Chapter 23
The De-contextualising of Engineering: A Myth or a Misunderstanding

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Abstract Engineers impact on how people live, where they live, and the physical environment in which they live. The interaction between society and engineering has a long history but it remains both complex and problematic. Complex because of the many factors involved including the political and economic dimensions. Problematic because it is not always clear how individuals, groups of individuals or society at large negotiate with engineers to ensure the right 'product' is created. One of the ways engineering deals with the problem is through context – the set of circumstances in both the foreground and background of any project. Understanding what counts as valid context and then formulating appropriate responses is something that is encountered to varying degrees first in educational programs and then through multiple processes as engineering is practiced. Some of these processes have legislative force and others are established as best practice. Ethics as the basis of making sound decisions is directly related to how contexts once understood result in appropriate action. And in that sense engineers reflect the norms of the society in which they work.

Keywords Context • Context awareness • Context sensitivity

Introduction

> Do the right thing. It will gratify some people and astonish the rest. (Mark Twain)

To do the 'right thing' one must understand and be responsive to the context surrounding whatever enterprise is being undertaken. But it is neither easy to understand fully what constitutes a context that is relevant to a particular situation nor is it always obvious how to take that context adequately into account. Like any other

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S.H. Christensen et al. (eds.), *Engineering Identities, Epistemologies and Values*, Philosophy of Engineering and Technology 21,
DOI 10.1007/978-3-319-16172-3_23

practical profession, such as medicine, engineering is continually faced with the challenge of addressing context. It is not unreasonable to say that the majority of engineers aim to meet the twin objectives of ‘doing the right thing’ and ‘doing it right’. In the latter case, ‘doing it right’, the challenge is essentially a technical one of working within a set of constraints be they legal, financial or of a scientific and technological nature. In the former case, ‘doing the right thing’, is in many respects more complex and often contentious. One only need mention a few examples to demonstrate this last point. Nuclear power stations have had an uneven history as regards their public acceptability; wind farms with numerous tall turbines, despite following a green or sustainability agenda, are not always welcomed in a rural community; fracking by which shale gas is retrieved is a current hotly contested matter in many countries; devices and equipment for military purposes such as cluster bombs and anti-personnel mines face ethical questions. All of these examples and more raise the issue of whether the ‘right thing’ is being created or produced. As a counter another list of ‘things’ that have high public acceptance with little or nothing in the way of controversy could include: medical devices; rehabilitation engineering; restoring vision or hearing; low-energy or green buildings; improved access to clean water and better sanitation; safer transport systems. These and many more would support but not necessarily prove the proposition that the ‘right thing’ has been developed. A number of questions immediately spring to mind. Who decides what is right as in giving approval to the development or creation of ‘the right thing’? Stating that it depends on the context is only part of the answer. And in any case, what might be considered ‘right’ in one context may well be thought wrong in another context. Context, then, is identified as the critical factor in determining whether or not a work of engineering is deemed appropriate and right, assuming in the first place the adequacy of all the associated technical aspects of the undertaking. Two points need to be stressed here. First, in the practical world of engineering there is no simple and satisfactory way of drawing a boundary around what constitutes context. Second, there is obviously a difference between the context considered at the time of design and implementation, and a more complete context that only emerges in time. It is not just a question of unintended consequences: value systems change with time and what appeared reasonable at one time can be found to be unacceptable later. Before proceeding some definition needs to be established as to what is meant here by context.

Context, from the Latin *contextus,* means a joining together or connection. So in a given text the passage leading up to a particular word establishes a background by which a fuller understanding of the use of that word can be achieved by the reader. In this chapter context is taken to be the circumstances constituting a background in which something, largely engineering in nature, is to be placed. The circumstances, or set of circumstances, are potentially anything but typically would include the following: economic, social, cultural, political, and environmental factors together with ethical considerations. Time is an additional factor: for example circumstances involving famine, war, drought or any major adverse event inevitably change what might otherwise have been a settled context.

