The Continuing Shock of the New: Some Thoughts on why Law, Regulation, and Codes are Not Enough to Guide Emerging Technologies

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Emerging technologies present special challenges for engineering education. In addition to technical education, tomorrow’s engineers and technologists need the knowledge and skills necessary to responsibly address the ethical, social, and environmental dimensions of their work. In this paper the authors argue that emerging technologies, such as nanotechnology, demand the skills of ethical analysis and judgment, coupled with ethical sensitivity, creativity, and wisdom, and that a focus on law, regulation, and codes is necessary but insufficient to guide responsible development and use of these new technologies. We do so by 1) explaining what is different about emerging technologies when compared to existing technologies and why ethics is necessary, 2) examining the functions and characteristics of law, regulation, and professional codes in engineering education and in providing guidance for practitioners, 3) arguing that law, regulation, and codes are not enough to guide practice, that this is especially true for emerging technologies, and thus engineering education must go beyond law, regulation, and codes and focus on developing skills of ethical analysis and judgment, and nurturing ethical sensitivity, creativity, and wisdom. We conclude with 4) a description of our work in developing two modular courses that include societal, ethical, environmental, health, and safety issues related to nanotechnology for undergraduates in engineering and engineering technology.

1) What is different about emerging technologies and the importance of ethics

One of the central characteristics of contemporary technological society is the ceaseless and intentional search for innovation. This is a fundamental change from earlier, pre-industrial periods of human history in which the human relationship to technology was largely either preservative (continuing existing techniques) or to treat technology as something other, magical, or divine. Contemporary residents of technologically advanced societies understand technology as a human product, and systematically seek to change existing technologies and create new ones. The development of new technologies aims to provide new material objects, new forms of efficient action, and new forms of social organization. New technologies present not only new means for existing tasks, but create new possibilities and thus new goals for human activity. This means that we have ever-new products, techniques, and goals, which consequently change individual lives, communities, nations and the international community, and nature itself. This also means that the presence of technology and constant change, intentionally sought, have come to be expected as the natural state of human existence, a taken-for-granted background condition. Additionally, new technologies have a power and a range of impacts – both spatially and temporally – greater than at any time in history, and also create situations of both great knowledge and great uncertainty.

Engineers, as architects of this new world produce products, and processes that impact, in various and differential ways, the lives of all people, and often in unexpected ways. Engineers and scientists, thus have responsibilities beyond developing and utilizing technical skills and
knowledge. Consider, for example, nanomaterials. The past decade has seen a rapid growth in the development and use of nanomaterials in everyday objects (cosmetics and socks) and specialized ones (wind turbine blades and geological sensors). Absent some clear and intentional attention to ethical concerns, engineers (similar to other professionals), and the institutions within which they work, will tend to focus on efficient performance and minimizing cost, or might avoid exploring nanomaterials out of caution. Realizing the full potential of this new technology thus demands guidance beyond the technical.

One reason to attend to ethical and social concerns is to mitigate criticism and resistance such as happened in the case of genetic research, genetic engineering, genetically modified foods, and reproductive technologies in Europe and the US during the 1970s-1990s. Another reason is that engineers and technologists have special responsibilities because of the role they play in developing and deploying new technologies. A further reason is that accreditation requirements mandate that students develop “an understanding of professional and ethical responsibility.” Additionally, as we shall review below, emerging technologies are researched, developed, and often deployed before there is any social consensus about the wisdom of those technologies. A final reason is that engineers and technologists are more than that, they are citizens, parents, children, neighbors, and so on, and thus students and practitioners have many interests beyond the technical aspects of their work.

As educators concerned about preparing future practitioners to be good engineers and good citizens, it falls to us to consider how best to encourage ethical and social awareness in our students. Considerable research suggests that courses in ethics help raise awareness of ethical issues and encourage more responsible and critical thinking and action. The most recent work suggests that ethics is best understood as internal to research, design, application, and production processes.

There are four qualities or skills that characterize an ethically mature and responsible person, a person who works not only to avoid problems but also to promote improved well-being, and it is these we wish to encourage in technologists and engineers:

- Ethical Sensitivity – awareness that the ethical dimensions of a situation, action, or institution.
- Ethical Judgment – capacity to evaluate the relevant ethical and factual decisions, to consult relevant sources of guidance, and to reach a decision about the best course of action
- Ethical Motivation – desire to follow the decided course of action
- Ethical Character – self-discipline to follow the decided course of action

As educators, the question we face is how best to encourage the development of these qualities and skills.

