The European Proceedings of
Social & Behavioural Sciences
EpSBS

Future Academy ISSN: 2357-1330

http://dx.doi.org/10.15405/epsbs.2017.07.02.30

RRI 2016
International Conference «Responsible Research and Innovation»

ENGINEERING ETHICS AND THE FUTURE

Elena V. Fell (a)*, Natalia A. Lukianova (a,b), Aleksandr K. Lukianov (b)

*Corresponding author

(a) Tomsk Polytechnic University, Lenina 30, Tomsk, 634050, Russia, elena.fell@ntlworld.com, 8(38-22)60-63-33
(b) Tomsk State University, Lenina 36, Tomsk, 634050, Russia, rector@tsu.ru, 8(38-22) 529 585

Abstract

Responding to the demands of the technology-driven global economy, engineers increase their technical competencies, improve cross-cultural communication skills, and become more innovative, entrepreneurial and flexible (Continental, 2006). As the demands on the engineer are increasing and the role of an engineer evolves and becomes more prominent, the importance of teaching engineering ethics to engineering students is increasing too. This article investigates current trends in the teaching of engineering ethics in the context of diverse approaches to evaluating the responsibility of an engineer. The article reveals the complexity of the issue, which confirms the need for future engineers to be competent in dealing with ethical dilemmas. The engineer must be aware of the fact that his or her invention will initiate a chain of events that will involve the use of this invention and will have various social, environmental and legal ramifications, which should be taken into account. The engineer must also be sufficiently prepared to make ethical decisions without sufficient guidance, as the full range of possible future scenarios cannot be foreseen.

Keywords: Engineering ethics, professional ethics, engineering practice, future engineers, moral neutrality of technology.

1. Introduction

The term ‘engineer’ can be traced to the Medieval Latin verb ‘ingeniare’ (to design or devise) which is derived from the Latin word ‘ingenium’ (clever invention) (Katehi et al., 2009). The broadness of this original concept correlates with the broadness of the term ‘engineer’ in the contemporary English language. Merriam Webster's Collegiate Dictionary defines engineer for example as ‘a person who has scientific training and who designs and builds complicated products, machines, systems, or structures: a

http://dx.doi.org/10.15405/epsbs.2017.07.02.30
Corresponding Author: Elena V. Fell
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

person who specializes in a branch of engineering' ("Engineer." Dictionary). Engineering practice, broadly conceived, consists in solving problems by finding practical solutions based on specialized knowledge as '[u]nlike scientists, engineers are tasked with being change agents (Sheppard et al., 2006).

2. Methods

What are the specific features of engineering ethics and what are the directions in which it is developing in the twenty-first century? The aim of this article is to capture the essence of the current debate that contextualizes the teaching of engineering ethics to future engineers. Using desktop research as a method of this enquiry, the authors identify current conceptual and methodological concerns regarding the key principles of engineering ethics and confirm that the complexity of the issue is likely to increase in the future.

2.1 What is engineering ethics?

National Society of Professional Engineers (NSPE) lists 19 specific branches of engineering: Aerospace, Agricultural, Biomedical, Chemical, Civil (General & Structural), Computer, Control Systems, Electrical & Electronics, Environmental, Fire Protection, Geotechnical, Industrial, Manufacturing, Mechanical, Mining, Nuclear, Petroleum, Sanitary, Traffic (NSPE: Essential Resources for Engineering Success, 2006).

Practicality and empirical concreteness characterise engineering practice regardless of a specific branch. Engineering ethics, therefore, is largely concerned with the practical impact that engineering practice makes on society and the world.

As part of their professional training engineering students are required to study engineering ethics focusing on specific challenges that engineers face as professionals. Engineering ethics is concerned with such issues as preventing disasters; professional misconduct; improving lives of people via technology; understanding the codes of ethics of specific engineering professional societies; possible conflicts between common morality and professional ethics. Students become aware of the ways in which their actions as practising engineers could affect the public in connection with globalized standards for engineering and such concepts as sustainability and acceptable risk (Harris et al., 2013).

2.2 Engineering practice in the future

Students' training involves the use of ethical theories as models that aid in predicting future events, but the teachers of future engineers face the challenge of preparing them for the future that may be very different from what we know. This will be the future which new engineers will be constructing themselves, and which may bring unforeseen moral challenges.