Because engineering impacts on our physical world it must always be situated within a context: engineering cannot be context free. It follows then that the profession is obliged to address the many challenges associated with the set of circumstances surrounding a given engineering event – be it positioning a new bridge, opening a new runway at an airport, locating a new hospital, or installing alternative energy systems such as wind farms. The central questions asked in this chapter focus on the degree to which engineering is sufficiently context sensitive and context responsible. An intriguing question not asked nor answered is whether engineering is better or worse in this respect compared to other professions such as architecture, medicine and law. The book *Engineering in Context* (Christensen et al. 2009) demonstrates the complexity of the subject of its title and not surprisingly offers diverse views. The main themes in the book are: Contextualism in Engineering, Engineering Education in Context, Engineering Design, Engineers in workplaces and institutions, and Engineers in Civil Society. Joseph Herkert claims that engineering codes of ethics focus on microethical (individual) responsibilities but are weak on macroethical (collective) responsibilities (Herkert 2009). And the more general charge has been made that engineering has become de-contextualized. Indeed it is claimed that 'engineers are often unaware of, and sometimes even trained to explicitly ignore, the broader contexts of their work' (Fisher and Miller 2009; Bucciarelli 1994). This might well be the case in some instances but such training runs counter to what is expected of engineering educational programs as discussed later in this chapter. In terms of ethical behavior or duty, closely related to addressing issues of context, there is the perceived duty of engineers, *plus respicere*, which can be broadly interpreted to mean 'go the extra mile' and thus take more into account (Mitcham 1994).

Another initial point that can be made is that individuals work within social environments, including their workplace, and their response to context will inevitably vary according to the circumstances. On the matter of the individual as distinct to the corporate engineer, Li Bocong examines a micro-meso-macro framework and in which ethical stances can be understood and hence positioned with respect to general issues of context (Li Bocong 2012). From a very different perspective Christelle Didier has explored the intersection between religious and political values and their transformation into an engineering ethos (Didier 2012). What is abundantly clear is the complexity of how an engineer, just as any other citizen, develops a worldview from which ethical stances evolve together with an understanding of the relevance of context in whatever situation they are faced.

To unravel the strands of the central question posed the remainder of this chapter looks briefly in turn at types of engineering educational programs, value systems in engineering, identification of grand engineering challenges, the role of professional institutions and academies of engineering, and text books in attempt to gain a understanding of how engineers and engineering address context. In addition some views are expressed as to how dialogue between society and the engineering profession can be enhanced and formalized when it comes to major undertakings.

Engineering Education

Undergraduate engineering programs exist within a wide orbit of models each of which in principle is eligible for approval by accreditation bodies based on published criteria that include amongst other items program learning outcomes. A number of authors have commented on the highly constrained nature of engineering curriculum where there is pressure from all quarters to accommodate additional material and not just technical subjects (Williams 2002). So it could be expected that context like any other aspect of engineering has to be specially pressed if it is to have adequate exposure. It is instructive then to examine the extent to which context is explicitly or implicitly included in the learning outcomes defined for engineering programs. Institutions of engineering have promoted the global harmonization of program learning outcomes and for the purposes of this chapter the work of the European Network for Accreditation of Engineering Education is used (ENAEE 2009). The Network authorizes accreditation and quality assurance agencies to award the EUR-ACE® label to accredited engineering degree programs (EUR-ACE 2008). Within the EUR-ACE standards framework document there are six sets of learning outcomes as follows:

- Knowledge and Understanding
- Engineering Analysis
- Engineering Design
- Investigations
- Engineering Practice
- Transferable Skills

Under the Knowledge and Understanding heading the document states that 'Graduates should demonstrate their knowledge and understanding of their engineering specialisation, and also of the wider context of engineering … and awareness of the wider multidisciplinary context of engineering'. It is left to the colleges offering engineering programs to interpret what is meant by the 'wider context' when an explanatory footnote in accreditation documents on what the accrediting body intends by 'wider context' would be helpful to engineering schools and review panels alike. One of the learning outcomes under Transferable Skills states that graduates should 'demonstrate awareness of the health, safety and legal issues and responsibilities of engineering practice, the impact of engineering solutions in a societal and environmental context, and commit to professional ethics, responsibilities and norms of engineering practice'. The intention then is clear. However the real strength or otherwise depends on how, first, engineering colleges respond to the stated criteria and second, the diligence of accreditation panels in ensuring the criteria are met. Bearing in mind that accreditation panels usually consist of only engineering academics and engineering practitioners some concern arises as to whether the societal aspects of engineering are adequately scrutinised (Grimson and Murphy 2013). Nevertheless in the first instance the onus resides within engineering schools to ensure that addressing societal aspects are incorporated into programs.