2) The Role of Law, Regulation, and Codes: the Compliance Approach

When faced with a question about what to do in a situation of uncertainty, individuals will seek guidance. One of our tasks as educators is to help students develop the skills necessary to seek, understand, evaluate, and implement this guidance along with knowledge of reliable and legitimate sources of such guidance. One of the more important ways we can do this is by
directing their attention to Law, Regulation, and Codes of Ethics (Professional, Governmental, and Corporate). Law and regulation are obviously closely connected – in contemporary democracies law results (primarily) from the decisions of legislative bodies and regulation is the applied guidance for following the law. Codes of Ethics sometimes have the standing of law (as in the case of state ethics codes for state employees). Additionally, laws are often justified by reference to the value or goods they promote or protect within a society.  

Laws, Regulations, and Codes are characterized by:  
- Promoting minimal standards of conduct with the aim of ensuring safety  
- A grounding in ethical principles and values (sometimes quite explicitly as in Principlism in Bioethics), but do not evaluate or contextualize those principles or values  
- Providing lists of allowable and prohibited actions, with considerably more of the second. Thus they provide guidance about what not to do, emphasizing what ethicists call our “negative duties.”  
- Sanctioning and punishment for failure to meet the standards required.  

In particular, Codes serve multiple functions, including:  
- Defining and promoting the profession’s image – internally and to the public  
- Providing support for practitioners  
- Serving as inspiration and guidance  
- Regulating behavior  
- Standardizing professional practice and communicating expectations to professionals, clients, citizens, and government.  

Law, and regulation, and professional and design codes thus will all provide some guidance to the safe and ethical development and use of new technologies. For technologies that are used in a variety of contexts by a variety of persons, “many of the ethical issues have already been identified by society.” In such a situation we find increasingly complex and useful guidance to action codified in laws and regulations that represent an emergent social wisdom, one arrived at through deliberation, trial and error, failures and successes, and political, economic and value debates. Codes of ethics also are updated in response to technological changes. Professionals and society depend on the guidance of law, regulation, and codes to deal responsibly with existing technologies. Thus helping students understand the importance of this guidance and helping them develop the skills necessary to appreciate and utilize this guidance is a necessary part of engineering education.

As demonstrated by the history of debate and the development of regulation and law and codes related to bioscience, biomedicine, and biotechnology research, law, regulation, and codes can serve to guide judgment and increase sensitivity. Considering the history of ethical abuses in biomedical research, the current situation, complex, cumbersome, and imperfect as it is, is a considerable and laudable improvement. In this example of bioethics law, regulation, and codes also serve the motivational function, although largely through the possibility of withdrawal of funding or legal and economic penalty. These are negative motivations when an agent does what is right to avoid a negative outcome and not because of the desire to pursue the good. In keeping with this, the sorts of moral characters encouraged are similarly shaped by negative
considerations – avoiding harm and penalty. This is the Compliance Approach to ethics, to think of ethics as primarily about compliance with existing explicit guidelines.33

3) Why Law, Regulation, and Codes Are Not Enough: Limits of the Compliance Approach in Nine Considerations

As discussed in Part 2, compliance is a necessary part of professional ethics. Law is necessary in any functioning and sustainable modern society. Regulation is necessary given the complexity of modern life and the dangers of failure to meet minimal standards (whether intentional or inadvertent). And Codes of Ethics, professional, governmental, and corporate, convey to employees, clients, customers, citizens, and other professionals the institutional and individual expectations for responsible actions. This guidance is invaluable, and it is a necessary first step. Nonetheless, there are limits to the guidance provided by Law, Regulation, and Codes.

1. One concern about a focus on compliance is the tendency to think of complying with existing guidelines as ethically sufficient, what has been identified as the Compliance Approach.33 This is so because law, regulation and codes: 1) are fundamentally different from ethics and largely negative devices that guide us in what to avoid but not what to do, 2) are not self-explanatory and demand thoughtful application, 3) contain conflicting and vague imperatives (“Part of the limitations of the codes of ethics is that there is no particular hierarchy of principles that govern in all situations,”19 and 4) do not cover all cases and are thus incomplete. This last is especially true when dealing with emerging technologies, as there will be considerable uncertainty about uses, benefits, risks, and other implications.

