

Education and Skills

(Engineering the Energy Transition)

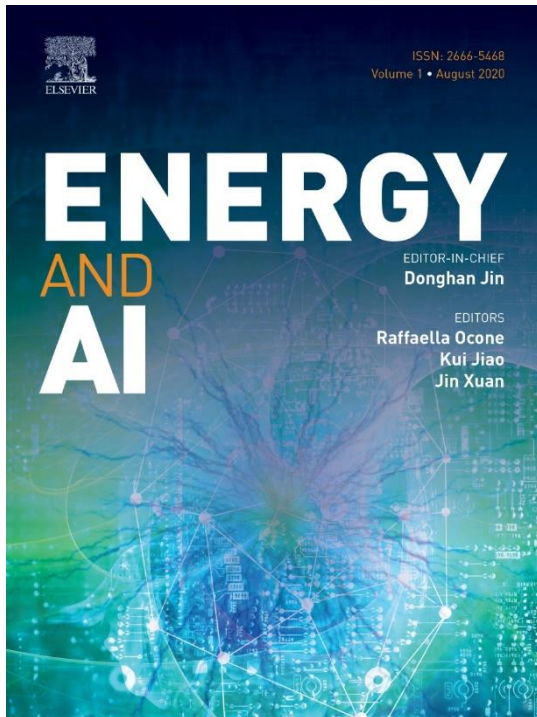
Raffaella Ocone

Chemical Engineering

School of Engineering and Physical Sciences

Heriot-Watt University, Edinburgh

Tianjin, Jan 2020 –Launch of a new Journal



- Automation of science discovery related to energy materials and chemistry
- Digital twining or big data analytics of complex energy processes/systems
- Data-driven design of energy materials, devices and systems
- Internet-of-things and cyber-physical energy systems
- AI for human factors in energy related activities
- Virtual reality applied to energy and environment
- Autonomous systems for energy efficiency maximalization
- Hardware for data collections in energy systems
- Data Science for energy applications
- Hybrid data-driven and physical modelling for energy related problems
- Intelligent control of energy systems
- AI, energy and society
- AI safety, reliability and ethics within energy applications
- AI for life-cycle assessment or energy and decarbonization roadmaps
- Energy robotics

It is not only about technology!

The Challenges of the 3rd Decade of the XXI Century

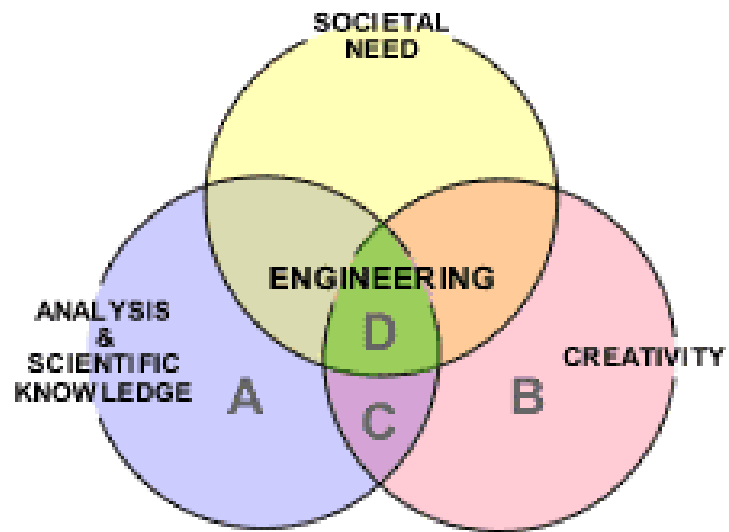
- **Pandemic**
- **Climate Emergency**
- **AI**
- **Energy security**
- **Cobots**
- **Quantum Computers**
- **Extended reality**
- ...

**COLLABORATION & SYSTEM APPROACH
WORKING WITH POLICY MAKERS
DIVERSITY & INCLUSION
TRAINING**

The Engineer

“Scientists discover the world that exists; engineers create the world that never was”

Theodore von Karman, Aerospace Engineer



Expert or Generalist?

Fox or Hedgehog?