'Raise the Bar for Engineering' (a resource for engineers) identified 14 challenges that the new generation engineers will face worldwide. They are as follows: make solar energy economical; provide energy from fusion; develop carbon sequestration methods; manage the nitrogen cycle; provide access to clean water; restore and improve urban infrastructure; advance health informatics; engineer better

http://dx.doi.org/10.15405/epsbs.2017.07.02.30
Corresponding Author: Elena V. Fell
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

medicines; reverse-engineer the brain; prevent nuclear terror; secure cyberspace; enhance virtual reality; advance personalized learning; engineer the tools of scientific discovery (The future engineer, 2016).

The National Academy of Engineering formulated a number of guiding principles that, according to NAE estimate, will guide engineering practice in the future: accelerating pace of technological innovation; increased global interconnectivity; diversity and multidisciplinarity of technology makers and users; political, cultural, social, and economic influences on technological innovation's success; increased use of technology in people's everyday lives (*The Engineer of 2020: Visions of Engineering in the New Century,* 2004) .

The role of an engineer in society will become increasingly important and thus will require a strong commitment to societal good as well as profound competence in professional ethics.

2.3 Moral properties of engineered technology: is technology morally neutral?

Contemporary discussions of moral problems specific to engineering include the question of the moral neutrality of technology per se. At the conference on ethics education in Poland "Ethical Education/Ethische Bildung/Edukacja etyczna" Łódź, 27-28/05/2016, this issue was raised in connection with preparing future engineers for developing responsible technologies.

The thesis of the moral neutrality of technology is the following. Technology is neither good nor bad, and it is the way we use it that matters (Huesemann, & Huesemann, 2011). For example, a gun is itself morally neutral and it is up to the user whether it would be good or bad (Green, 2001).

Langdon Winner contests the thesis of the neutrality of technology by claiming that technology is invested with implicit scenarios that determine the relationship between the maker and the user. The maker's intention is realised via the user's involvement in technology: for example, as the user gets into a car, he or she becomes a driver, which in turn changes his or her perspective on the environment. The user's being a driver was intended by the maker of the car. Winner 'identifies certain technologies as political phenomena in their own right' where by politics he means 'arrangements of power and authority in human associations as well as the activities that take place within those arrangements' (Winner, 1980).

One could illustrate Winner's position and contest the neutrality of a gun per se by drawing on Chekhov's gun example. The playwright's advice 'If a gun is hanging on the wall in the first act, it must be fired in the last' (Burt, 2008) refers to the realisation of the dramatist's intentions lodged in the hanging of the gun and actualized in subsequent acting carried out by actors. Chekhov's remark that links the intention of the scripter and the subsequent actualization of this intention by other people could be extended to the reality beyond theatrical performance and the pretend use of a replica gun. If a real gun hangs on a real wall in a real life situation, it contains within itself the potentiality of it being discharged by someone, which has been lodged in it by the person who had placed the gun there. Moreover, the lodging of this potentiality into the gun can be traced back to the gun's manufacturer and further back to its primary creator – the engineer. The engineer does not design a gun as some object of indefinite or unspecified use but as a specific tool intended for specific function, and when the gun is used, the intention of the engineer merges with the intention of the gun user who discharges the weapon in order to kill.

http://dx.doi.org/10.15405/epsbs.2017.07.02.30
Corresponding Author: Elena V. Fell
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

2.4 Distributed moral responsibility versus individual responsibility

The discussion of the moral neutrality of technology focuses on the issue of personal responsibility and the assumption that an individual, either engineer or user, is responsible for the outcome of the use of technology. The concept of distributed moral responsibility resolves the problem of individual responsibility by diluting it. The idea of distributed moral responsibility accounts for situations where various agents, both human and artificial (such as software platforms) may jointly produce a distributed moral action that can result from the sum of morally neutral actions (Luciano, 2013), and the same could be said about events surrounding the creation and use of weapons.

