4. Here we use a more classical definition of sociotechnical network. In actor-network theory, not only human actors but also nonhuman actors, or so-called actants, are seen as nodes

in the networks that can "act," and that can transform the network itself and translate the actions of other actors, including nonhuman actors in the network (e.g., Latour 1993). It is not entirely clear which exact definition of sociotechnical network Henderson and Mehalik and Gorman use in their articles.

5. This is not to deny that other motives may have played a role as well. Nor do we want to argue here that these engineers did the right thing from a normative point of view. We simply want to make the point that an experience of responsibility may motivate people to make certain design choices or to switch from normal to radical design.

6. In practice, it may be very hard to draft goal-setting regulation or standards that contain no prescriptive elements, as is illustrated by the examples given by Henderson. One reason for this is that it may sometimes be very difficult to define performance parameters independent from the specific hardware configuration.

7. This is an important argument for goal-setting regulation, but, as Coeckelbergh rightly stresses, the issue of prescriptive or goal-setting regulation is more complicated than that. Goals may sometimes be very difficult to measure, and goal setting requires a certain trust between regulator and regulated, which may not be realistic to expect in each industrial sector (cf. also Kirwan, Hale, and Hopkins 2002).

8. See, for example, McIntyre (1984) and Dancy (1993).

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