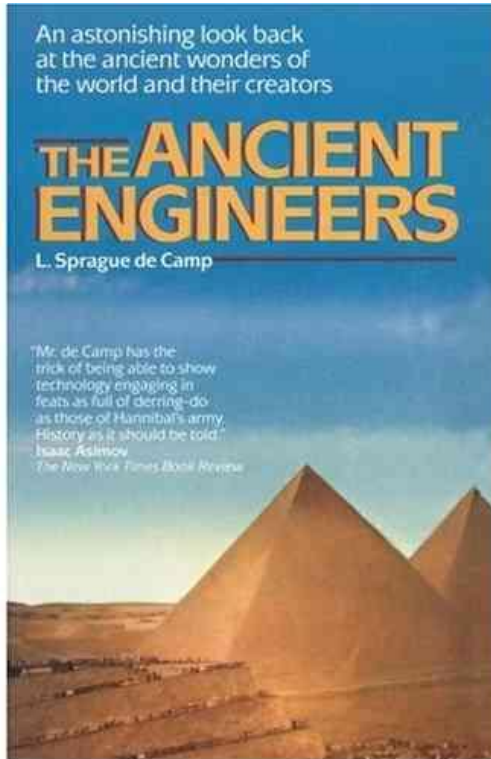


“The fox knows many things; the hedgehog knows one big thing.”

—Archilochus 8th Century BC



The “Ancient” Engineer



“Civilisation is a matter of power over the world of nature and skill in exploiting this world. It has nothing to do with kindness, honesty, or peacefulness.”

“No doubt it would be a good thing if they were universal, but the engineer is not the man to ask this of.”

“He can heat your house, dam your river, or build your space ship, but it **is hardly fair to expect him also to make you love your fellow man.**”

Programme Outcomes



- Knowledge and understanding of the mathematics, sciences, engineering sciences and technologies underpinning engineering
- The ability to identify, formulate, analyse and solve engineering problems
- The ability to design components, systems or processes to meet specific needs
- The ability to design and conduct experiments and to apply a range of standard and specialised research tools and techniques
- Understanding of the need for high ethical standards in the practice of engineering, including the responsibilities of the engineering profession towards people and the environment
- The ability to work effectively as an individual, in teams and in multi-disciplinary settings, together with the capacity to undertake lifelong learning
- The ability to communicate effectively with the engineering community and with society at large

21st Century (my personal analysis)

- **1st Decade**

- "Converging Technologies for Improving Human Performance" (CTIHP) (2002)

- Nanotechnology
- Biotechnology
- Information Technology
- Cognitive Science

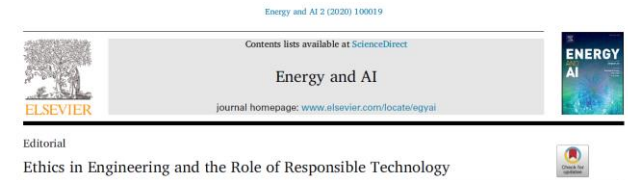
- **2nd Decade**

- Sustainable Development Goals
- Emerging Technologies

- **3rd Decade** (and beyond)

- Responsible Technologies

- (Transhumanism?)



The idea of writing an Editorial on Responsible Technology sprung from the plenary lecture that I gave at the *The First International Conference on Energy and AI* in Tianjin, China, where this Journal was launched. It was January 2020 and it was only a few weeks before a major shock hit the world: nobody could have predicted the approach of a pandemic that would affect the lives of every single person in the world. Has the pandemic changed what I wanted to say in my Editorial? Probably, yes. Undoubtedly the pandemic has reinforced the relevance of technology. We all are living in unprecedented times and we all share similar challenges: never as at this time have the effects of globalisation been so imprinted upon everyone. All those, like me, working from home, are probably spending a good amount of their time attending online meetings. Even those who do not work from home, are likely encountering many IT platforms such as Zoom, Teams, Skype, as new ways of communicating with friends and family. The latest figures show that Zoom alone is handling over 200 million users daily and this figure is certainly destined to increase. This is only one example. Robotics, health screening, logistics are a few additional examples of how technology is affecting our everyday lives. And, whilst I recognise that my work today would not be possible without the current technological developments, I cannot but note the high importance of some unwanted and unforeseen consequences of this same enabling technology. We should all be aware of such consequences and work together towards avoiding them or managing them effectively.

In the last two decades I have been interested in studying the role of ethics in engineering (e.g., [1–3]), advocating that ethical considerations must permeate every technological activity. Ethics should not be simply “bolted onto” engineering and technological activities, but rather it should be systemic, i.e. integrated in the way we operate as engineers, technologists and scientists. Those considerations lead naturally to the relevance of responsible technology as an aspect that must affect and be embedded in any activity that involves technological research, development and innovation.

In this Editorial, in order to introduce my considerations on responsible technology, I start by recalling briefly my personal idea of ethics in engineering [1–3] and I will explore specifically the relationships between ethics and technological innovation. I am not a philosopher and I do not know philosophy in depth, nevertheless, philosophy has helped and influenced my thoughts on ethics and, less intuitively, on technology (this is also a call for a more holistic approach to engineering).