A question can be asked as to whether different types of program make it more or less likely that context, societal, ethical and directly related topics are given sufficient attention. It is not the purpose here to describe in detail the structure of engineering programs, rather the intention is to give sufficient information to allow some comments to be made on their suitability to deal with context. Whilst there is a wide range of curriculum implementations the following ones are the dominant ones. First, what might be called the conventional engineering education model with its mixture of mathematics, science and technology covers engineering principles applied to a limited field. Such programs were originally general in character in that the first and second years prepared for the introduction of a range of sub-disciplines in the latter stages of the course. In various colleges a liberal studies element was also included. The breadth of coverage however came at the price of limiting the depth of material. Analysis dominated though design did feature in such programs but was not overly emphasized. Most engineers over the age of forty would have graduated from such a program. In time specialism became a feature of many engineering programs with say electronic engineering being the target subject throughout the entire course of study. On one hand the graduates of such programs were technically more competent in their chosen field than heretofore, but on the other hand they were less flexible and often lacked a wider engineering vision.

The second type of approach resulted in what became known as engineering science. In such programs the focus is primarily on the science concerned with the physical and mathematical basis of engineering. Correspondingly less attention is given both to engineering practice, which often has its roots in craft, and the use of approaches such as heuristics as described by Billy Koen with great force (Koen 2003). Further, it is claimed that design is marginalized in engineering science. This is not a necessary consequence of adopting such an approach but the greater emphasis on science does come at a cost. To counter what is effectively the lack of a holistic approach where many factors have to be taken into account, engineering schools developed a third way generally called systems engineering: MIT in particular were early adopters. One of the key characteristics of systems engineering is that it is intrinsically interdisciplinary. The NASA Systems Engineering Handbook states that 'systems engineering is a robust approach to the design, creation, and operation of systems. In simple terms, the approach consists of identification and quantification of system goals, creation of alternative system design concepts, performance of design trades, selection and implementation of the best design, verification that the design is properly built and integrated, and post-implementation assessment of how well the system meets (or met) the goals' (NASA 1995). The final important variety of program is the one where it is project based. Here the project comes first, with a small team of students who 'discover' what knowledge they require to complete their project. It is the team working aspect plus the opportunity to learn about what to learn that gives project based programs their main advantage. Whilst each type of program has its defining characteristic it must be noted that they all have much in common. And all are capable of meeting the program accreditation criteria in jurisdictions where such schemes are in operation.

Returning to the question of whether context is more likely to receive adequate attention in one type of program compared to another. Whilst context can always be introduced by an instructor in any of the program types outlined above there can be little doubt that both the systems engineering and project based approaches lend themselves to dealing with context in a natural or organic manner. Ruth Graham has explored this question in a white paper and notes that project based learning facilitates the 'greater emphasis on embedding sustainability and ethics within the project context' and 'the creation of new cross-campus multi-disciplinary projects, centred on engineering challenges' (Graham 2010). Sustainability and ethics are not necessarily the totality of context in any given situation but it illustrates the point that project based learning is a good vehicle for its inclusion in the engineering process. Likewise the multi-disciplinary dimension can only enhance context having greater visibility.

One mechanism by which a student can be made aware of context is through work placement. Work placements that focus on narrow technical areas where specialised knowledge and skills can be developed are not necessarily good candidates for developing context awareness and context sensitivity. At the other end of the spectrum, placements abroad as part of, say, humanitarian efforts are likely to instil an awareness that simply cannot be gained in the classroom. Work placement has as a basic objective the aim of showing an undergraduate engineer what it 'feels' like to be a 'real' professional, that is to say one working in the real world. To that end placements that present broadly based opportunities are likely to be of the most benefit. In addition organisations such as *Ingénieurs sans Frontières* have as their ideal the act of addressing societal concerns that contribute to the general context in which engineering takes place.