2. Another concern is the consideration that individuals will follow rules when those rules cohere with internal, or institutional values.36 So, good individuals will follow the rules, bad ones will follow them only when convenient (such as to avoid sanction or punishment). “research into the impact of codes of ethics on decisions finds little impact.”31

3. Additionally, the presence of the rules can be taken to indicate that following the rules is all that is necessary, along with the view that understanding what the rules means is a straightforward matter of reading. This cultivates “the Ethic of Technical Compliance”56 which focuses narrowly on meeting the letter of the law, regulation, or code as written and considers neither the larger context nor the goals of the law, regulation, or code.

4. Some research indicates that the greater the level of publicity about an ethics code in any given context“ without adequate attention to the quality of communication, its content, and embeddedness by management, the higher the frequency of observed unethical behavior.”26 So, the existence of codes, laws, and regulations rather than serving to increase responsible action can, in some contexts, actually encourage unethical activity.

5. Practitioners have a considerable challenge addressing the technical demands of their work, thus limiting time, energy, and willingness to engage in what might be seen as an external task – ethical evaluation and judgment. Work by a multidisciplinary work group and the Association of Industrial Engineers of Valencia (Colegio Oficial de Ingenieros Industriales de Valencia) found the compliance approach inadequate under these circumstances. One instantiation of this was the low participation of engineers in developing a new set of ethical guidelines even when most believed the existing compliance approach was inadequate.33
These first five considerations are in many ways relevant to all instances of using law or regulation or a code to guide beliefs and actions on the ethical and social dimensions of technology. The last four considerations all revolve specifically around the newness of emerging technologies.

6. One concern is that precisely because of the newness of emerging technologies, existing law, regulations, and codes will fail to provide guidance. For example, European Union groups have advised using existing regulations for nanotechnology. But, nanotechnology has unprecedented properties, is often hybrid in composition and thus not easily classified, crosses boundaries of mechanics, biology, and chemistry and present the potential to enter and enable technologies in many other areas (including medicine, information, energy, and environmental). There is also considerable scientific uncertainty about nanoparticles and risk assessment is very difficult. A minute change in the dimension of a particle can change its behavior from benign to dangerous. Thus, “nanotechnology outcomes are not properly addressed by existing laws,” which tend to create artificial size groupings.

7. Going further, analyses of the structure and nature of contemporary science and technology, and of its effects show that because of the power and scope of contemporary science and technology, existing guidelines and ethics may be inadequate to provide guidance for novel technologies.

8. The penultimate concern is that when addressing emerging technologies is a regulatory burden, when law or regulation overreach and place unnecessary burdens on research and development of new technologies. Again, consider nanotechnology. Given the newness of the research, regulators do not have adequate knowledge to craft reasonable regulations and are likely to make regulations that restrict research and advancement or create regulations that are not possible to follow. This was for many years true of guidelines for federal funding of stem-cell research in the United States. As one scholar notes, “[a] strong legal restriction on basic research in nanotechnology, which the regulators could only formulate based on guesswork, could potentially eliminate findings which might be valuable starting points for applied, follow-up research.”

9. Finally, the guidance of law, regulation, and codes typically emerges out of a social consensus that is rarely present when addressing emerging technologies and their implications. This is so in large part because of the uncertainty present. In early stages the uncertainty is about precisely what uses or devices will be developed, in later stages there is uncertainty about how new devices and process will be accepted, how they will be used, and what effects they will have. In light of these uncertainties, there cannot be a social consensus about emerging technologies. This also means that practitioners cannot turn to settled social views about the work for support or guidance.

In contrast to Laws, Regulations, and Codes, Ethics is characterized by: Promoting more than minimal standards of conduct with the aim of encouraging considerations of what is good and most desirable. Ethics thus is aspirational and includes also Positive Duties.
- A reflexive relation to ethical principles and values, with the goal of better understanding, refining, and justifying underlying concepts, ethical principles, and ethical values.  
- In some cases providing good grounds for judging some law or regulation or section of code to be unethical or unjust, providing grounds for discussion and possible change.  
- The sanctions of ethical failure or success are praise and blame within a profession or community and by one’s conscience.

Attention to the social and ethical dimensions of engineering and technology is necessary, and limiting this to law or regulation or codes will leave practitioners without sufficient guidance. Engineers need to nurture ethical sensitivity, creativity, and wisdom, and practice skills of ethical analysis and judgment. Together, these provide an ethical toolbox for dealing with novel situations. Research shows that students typically enter a course focused on ethical and social dimensions of nanotechnology with an attitude of guarded optimism about the new technology. It turns out that they tend also to leave the course with an attitude of guarded optimism, but now based on better information and more sophisticated reasoning.  