Although my considerations concern technology in general, “Energy and AI” should be mentioned in the specific, given the aims of this Journal. The climate emergency will continue influencing the energy arena, the deployment of established low carbon technologies and the development of new technological solutions. Hopefully the “Energy and AI”

Journal will become the natural platform to publish and debate research in the ethics of Energy and AI.

1. Engineering Ethics: action vs analysis

Ethics in engineering is not a new concept. Indeed, codes of conduct have always been a central aspect of the engineering profession and *professionalism* implies ethical behaviour. Ethics in engineering often leads to ethical dilemmas which, in turn and inevitably, might be reminiscent of bad practice and engineering disasters. This is unfortunate and is based on a very limited vision of engineering ethics. Previous work [4–5] has argued that ethics in engineering is quite different from ethics in philosophy. This is because in philosophy ethics is about *analysis*: it is about understanding an ethical theory and dispassionately comparing its application to an ethical problem. In contrast, engineering ethics is about *synthesis*. The engineer has to find ‘solutions’ to ethical problems (i.e. the best “right” courses of action). The engineer is embedded in the process rather than standing outside of it, as is the case for a philosopher. Hence, engineering ethics should be exercised in the various contexts in which the ethical dilemmas may arise, with a focus on making ethical decisions rather than analysing ethical theories. To me, this suggests a similarity between engineering and medical ethics.

I have argued [5] that ethics in engineering goes behind synthesis alone; it is more than just the ethical dilemmas and the application of ethical principles. Ethics in engineering coincides with the social aspects of engineering and, in this respect, it is very similar to the interpretation that the ancient philosophers gave of philosophy, which was seen as coinciding with social life itself. The connection between this ancient view of practice and philosophy is a fairly recent development; classical societies such as the Greeks and Romans attributed great importance to practical behaviour which was considered the same as ethics. Hegel defined the ancient Greek world as the era of *voluntary* ethics where the individuals lived in immediate symbiosis with their community: only successively, with the advent of theories about individualism, was the link between the individual and society weakened. Nowadays, we tend to identify *culture* with thinking; the philosophical schools of the past rejected the consideration of philosophical activity as purely intellectual, theoretical and formal, considering philosophy as a choice influencing life in its totality. The philosopher did not teach only how to talk and think but also how to live in the most complete sense. Ethics was not just a concept, but rather a form of action, i.e. acting in and for the society. This is the lesson that we should keep in mind when teaching and exerting engineering: engineers must integrate the technical aspect of their jobs with the social aspect of life. The engineer is a practical individual who operates within and for the society; their ethical behaviour cannot be disconnected from their profession, and the two seemingly separate issues are the same in their essence.

<https://doi.org/10.1016/j.egyai.2020.100019>
2666-5668/© 2020 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license.
(<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

Global Humanitarian Challenges



Need to **embed** D&I in ALL SDGs.
Each goal (or challenge) implies engineering and science solutions and products.
There will be the need for more digital skills.

Climate Change and AI

- **AI's relevance to help tackle and fight climate change is undiscussed** (e.g., enable smarter decision-making for decarbonising industries and transportation; understand how to allocate renewable energy; etc.)

HOWEVER

- **Ethical concerns are become more and more relevant** and those are linked largely to the machine-learning technology:
 - Public surveillance
 - Intentional misuse of data
 - Privacy
 - Transparency
 - Data bias that can lead to discrimination and inequality

Artificial Intelligence

- ***A pervasive, enabling technology*** → its consequences will affect various areas and disciplines, the environment, the human being...
- **Already widely in use**

Do we understand AI and its implications?

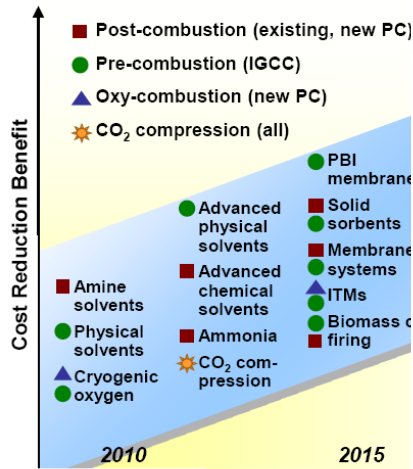
If handled carefully, AI could bring excellent opportunities for the wealth and security of our society

HOWEVER

IT IS ALREADY HERE (and the totality of ethical issues associated with it are not completely understood and tackled)

REGULATION and **EDUCATION** still in need

A Technological



Time to Commerce

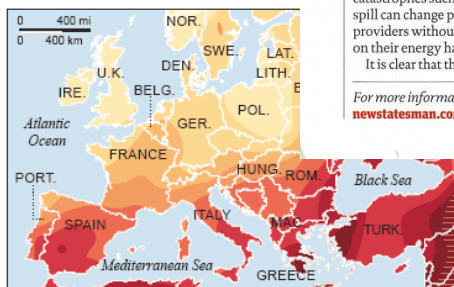
Reproduction rights obtainable
www.CartoonStock.com

Ethical Fix

Oppressive heat settles in

Officials warned citizens, especially the elderly, to drink plenty of water during the summer's searing heat.