Textbooks deserve a special mention. Most textbooks for engineering undergraduates do not set out contexts in which the technical material that follows might apply. It is not hard to see why this might be the case, for the treatment of subjects aims to be as general as possible and is therefore not so much context free as context neutral. This is especially the case for introductory textbooks where it is clear that the basics must first be established. As an analogy the pianist would be restricted to learning piano scales and then embracing the Czerny exercises before being let loose on real music however simple it might be. In Electronic Engineering signal processing is heavily dependent on Fourier series and Fourier transforms yet few introductory textbooks seem to be prepared to set out in advance the overwhelming rationale for their use. A few exercises at the end of each chapter are a poor substitute for a rounded discourse on the rich set of applications of this subject material. Is it then just left to the lecturer or instructor to provide some context? The situation in general improves though when graduate course textbooks are encountered. The use of case studies helps greatly in anchoring the technical discussion in realistic settings.

One last point related to the engineering curriculum, bearing in mind the importance of context, there is merit in having mandatory courses in the History of Engineering, Science and Technology. Ideally such courses would include students from other disciplines which would enrich class discussions and expose the engineering students to other viewpoints. Coupled with Philosophy, which promotes right and critical reasoning, the case for including these subjects as part of a Liberal Studies component in the curriculum is strong (Grimson et al. 2008). The notion of banishing engineering to some form of a boot-camp cut off from the ideal university would hardly serve the needs of engineering to be context aware (Robert Wolff 1992). Indeed the idea of humanists and engineers working together to form a 'global democratic culture' has great appeal (White 1967).

Attributes of an Engineer

A number of bodies have conducted exercises to establish the essential skills of an engineer and these are discussed by Ela Krawczyk and Mike Murphy as part of reviewing the challenges in educating engineers. Professional bodies, business, and new graduates all have their favorite priorities. From the lists examined 'context' or the ability to appreciate context does not appear (Krawczyk and Murphy 2012). Further it would take a degree of imagination to choose some of the attributes listed to at least point in the direction of 'context'. Perhaps this gets to the core of the matter: engineering is inherently contextual but context is in many respects only implicit in what transpires. As is demonstrated elsewhere in this chapter there are manifold 'hooks' or opportunities by which context is or can be made explicit. Perhaps in the future a list of attributes will include an item such as 'contextual awareness'! Interestingly the same authors rank the desirability of skills and competences for three very different scenarios: one, where there is a growing libertarianism; one where a balance is strived for between civic society, governments and business; and one where after a long economic stagnation and a fragile socio-political environment people turn back to their local communities and cultural roots for comfort. A brief analysis of the desirability/scenario matrix shows that Social and Ethical Awareness, and Cultural Awareness (close relatives of context awareness) are both ranked low. This reinforces, one would think, the point that issues surrounding context need to be made explicit.

Value Systems

Engineers and engineering have inherited value systems which can be thought of as a set of ethical values that are consistent and which are derived in a personal and corporate manner. It is probably true though that such value systems are more varied than in any other profession, such as medicine, partially due to the wide divergence across the many and varied sub-disciplines of engineering and the range of levels at which it is practiced. In addition at least some of the value system must reflect norms within any given country and culture. Nevertheless engineering institutions and societies across many countries have codes of ethics that are very similar in content. Whilst the existence of a moral code does not necessarily imply that context will be properly addressed in all situations, it does provide a framework in which engineers should work and therefore has relevance to both the identification of context(s) and their resolutions in terms of subsequent engineering activities. The Code of Ethics for Engineers Ireland is not atypical and consists of four parts: (i) Relations with Colleagues, Clients, Employers and Society in general; (ii) Environmental and Social Obligations; (iii) Maintenance and Development of Professional Conduct and Standards; and (iv) Enforcement Procedures and Disciplinary Action (Engineers Ireland 2009). Within section (ii) it states that:

- Members shall have due regard to the effects of their work on the health and safety of individuals, and on the welfare of society and of its impacts on the natural environment.
- Members shall promote the principles and practices of sustainable development and the needs of present and future generations.
- Members shall strive to ensure that engineering projects for which they are responsible will, as far as is practicable, have minimal adverse effects on the environment, on the health and safety of the public and on social and cultural structures
- Members shall strive to accomplish the objectives of their work with the most efficient consumption of natural resources which is practicable economically, including the maximum reduction in energy usage, waste and pollution.
- Members shall promote the importance of social and environmental factors to professional colleagues, employers and clients with whom they share responsibility and collaborate with other professions to mitigate the adverse impacts of their common endeavours.
- Members shall foster environmental awareness within the profession and among the public.

