From engineering to bioengineering: towards an ethical turning point

*P. du Jardin**
Gembloux Agro-Bio Tech, University of Liège, Avenue Maréchal Juin, Bât. 48, 5030 Gembloux, Belgium
**E-mail: patrick.dujardin@uliege.be*

Abstract

The identity of engineers can be defined in historical, sociological, epistemological or deontological terms. Depending on the countries, it appears that the ethos of professional engineers stems from either a tradition of 'state engineers' educated in state engineering schools, or from the free association of practitioners trained by their peers and creating professional orders regulating their profession. Whatever the pathway for making engineers, they appear to adhere to ethical values typical of industrial modernity, pursuing the public interest by relying on scientific and technical progress, considering the techniques as instrumental, artefacts having functions and values limited to their utilities; in this perspective the moral world is anthropocentric, the natural environment providing the resources needed for human health and welfare, within the capacities of ecosystems. In some countries, the term "bioengineer" has been coined to refer to curriculums in the field of agricultural or biological engineering. In order to facilitate the ecological transition, should the ethics of bioengineering be different from that of 'traditional' engineering, as outlined above? The following changes, promoting an 'ethical turning point', are proposed for discussion: (1) regarding living beings – from organisms to ecosystems- as autonomous and complex systems, substituting the aim of 'controlling nature' by the aim of dealing with the intrinsic, dynamic processes of nature (*i.e.* as in agroecology and 'regenerative' agriculture); (2) seeing the components of the natural environment as partners and not as resources; (3) thinking over the temporality of human development by considering the temporality of biodiversity and its preservation, and not only in terms of intergenerational solidarity between human beings; (4) substituting the anthropocentric outlook by bio- and ecocentric ones; (5) embedding technical objects, devices and algorithms into a new 'techno-eco-humanism', making artefacts relational objects with some degree of 'agency'. Although bioengineers should to be prone to adopt such a new ethical stance, we propose that they pave the way to a change in the culture of engineering as a whole, capable of meeting the challenges of global change, as well as the expectations of new generations of engineers.

Keywords: code of conduct, ecological transition, living systems, technology

The ethos of engineers

There are different ways of defining the professional engineer: in historical and sociological terms by describing the origin of the name, profession and title, in epistemological terms accounting for a particular way of 'thinking', and in deontological terms addressing 'codes of conduct' adopted by associations of engineers. Altogether, they will make up the *ethos* of the engineer, his/her identity within society.

According to the French '*Centre de Ressources textuelles et lexicales*', the word engineer comes from the old French *engigneor*, which names the manufacturer of war engines in the XIIth century. The word *engigneor* would itself come from the Latin *ingenium*, which describes the natural attribute of something, *e.g.* for a human being, his unique capacity to make use of his intelligence for the design of artefacts. During the

M.F. Giersberg, B. Bovenkerk and F.L.B. Meijboom ***Back to the future***
EurSafe 2024 – DOI 10.3920/978-90-0471-550-9_57, © Brill | Wageningen Academic 2024

Renaissance, the use of the word engineer was extended to a profession of experts in military and civil arts, promoting the power and magnificence of the royal and papal courts of these times.

A milestone in the professionalization of engineers was the creation in Europe of dedicated schools of professional engineers, responding to the expansionist and mercantilist policies of the nation states from the 17^{th} century. These schools did provide highly qualified 'state engineers', promoting industrialization, colonization of oversea territories and international trade. Nowadays, such schools still graduate engineers with legally recognized titles. To a certain extent, they maintain the elitist heritage of the former schools, e.g. by their auditing by certifying authorities.

Yet, not all countries have endorsed such a culture of state engineers like in France or in Belgium. In UK and in North America, the profession as a social category originated from the self-organization of associations of engineers, which are primarily practitioners educated by their peers in the realm of industry. Canada is a good example, where Orders of engineers have been established in some provinces, with a regulatory power over their members (Didier, 2015a,b).

The profession of engineers has also epistemological grounds, which is beyond the scope of this short paper (reviewed in Christensen *et al.*, 2015). In brief, engineers do not aim at delivering a universal knowledge of the universe, but localized solutions to local problems. Thereby following Aristotle in his Metaphysics, saying: 'actions and productions are all concerned with the individual; for the physician does not cure man, except in an incidental way, but Callias or Socrates or some other called by some such individual name, who happens to be a man' (Aristotle, 2001). As pointed out by Newberry in Christensen *et al.* (2015), this results in engineering concentrating 'on the local and the specific. Localization manifests itself in two primary ways in engineering, one circumstantial and the other methodological.' Circumstantial localization means 'particularity' – the solution applicable here and now does not say much about its applicability in other contexts -, while methodological localization calls for a reductionist approach. 'In order to cope with real world complexity and uncertainty, engineers invariably isolate, subdivide, and simplify', as written by Berry in Christensen *et al.* (2015).