Temperature, Wednesday, 10 a.m. EDT



NOTE: Average temperatures from highest to lowest elevation

SOURCE: Weather Underground

AP

Perspectives on Energy

What is the future of consumer energy demand?

Changing behaviours

Governments, activists and scientists are united on one fact: consumer behaviour is key to creating energy efficiency. But studies have found that only about 20 per cent of people are willing to change their behaviour. How can the other 80 per cent be engaged?

When policymakers first launched energy efficiency campaigns around 30 years ago, they focused on educating consumers and encouraging them to cut back. Over the years, this has been refined, with standards for energy-efficient appliances and new buildings introduced. Yet, despite such moves, energy consumption continues to grow in both absolute and per capita terms.

A big problem is getting people who already lead busy lives to change their behaviour. In these straitened times, a large

Telling people they consume more energy than their neighbours makes them more likely to take notice

group of consumers is struggling financially and does not think about the future.

In such circumstances, obligatory higher prices are not an attractive way of getting people to change their habits. Moreover, studies show that hikes must be substantial before the average consumer starts to notice. The focus is now shifting to alternative methods, including peer pressure.

Psychological studies have shown that people are influenced by comparison. Thus, telling people that their energy consumption is higher than their neighbours' makes them more likely to take notice and make a change.

Psychological methods of this sort address the basic problem that it is difficult to get people to engage. With something as invisible as gas or electricity, most consumers do not make the direct connection between their personal energy usage and the distant spectre of climate change. Thus, huge catastrophes such as the Gulf of Mexico oil spill can change public perceptions of energy providers without having a knock-on effect on their energy habits.

It is clear that there are big challenges ahead.

For more information on Perspectives go to: newstatesman.com/energy



THE EXPERT

“Behaviour doesn’t happen in a vacuum”

Dr Sarah Darby, deputy programme leader, Environmental Change Institute, Oxford University

Do most energy customers still need to be persuaded that cutting energy consumption is worth all the bother?

They don't on the whole think in terms of cutting energy consumption, they think in terms of the way they live their lives. And if their bills are getting really high – and they are, of course, for a lot of people – then that's a worrying thing. They will start to be motivated when they begin trying to get those bills down.

So the real motivation is when people realise they want to save money?

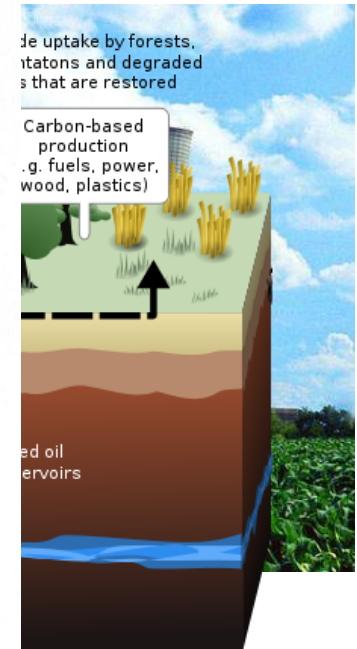
For a lot of people it is. For other people, they

may just be thinking about the way they live their lives and the impact they have on the environment. Motivations differ, but what is often missing is how those two link up.

Perhaps we should simply encourage people to turn the lights off when they leave the room?

Well, it certainly helps... but behaviour doesn't happen in a vacuum; behaviour happens in particular buildings in particular places.