According to Doorn, & van de Poel (2012), engineering ethics is a more complex field than general ethics because general ethics is usually concerned with an individual making moral choices. As the authors note, 'engineering and technology development typically take place in collective settings, in which a lot of different agents, apart from the engineers involved, eventually shape the technology developed and its social consequences' (Doorn & van de Poel, 2012). Moreover, 'engineering and technology development are complex processes, which are characterized by long causal chains between the actions of engineers and scientists and the eventual effects that raise ethical concern' (Doorn & van de Poel, 2012). Also, 'social consequences of technology are often hard to predict beforehand' (Doorn & van de Poel, 2012). Doorn (2012) considers these difficulties and examines concepts of responsibility applicable to engineering ethics. The author welcomes the recent tendency in engineering ethics to move away from the blame-oriented vision of responsibility (or merit-based vision of responsibility) and develop a forward-looking perspective to technological research. She also finds that the consequentialist perspective on engineering practice is most effective whilst making an ethical choice (Doorn, 2012). Coeckelbergh (2012) applies Kierkegaard's concepts of tragedy and moral responsibility to tragic consequences of technological actions arguing that when ascribing responsibility in engineering contexts, society should account for the lack of control on behalf of an individual, uncertainty of the future and other factors such as role conflicts, tragic choice and social dependence. The author does not suggest that individual or corporate responsibility should be evaded but rather encourages sensitivity in approaching these issues. Coeckelbergh reinstates the concept of tragedy in technological processes and experiences of technology. However, he does not refer to the acceptance of fate but 'to the dynamics between, on the one hand, the experience of fate, luck, and contingency and, on the other hand, how we respond to these events and experiences as beings that are free and in control to some extent' (Coeckelbergh, 2012).

Coeckelbergh rejects the idea that technological processes can be fully controlled in principle and calls for the understanding that complete control cannot be achieved and we should accept that suffering is eventually inevitable due to this lack of control.

Davis (2012), however, is suspicious of considering responsibility in engineering practice in this way. He warns that when we explain what happened by impersonal causes such as fate, system, society (or in engineering practice, by technology and organization) this creates opportunities for avoiding personal responsibility altogether. The author argues that engineers, like everyone else, should face responsibility for their actions (Davis, 2012).

http://dx.doi.org/10.15405/epsbs.2017.07.02.30
Corresponding Author: Elena V. Fell
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

2.5 Teaching engineering ethics

Future engineers study engineering ethics and consider ethical dilemmas associated with engineering practice during their professional training. As Harris et al. state, 'Engineering ethics is part of thinking like an engineer. Teaching engineering ethics is part of teaching engineering' (Harris, Davis, Pritchard & Rabins, 1996). However, engineering ethics education is not a straightforward process as it involves dynamic topics and student audience is diverse.

Li, J. & Fu S. (2012) claim that the complexity of engineering ethics education has not been sufficiently addressed and propose to tailor engineering education programs to the context-specific needs of engineering students according to their engineering discipline.

Kisselburgh et al. (2014) recommend a different approach in their paper published by American Society for Engineering Education. The authors propose a pedagogical framework that involves 'scaffolded, integrated, and reflexive analysis of ethics cases to enhance the development of moral reasoning that extends beyond case-based analyses'. Rather than narrowing the discussions down to discipline specific cases, Kisselburgh et al. favour a method that can be implemented across disciplines.

Conlon, & Zandvoort (2011) are concerned that engineering ethics teaching programs consider engineers exclusively as individual agents whilst ignoring the social environment that contextualizes their work.

Aközer, & Aközer (2016) call for the introduction of philosophical ethics as a component of science and engineering curricula. The authors believe that the philosophical consideration of the virtuous would enable and enhance future professionals' autonomous principled moral reasoning and safeguard them against potential indoctrination (Aközer, & Aközer, 2016). In a previous paper, the same authors argue against a "no ethics" principle in science and in favour of drawing on the value of human dignity as the principle that should govern science ethics (Aközer, &Aközer, 2015) the value of human dignity as the principle that should govern science ethics (Aközer, & Aközer, 2015).

2.6 Using case studies for teaching engineering ethics

The following is a sample selection of case studies used to teach engineering ethics to future engineers in the Department of Philosophy and the Department of Mechanical Engineering (Texas A&M University).

In the 'Aberdeen Three' case, students learn about engineers working in the Aberdeen Proving Ground in Maryland developing chemical weapons who handled, stored and disposed of hazardous waste inappropriately. By doing so, they violated the Resource Conservation and Recovery Act from 1983-1986 and subsequently convicted. This case demonstrates legal consequences for failing to fulfil engineers' responsibility towards society and environment as well as growing concern over toxic waste. Although this case is specifically useful for environmental engineering students, it can be used across engineering disciplines.