By incorporating these nine considerations into courses addressing the ethical and social dimensions of emerging technologies we can help prepare students to deal responsibly with technological change in conditions of uncertainty.

4) Our Project

Under a grant from NSF, we are developing, implementing, and assessing two modular courses that include societal, ethical, environmental, health, and safety issues related to nanotechnology for undergraduates in engineering and engineering technology. The work is being conducted by a highly interdisciplinary team of faculty who bring to the project expertise from mechanical engineering, manufacturing engineering, civil engineering, electrical engineering, industrial education and technology, physics, biology, philosophy, and ethics. The team also has hands-on experience in industrial research management. Not only is our project multidisciplinary, it is multi-institutional.

Our project starts with the notion that ethical and social responsibility (and here we include safety, health, and environmental considerations, among others) is an integral part of the practice of engineers and technologists. Shaping engineering education with this idea in mind is attentive to the role of identity in what people do,  
and can serve to provide intellectual, conceptual, and narrative resources to assist professionals as they navigate their work world. Engineering, similar to other professions, has a language,  
and that language frames how practitioners think of themselves and their work. As Korte notes in a 2013 study, “the developing professional identities of new engineers are reflected in the narratives they construct regarding who they are and how they fit in to the profession and their work.” Thus, people make decisions about what is appropriate to do based, at least in significant part, on our conceptions of who we are as professionals. Our curricular approach allows the introduction of both preventative and aspirational ethics, illustrated as part of the practice of engineering. Preventative views of ethics treat ethics as settled, as after-the-fact, and as aiming to prevent problems.  
Aspirational ethics focus on improving human well-being. By helping students understand that ethical issues emerge
in the regular practice of engineering, and that the good engineer does more than avoid problems, we can provide students with tools to be more responsible professionals.

We have developed two courses – a lower-level undergraduate course that focuses on ethical and social issues in nanotechnology, and an upper-level course that furthers the considerations of ethical and social issues with a greater emphasis on risk and safety and compliance. The courses are modular in construction and are currently offered as full courses on-line (at the University of Texas at Tyler) and by infusing modules into existing face-to-face courses (at Texas State University). In the face-to-face infusion, modules are presented in differing formats and detail with from one to four 80-minute class periods devoted to a single module. The modules are inserted in courses including a required 1-hr University Seminar (a fairly typical 1st-year experience course that introduces students to the university), a required Ethics and Society Course, a 2nd-year course in Materials Engineering, and a required Senior Design course. The on-line course is directed not only to engineering and technology students, but also to industry and regulatory professionals.

One hallmark of the materials developed is to highlight the special challenges posed by the newness and uncertainty of nanotechnology, and the necessity of cultivating ethical sensitivity. We introduce a framework for ethical evaluations and decisions that is modeled on the design process, thus helping our students understand that responsible decisions and actions can be better achieved through an intentional method – in ethics as in design. The framework focuses on the presence of value conflicts in design, execution, marketing, usage, and so on. The Framework presents discrete steps in evaluation and decision-making aimed at resolving value conflicts in a reasonable way. The course materials also present ethical, social, safety, health, and environmental issues as internal to research, development, and production of nanotechnologies, thus presenting framing ethical and social responsibility as integral to the pursuit of technological advance and the many positives it will bring. In this way, as students consider the technical aspects of the aspirations and hopes found in the pursuit of new technologies, they are also encouraged to consider the ethical, social, health, safety, and environmental dimensions as well.

Because of the diversity of materials, the differing modes of presentation, and the varied course contexts, we will use multiple forms of assessment. Students complete assessments for each module, as well as for full courses, thus providing immediate and detailed feedback as well as more holistic responses. They also have quizzes and short-essay homework assignments for each module, providing additional data. At the end of each semester (at both UT-Tyler and Texas State), an external evaluator reviews student assessments and conducts student focus-groups to derive additional information about the successes and shortcomings of each module. Additionally, the module development is assisted by consultations with a Nanotechnology Advisory Council (NAC) comprised of leaders from academia and industry. The NAC provides feedback throughout, beginning with initial curricular development and continuing as assessment data is obtained from students and from reports by the external evaluator.

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