Perhaps these six statements are open to some criticism, as in a lack of explicit reference to gender, race, religion etc., but it could be argued that such issues are already the subject of national equality legislation in most countries. Gender is mentioned as it can be an important context in major engineering projects as illustrated by Nina Laurie (Laurie 2011). And examples are not hard to find where race and equality in general are important issues: just think of the distribution and provision of hospitals, housing and education in developed countries let alone across the world. Nevertheless the above Code of Ethics sets a standard that is high and is framed in a manner that compliance is, in principle, measurable. And that perhaps is the key issue, namely, whilst engineers have collectively signed up to acting in an exemplary manner, is there sufficient adherence to its stated high ideals? This is somewhat akin to comparing the ideals of a Christian, say, with the actual behaviour of individuals of that religion. And similar statements could be made about the adherents to any belief system. On the general matter of compliance it is fair to say that transgressions brought before disciplinary panels are rare and more often than not are about matters related to 'Relations with Colleagues, Clients, Employers'. Finally, it is worth comparing the six items listed above with the eight habits of mind that Clark Miller and Sarah Pfatteicher promote as being appropriate for engineers and repeated in Engineering in Context (Miller and Pfatteicher 2008), (Fisher and Miller 2009).

1. Recognize that engineering work is a form of social engineering.
2. Develop a commitment to systematically inquire into the broad impact and import of engineering work.
3. Regularly seek out opportunities to learn new skills to successfully pursue such inquiries.
4. Recognize the obligation of engineers to work in partnership with those who will inhabit the technological worlds the engineers design and build.
5. Recognize that all design decisions involve the need to balance, choose, and evaluate interests, views and perspectives.
6. Look for ways to make those choices an explicit and integral part of the dialogues ta surrounds design decisions.
7. Develop a tolerance and appreciation for dissention, debate, and dialogue.
8. Involve the public more actively as participants in deliberations about the public good as embedded in technological systems.

What is worth noting is the similarity between the two lists and the sameness of tone, though the latter is more nuanced. What both lists imply is that engineers work in a socio-technical environment and not just a technical one and hence their interaction with engineers and non-engineers needs to be moderated: precisely the point of having a code of ethics. In a more general manner the social context of technology can be considered a process and hence similar in principle to the processes in engineering (Kroes and van de Poel 2009). This approach whilst not guaranteeing a successful resolution of contextual challenges at least incorporates context into a readily understood framework.

An Economic Perspective

Not surprisingly there are economic forces bearing on engineering education. On one hand some of the longest established and most confident engineering schools appear slow to adapt to changing circumstances where the rationale is one of taking a long term perspective whilst concentrating on universal basics. On the other hand younger engineering schools are often eager to adopt change and become early adopters in areas associated with technological shifts and new engineering paradigms. New contexts emerge and in a loosely coupled manner two-way interactions between society and academia develop – not always for good nor are they necessarily bad. As examples, most of the initial fears concerning nanotechnology appear to have abated whilst the technology supporting social media is lagging behind what could be required by way of either formal or informal regulation. What is clear is that context becomes an issue after the technology is introduced and as a result it is more difficult for engineers and indeed others to anticipate what will be unintended consequences. Perhaps this is always the case with new technologies (for example, consider the adverse effects following large irrigation and dam construction). Either way, context is at its most challenging when engineering takes the form of what Walter Vincenti referred to as *Radical Design* (Vincenti 1990).