Is it acceptable for an engineer to receive an inexpensive pen as a gift from the vendor? Most people may think that it is. On the other hand, most people may think that accepting substantial gifts is not acceptable. However, how do you draw the line between what is permissible and what is not? Senior-

http://dx.doi.org/10.15405/epsbs.2017.07.02.30
Corresponding Author: Elena V. Fell
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

level engineering students explore scenarios of receiving gifts from vendors in the ‘Accepting Gifts and Amenities’ case.

The ‘Gilbane Gold’ case explores a hypothetical scenario of a young engineer discovering that his company discharges lead and arsenic into the public sewer system. The engineer is caught between his obligations to this company and to the public. This case can be beneficial for environmental engineering specifically, and generally for all engineers as it deals with an engineer’s obligations as a company’s employee and as a professional who has a duty to the public.

The ‘Kansas City, Missouri Hyatt Regency Hotel Walkways Collapse’ case links accuracy and detail in engineering and demonstrates the disastrous consequences of failing to observe accuracy when revising shop drawings. This case, particularly useful for structural designers, depicts the collapse of the Kansas City Hyatt Regency walkways leaving 114 people dead and over 200 people injured. The negligence occurred because of communication failure between an engineering design firm, a fabricator, and the contracting engineering firm (Engineering ethics).

3. Results and Conclusion

Having reviewed recently published research and we find that an engineer’s relationship with the future is complex. Engineering practice is essentially future orientated as the engineer develops objects that are intended to exist and be used in the future. By creating new technology the engineer initiates a chain of events associated with the use of this technology and he or she must balance the need for creation and innovation with ethical demands for safety and sustainability. Making an ethical choice sometimes is not straightforward and, given the diversity of theoretical approaches to the evaluation of the role of an engineer, in some situations the engineer may have to make ethical decisions without sufficient guidance. The professional world is rapidly changing and scenarios that engineering students study today may be outdated by the time the young professionals face real life situations. Future engineers may have to *author* their ethical decisions if faced with unprecedented circumstances that their teachers cannot anticipate now, therefore unable to offer specific guidance. However, a firm grounding in professional ethics and being informed about the complexity of the current debate should prepare engineering students for unforeseen challenges in the future. This will be possible if students specifically strive to improve their abstract reasoning. Philosophy training would be beneficial too as Aközer, & Aközer (2016) suggest because it would empower engineers with the understanding that by engaging in complex communication practices involving the creation of new technology they participate in cultural and societal meaning making rather than been carried forth by established and stable societal practices and traditions (Lukianova & Fell, 2015).

Acknowledgements

RHSF Grant Number 15-03-00812a.

http://dx.doi.org/10.15405/epsbs.2017.07.02.30
Corresponding Author: Elena V. Fell
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

References

Aközer, M. & Aközer, E. (2016). Ethics Teaching in Higher Education for Principled Reasoning: A Gateway for Reconciling Scientific Practice with Ethical Deliberation. *Science and Engineering Ethics*, 1–36 . Retrieved from URL: http://link.springer.com/article/10.1007/s11948-016-9813-y

Aközer, M., & Aközer, E. (2015). Basing science ethics on respect for human dignity. *Science and Engineering Ethics*. 1-21. Retrieved from URL: http://link.springer.com/article/10.1007/s11948-015-9731-4

Burt, D.S. (2008). The Literature 100: A Ranking of the Most Influential Novelists, Playwrights, and Poets of All Time, Infobase Publishing.

Coeckelbergh, M. (2012). Moral Responsibility, Technology, and Experiences of the Tragic: From Kierkegaard to Offshore Engineering. *Science and Engineering Ethics,* 18(1): 35–48. Retrieved from URL: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3275727/

Conlon, E., & Zandvoort, H. (2011). Broadening ethics teaching in engineering: Beyond the individualistic approach. *Science and Engineering Ethics, 17*(2), 217–232. Retrieved from URL: http://link.springer.com/article/10.1007%2Fs11948-010-9205-7

Davis, M. (2012). "Ain't no one here but us social forces": constructing the professional responsibility of engineers. *Science and Engineering Ethics,* 18(1):13-34. Retrieved from URL: http://www.ncbi.nlm.nih.gov/pubmed/20686869