According to Picon (2007), these epistemological grounds, together with the mission of state engineers, have converged to some 'more general connivance between engineering culture and technocratic ideals.' Technocracy is defined by this author as 'the tendency to give precedence to technological competence over political legitimacy, to rational administration over the hazards of public debate'. Although the word was coined in the USA during the first half of the 20^{th} century, the corresponding attitude can be traced back to the historical foundations of engineering as defined above.

In conclusion, we attempt to summarize the ethos of 'traditional' engineers in a few words: the engineer develops contextualized solutions based on a reductionist knowledge of the systems involved, encouraged by public policies and by economic interests, supporting the ideal of social and economic progress of industrial modernity.

It should be acknowledged that this view is inherited from the past and that many young engineers today certainly do not find themselves in this description.

From ethos to ethics, the 'codes of conducts' of professional engineers

Professional associations of engineers have adopted 'codes of conducts', which are important components of their identity. What do we find in these documents?

In Europe, 'Engineers Europe' (formerly FEANI), the European federation of national engineering associations, has adopted a position paper on Code of Conduct of Professional Engineers in 2006 (Box 1). This statement of the federation acknowledges the convergence of the codes of conducts of their national associations, leading to a so-called 'universal statement regarding the conduct of professional engineers'. This short statement is usefully completed by the guidance and recommendations provided by national associations, and we provide the URLs of three of them, from France, Belgium and UK in box 1.

Taking all this information together, three sets of ethical requirements and abilities can be distinguished, which make up the identity of professional engineers. The first one refers to professionalism. The engineer shall ensure a high level of competence, the maintenance of this competence throughout his career, and transparency about the tasks for which he/she is competent or not. The second ethical requirement is about integrity, the quality of the relationships and communication with employers and stakeholders, including respect of confidentiality and avoidance of conflicts of interests. The third one is about responsibility towards society and the environment, having regard to the fact that 'the decisions and actions of engineers have a large impact on the environment and on society. The engineering profession thus has an obligation to ensure that it works in the public interest and with regard for health, safety and sustainability'. This statement is indicated by FEANI as the 'Ethical principle' introducing all provisions of the framework statement itself.

From engineering ethics to bioengineering ethics

The codes of conducts can be seen as collections of norms, which they primarily are, but they also point to values subtending the ethical stance of engineers. From the reading of the codes of conducts, we would like to put forward the following interpretations:

1. the public interest should be sought by maximizing the ratio between beneficial / adverse effects of technology;
2. engineers aim at controlling the systems they act upon by making them predictable and calculable;
3. technology is instrumental in an anthropocentric world;
4. the natural environment is seen as resources, the boundaries of human action being set by the maintenance capacity of ecosystems (homeostasis and resilience);
5. responsibility is directed towards future generations, which deserve access to the same natural capital we have inherited from our parents.

Box 1. Codes of conduct of engineering associations

European Federation of National Engineering Associations

FEANI position paper on Code of Conduct: Ethics and Conduct of Professional Engineers
approved by the FEANI General Assembly on 29 September 2006

<u>Ethical Principle</u>

The decisions and actions of engineers have a large impact on the environment and on society. The engineering profession thus has an obligation to ensure that it works in the public interest and with regard for health, safety and sustainability.

<u>Framework Statement</u>
(...)

Individual engineers have a personal obligation to act with integrity, in the public interest, and to exercise all reasonable skill and care in carrying out their work. In so doing engineers:

- Shall maintain their relevant competences at the necessary level and only undertake tasks for which they are competent
- Shall not misrepresent their educational qualifications or professional titles
- Shall provide impartial analysis and judgement to employer or clients, avoid conflicts of interest, and observe proper duties of confidentiality
- Shall carry out their tasks so as to prevent avoidable danger to health and safety, and prevent avoidable adverse impact on the environment
- Shall accept appropriate responsibility for their work and that carried out under their supervision
- Shall respect the personal rights of people with whom they work and the legal and cultural values of the societies in which they carry out assignments
- Shall be prepared to contribute to public debate on matters of technical understanding in fields in which they are competent to comment

Codes of Conduct

The pan-european statement on engineering ethics and conduct presented above is best implemented through the codes issued by national engineering associations. These codes can, and in general already do, incorporate the listed objectives in a form which reflects national circumstances and allow additional objectives to be added as required by national practice.

Codes of conduct of national engineering associations:

In UK: Engineering Council and Royal academy of engineering (2014). Statement of ethical principles for the engineering profession
https://www.engc.org.uk/media/2337/statement-of-ethical-principles-2014.pdf

In France: IESF (*Société des Ingénieurs et Scientifiques de France,* formerly CNISF, *Conseil National des Ingénieurs et Scientifiques de France*). (2001). *Charte éthique de l'ingénieur*
http://home.iesf.fr/offres/doc_inline_src/752/150731_Charte_ethique.pdf

In Belgium : FABI, *fédération des associations belges d'ingénieurs civils, d'ingénieurs agronomes et de biongénieurs. L'éthique de l'ingénieur à l'aube du XXIe siècle* (consulted on March 21st 2024)
https://www.fabi.be/l-ingenieur-charte

Bioengineers are engineers educated in life sciences, agricultural and environmental sciences, and this wording has been adopted over the recent years by various curriculums related to biological engineering, including agricultural sciences, biotechnology, and related fields. In this article, bioengineering encompasses agricultural and biological engineering.