There are other ways in which economics and associated policies influence engineering and engineering education. National research agendas and consequently funding are normally government led and have considerable power over what research takes place. In turn this has a trickle down impact on both graduate, first, education and then undergraduate education. In addition Andrew Jamison has referred to the greening of engineering and engineering education in which the borders between the academic and business worlds are increasingly transgressed (Jamison 2012). As a general observation the business or industry influence on education is significant across the world with contexts set by those external to the universities. In large parts of the former Soviet Union many universities were and still are vocationally based (mining, locomotive, chemical) where the context is effectively handed down. And finally and perhaps controversially, defense contracts have featured strongly in research funding for universities (not restricted to engineering) where again context is set by the funders. Unless a college has a strong resource base it is inevitable that the education it provides is in part determined by external economic factors.

Grand Challenges

The influential Finnish architect Eliel Saarinen held that one should 'always design a thing by considering it in its next larger context – a chair in a room, a room in a house, a house in an environment, an environment in a city plan.' Whilst this injunction has an obvious appeal – concentrate on one thing at a time – it is open to the criticism that proceeding from the bottom to the top does not necessarily yield a satisfactory overall outcome. But it must be admitted that much of engineering adheres to Saarinen's instruction. However one notable example of where engineering has taken a macro view is in the choice of the challenges for the twenty first Century as chosen by the US National Academy of Engineering (NAE 2013). There are 14 challenges and it is worth listing them here.

1. Make solar energy economical
2. Provide energy from fusion
3. Develop carbon sequestration methods
4. Manage the nitrogen cycle
5. Provide access to clean water
6. Restore and improve urban infrastructure
7. Advance health informatics
8. Engineer better medicines

9. Reverse-engineer the brain
10. Prevent nuclear terror
11. Secure cyberspace
12. Enhance virtual reality
13. Advance personalized learning
14. Engineer the tools of scientific discovery

Arguments can be made both for the rejection of some of these challenges and for the inclusion of others, nevertheless the list is evidence that one way or another context has been taken into account at a macro level. At least three of the challenges are directly concerned with climate change. Three straightforwardly are health related, and four others deal with the background in which we live and ideally prosper. But it is not the list of the challenges that is important since it is expected that other nations will have a different set of priorities with many Third World Countries having needs not considered important by the more developed countries. And in any case time will inevitably force the list to be revised. Instead it is, first, the process by which such challenges are identified and, second, the follow-through by which each challenge is addressed. Regarding the first, the National Academy of Engineering (NAE) did not rely solely on the engineering profession and the committee tasked with identifying the challenges consisted of 'a diverse group of people dedicated to improving quality of life around the globe'. In such an exercise it is the diversity of the group that brings some robustness to the process. Recognising the significance of NAE's Grand Challenges, the Royal Academy of Engineering (UK) held the inaugural Global Grand Challenges Summit in March 2013 involving over 450 leading engineers, artists, economists, designers, philosophers, scientists, politicians, industry leaders, educators and policy makers from across the globe (Global Grand Challenges Summit 2013). Again it is the diverse range of participants that justifies the hope that the challenges identified are indeed valid and deserving of sustained attention and effort. Regarding the second matter – the follow-through – this is more problematic and at root troubling. Significant resources and commitment need to be in place for a prolonged period of time if progress is to be made and this requires society mostly through governments to accept a responsibility that perhaps they are reluctant to accept. As an example the wrangling over various protocols and agreements together with lack of progress on climate change do not augur well for global success in meeting the grand challenges. And perhaps it is here that engineering has its biggest challenge, namely to canvas support at all levels, from corporations, foundations, various agencies and governments, to commit resources and effort to what are perceived to be the real and significant problems. Oddly enough the problem is still one of context but now it is essentially a socio-political one. In a partial conclusion, it could be argued that fundamental challenges with their associated contexts have not been ignored by engineering, but it is as yet unclear whether the profession is sufficiently persuasive to ensure the grand challenges are accepted, and acted upon, by society acting through governments and other agencies.