Doorn, N. (2012). Responsibility Ascriptions in Technology Development and Engineering: Three Perspectives. *Science and Engineering Ethics.* March 2012, Volume 18, Issue 1, pp 69–90. Retrieved from URL: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3275746/

Doorn, N., & van de Poel, I. (2012). Editors' Overview: Moral Responsibility in Technology and Engineering. *Science and Engineering Ethics*, 18(1), 1–11. Retrieved from URL: http://doi.org/10.1007/s11948-011-9285-z

Engineering ethics. Introducing Ethics Case Studies Into Required Undergraduate Engineering Courses Department of Philosophy and Department of Mechanical Engineering. Texas A&M University. Retrieved from URL: http://ethics.tamu.edu/Portals/3/Essays/ethics.tamu.edu_ethics_essays_professionalism.pdf

Green, L. (2001). Technoculture: From Alphabet to Cybersex. Crows Nest: Allen & Unwin.288

Harris, C.E., JR., Davis, M., Pritchard, M.S. & Rabins, M. J. (1996). Engineering Ethics: What? Why? How? And When? *American Society for Engineering Education*, 1996, 85 (2), 93. Retrieved from URL: http://course.sdu.edu.cn/G2S/eWebEditor/uploadfile/20131018102817410.pdf

Harris, Jr.C.E., Pritchard M.S., Rabins, M. J., James, R. & Englehardt E. (2013). Engineering Ethics: Concepts and Cases, Cengage Learning; 5 edition.

Huesemann, M. H. & Huesemann J.A. (2011). Technofix: Why Technology Won't Save Us or the Environment, "The Myth of Value-Neutrality", New Society Publishers, Gabriola Island, British Columbia, Canada, 235-241.

Katehi L., Pearson G., & Feder M. (2009). Engineering in K-12 Education: Understanding the Status and Improving the Prospects. Retrieved from URL: https://www.nap.edu/read/12635/chapter/1

Kisselburgh L., Zoltowski C.B., Beever J., Hess J.L, Iliadis A. J. &Brightman A.O. (2014). Effectively engaging engineers in ethical reasoning about emerging technologies: A cyber-enabled framework of scaffolded, integrated, and reflexive analysis of cases. 121 *ASEE Annual Conference and Exposition*, Indianapolis, IN, June 15-18, 2014. Retrieved from URL: https://www.asee.org/public/conferences/32/papers/10074/download

Li, J. &Fu, S. (2012). A Systematic Approach to Engineering Ethics Education. *Science and Engineering Ethics.* June 2012, Volume 18 (2), 339–349. Retrieved from URL: http://link.springer.com/article/10.1007/s11948-010-9249-8

Luciano, F. (2013). Distributed Morality in an Information Society. *Science and Engineering Ethics* 19 (3):727-743 Retrieved from URL: http://link.springer.com/article/10.1007/s11948-012-9413-4

Lukianova N. & Fell E. (2015). Meaning Making in Communication Processes: The Role of a Human Agency. *Procedia - Social and Behavioral Sciences*, 200, 614–617.

http://dx.doi.org/10.15405/epsbs.2017.07.02.30
Corresponding Author: Elena V. Fell
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

Merriam-Webster. "Engineer" Dictionary. Retrieved from URL: http://www.merriam-webster.com/dictionary/engineer

NSPE: Essential Resources for Engineering Success, (2006). Retrieved from URL: https://web.archive.org/web/20060522214617/http://www.nspe.org/media/mr1-faqs.asp

Sheppard, S., Colby, A., Macatangay, K. & Sullivan, W., (2006). What is Engineering Practice? *The International Journal of Engineering Education*, vol. 22, no. 3, p. 431, June 2006. Retrieved from URL: http://www.ijee.ie/articles/Vol22-3/02_ijee1751.pdf.

The Engineer of 2020: Visions of Engineering in the New Century. National Academy of Engineering. Washington, DC: The National Academies Press. (2004), doi:10.17226/10999. Retrieved from URL: https://www.nap.edu/read/10999/chapter/1#xi

The future engineer (2016). Retrieved from URL: http://www.raisethebarforengineering.org/future-engineer.

Winner, L. (1980). Do Artefacts Have Politics? *Daedalus*, Modern Technology: Problem or Opportunity? 109 (1), 123. Retrieved from URL: http://innovate.ucsb.edu/wp-content/uploads/2010/02/Winner-Do-Artifacts-Have-Politics-1980.pdf