Living systems have unique properties making biological engineering a distinct discipline within engineering. Thus, living systems are:

1. autonomous, self-organized and self-replicating;
2. they combine invariance with mechanisms of genetic changes, making them capable of Darwinian evolution;

3. they are 'non-optimized' systems, accommodating some 'noise' in the way they process information, as well as a degree of functional redundancy, which are essential aspects of their evolutionary capacity;
4. they are metastable systems, deviated from thermodynamic equilibrium, thereby storing free energy used to perform work;
5. they are multi-level, hierarchized systems (molecules building cells, building tissues, etc.), with emerging properties at each level, making them typically complex systems.

Not only are living systems special playgrounds for the bioengineer, but the public health and environmental crises of our times highlight the intricacy between human welfare and our living environment — cf. the climatic disorders, the pandemics, etc.- lending substance to the increasingly popular concept of 'One health'.

The question is now: is the ethical stance of 'traditional' engineers adapted to the new challenges of biological and environmental engineering? Considering the special features of living systems on one hand and the moral attitude of 'traditional' engineers outlined above on the other hand, we would like to propose an ethical turning point for bioengineers.

Thus, the following ethical tenets are proposed for discussion:
1. to regard living beings – from organisms to ecosystems- as autonomous and complex systems, substituting the objective of 'controlling nature' by the aim of dealing with the intrinsic, dynamic processes of nature (*i.e.* as in agroecology and 'regenerative agriculture');
2. to consider the natural environment as partner and not as resource. Components of the ecosystems are recruited as suppliers of ecological functions, which become production factors for a so-called 'ecological intensification of agriculture'. For example, synthetic pesticides are substituted by natural biological agents controlling pests and diseases, and synthetic fertilizers are substituted by microorganisms increasing the availability of soil nutrients to plants;
3. to think over the sustainability of human development by considering the temporality of biodiversity and its preservation, and not only in terms of intergenerational solidarity between human beings. In situ preservation of biodiversity needs timeframes which allow the intrinsic dynamics of living communities to operate. In such a framework, biodiversity is not preserved as a static, steady-state entity, but is actually amplified by promoting its own evolutionary capacities;
4. to substitute the anthropocentric outlook by bio- and ecocentric ones. The center of moral values is not mankind, but living beings and ecosystems, regarded as 'teleonomic centers' for which there is a 'good' and a 'bad' for their own sake. Mankind is expected to benefit from this moral perspective in the long term;
5. to embed technical objects, devices and algorithms into a new 'techno-eco-humanism', making artefacts 'relational objects' (following the French philosopher Gilbert Simondon, 1958). Our instruments are not only instrumental, but integrate into human cultures, where they acquire a certain level of 'agency'. Human beings should accept them as such, away from the technophilic attitude regarding artefacts as mere enhancers of human capacities, as well from technophobic attitudes considering that man has become the instrument of his instruments (following the critics of 'technicism' by the French philosopher Jacques Ellul).

Conclusions, from bioengineering ethics (back) to engineering ethics

The ethos and the ethics of engineers are rooted in their historical, sociological and epistemological grounds. This engineering culture seems to be hardly adapted to the challenges raised by the ecological transition in the context of the global change. To this aim, our understanding of living systems brought about by modern biology and ecology, and their 're-valuation' by environmental philosophies should help develop a new engineering. This engineering would revisit our interactions with living beings, but also with our own artefacts, inside the complexity of ecosystems. Bioengineering is expected to pioneer this ethical stance, but, as a liaison between engineering and biological sciences, it is hoped to pave the way for all engineering disciplines.

References

Aristotle. Metaphysics. B.I, Ch I. §9. In Aristotle. (2001). The basic works of Aristotle. The Modern Library, New York, NY.

Christensen, S.H., Didier, C., Jamison, A., Meganck, M., Mitcham, C. and Newberry, B. (2015). Engineering Education and Practice in Context, Volume 2. Philosophy of Engineering and Technology 21. Springer, Berlin.

Didier, C. (2015a). Ethique de l'ingénieur – Un champ émergent pour le développement professionnel. Techniques de l'Ingénieur. Ref AG102 V1.

Didier C. (2015b). Engineering Ethics: European Perspectives. In: Holbrook, J.B. (ed.) Ethics, science, technology, and engineering: A global resource, Vol. 2, 2nd edn. Macmillan Reference, Farmington Hills, MI, pp. 87–90.

Picon, A. (2007). French Engineers and Social Thought, 18-20th Centuries: An Archeology of Technocratic Ideals. History and Technology. 23: 197-208.

Simondon, G. (1989). Du mode d'existence des objets techniques, 3ème édn. Aubier, Paris. (English translation available 'On the Mode of Existence of Technical Objects', translated by Malaspina, C. and Rogove, J., 2017).