From a transport point of view, for example, you can walk across the road to your village shop, or you may have to drive ten miles into the nearest town once that shop closes. If you



Learning about the Social Issues helps Engineering Students to:

- Be able to **identify** the social element of any decision that they are called to make
- **Understand** the nature of professional and personal responsibility
- Be able to **address** problems arising from questionable practice
- Develop critical thinking skills and **judgment**
- **Understand** practical difficulties and use suitable approaches and techniques to help people produce better outcomes
- **Develop** an ethical identity to carry forward to their working life

The Advantages of an Integrated Teaching Approach

- Opportunity for the students to see the “hard” engineering core in action
- The social aspect is presented as intrinsic in the discipline; it demonstrates as Engineering is an ethical profession in its essence

Ethical Consideration: *a posteriori* approach

➤ Ethics is about Synthesis

- Finding “*solutions*” to ethical problems (the best course of action)
- Making use of previous “data”

The engineer is embedded in the process
being prepared for dealing with specific kinds of ethical problems
that will arise in real practical situations
They evaluate and direct a greater set of existing phenomena

Ethics in the context of making a practical decision

The ethics of entrenched technologies can lead to better informed
ethical evaluations

Ethical Consideration: *a priori* approach

- **Ethics is about Synthesis**
 - Finding “*solutions*” to ethical problems (the best course of action)
 - Making use of *speculative* “data”

Based on research and development of the technologies, redirection possible on the basis ethical assessments

Ethics can help at the development stage of the technology, however the limitation is making use of speculative data

Ways of teaching

- Look for ways to incorporate the social aspects of engineering into the existing curriculum – approach social issues laterally
- Use case studies and role play to illustrate and explore dilemmas
- Allow students to discover for themselves – through role play and debate
- Involve multidisciplinary teams, including **philosophy, sociology, politics**
- Invite practising engineers to speak – bring social issues to life
- Aim at developing skills, rather than teaching rules

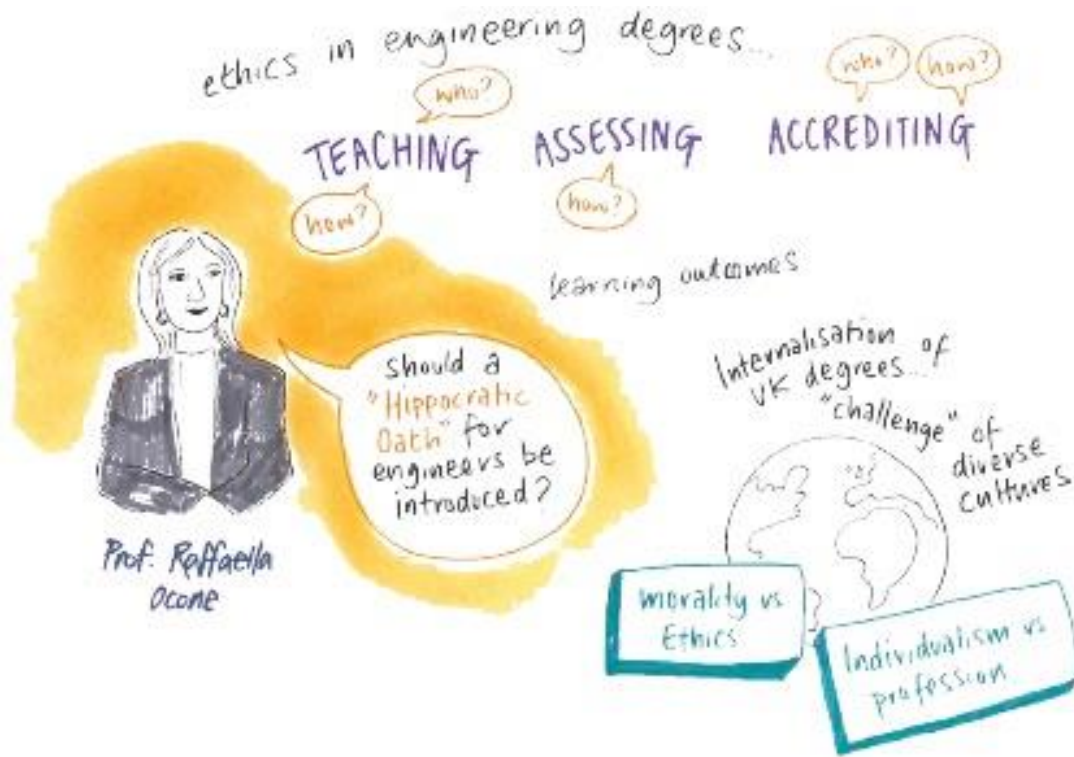
Multicultural student groups

- Students on engineering degrees often come from a variety of different cultures and backgrounds
- Consider how familiar students are with debating issues in the classroom – don't assume all students will easily engage in debate
- Take language into account in assessment – don't rely on long essays which may be challenging for overseas students
- Try to make assessment varied and fair for all students

Some opportunities (accelerating the pace)

- More “synergetic” efforts
- More diversity of ideas and skills
- More support for re-skilling and training
- More opportunity for gig-work
-

**The pandemic has shown that we can
accelerate the pace -e.g., vaccine
development, ventilators challenge, etc..**



Thank you!