The Role of Professional Institutions and Academies of Engineering

Whilst undergraduate education is the main vehicle by which engineers are or can be sensitised to issues surrounding context it does not follow that exposure to this matter stops at graduation. In fact context becomes more important if not inevitable once an engineer commences practicing their profession. It follows that continuing professional development (CPD) plays a role in educating and re-educating engineers throughout their careers. In general institutions are well placed to identify topics that have particular importance and in many cases organise symposia, colloquia and conferences to address current and emerging subjects. An example would be the type of report that looks at the energy question where orthodox sources of power such as coal and nuclear are considered together with a range of alternative ones, and including material on sustainability, climate change, impact on economies, socio-political matters, local environmental conditions and other contexts. Other topics found on academy websites include reports on engineering the future of water, human enhancement and the future of work, energy storage, and the philosophy of engineering – in fact a rich and eclectic set of reports can easily be found each with their own relevant contexts.[1] In turn the material in such reports finds its way into textbooks intended for use in colleges and universities.

Legislation

Legislation as it impinges on engineering is essentially good practice that is encoded or framed in a way that forces the profession to comply. Health & Safety is one obvious area that has resulted in a raft of law setting out the conditions under which individuals must operate. Legislation of this type protects both the client and the engineer. Other types of legislation ensure that the greater interests of society are represented in the work of engineers and particularly at the early stages of a project. For example Environmental Impact Studies (EIS) are a mandatory part of any project such as building a new road or airport and take into account one set of contexts. Further, planning bodies then rule as to whether or not the relevant challenges for these contexts have been properly addressed. There are other less obvious mechanisms. For example in some jurisdictions professional engineers are regulated by an institution which is empowered through law to maintain a register of its members and who must act according to the bye-laws and regulations of that body. Ethical conduct expected of a member would normally be a strong feature of such bodies' laws. The systems in place may not be perfect but a general framework is in place through state legislation and the role of institutions in ensuring as far as

[1] See for example http://www.raeng.org.uk/news/publications/list/mostrecent.htm, http://www.nae.edu/Publications/Reports.aspx and http://www.iae.ie/publications/

practicable that engineers carry out their function in society in a responsible manner.

Dialogue Between Society and Engineering

The burden of identifying and then accounting in some reasonable manner for context should not be seen to rest solely on the shoulders of engineering. Society through groups and individuals has a role to play and not just the adversarial one that attracts the attention of the news media. Useful dialogue and the negotiation that needs to have formal support whereby those involved are properly informed. One such example is the Aarhus Convention supported by three 'pillars'; namely, Access to Information, Public Participation in Decision-making, and Access to Justice, in Environmental Matters (www.unece.org). The underlying rationale, as the website makes clear, is that sustainable development is directly dependent on the meaningful engagement of civil society in decision-making. Whilst the primary concern is environmental, which in any case relates to much of what concerns society, the general approach is adoptable across the whole breadth of engineering as it is practiced.

Conclusion

No special claim can be made for engineering when it comes to the question of context in all its many facets. Without strong evidence to the contrary it can be assumed that engineering takes the issues surrounding context(s) no less seriously than other practical professions. But it can hardly be disputed that the effect on an 'environment' in the case of engineering endeavours where context has not been either understood or addressed can be of huge or even disastrous consequences. Even when well intentioned, engineering projects can be the victim of either unintended consequences or a lack of understanding of associated and previously known contexts. One area that has attracted adverse comment has been the building of dams and in general altering water courses. Too often such projects are undertaken by developed countries in developing countries and have resulted in a number of well publicized disasters. One feature of some of these failures has been a lack of real dialogue between project managers and local people who understand perfectly well their own surroundings. It has been pointed out by Peter McEvoy, Jane Grimson and William Grimson that engineers are well placed to contribute to what has been called 'negotiated development' for the simple reason that they are at the core of so many developments (McEvoy et al. 2012).

Civil engineering was so called to differentiate it from military engineering which for many centuries dealt with fortifications and weapons to breach enemies' ramparts. The picture today is more complex with all branches of engineering deployed from time to time to support military engagements and interventions. The contexts surrounding military operations and peace are manifold and range from humanitarian to economic aspects. Engineering cannot be divorced from this complex background situation, with positions taken both in accord with international agreements and moral norms within any given country. For example, consider the use, production, transfer and stockpiling of cluster munitions (http://www.cluster-convention.org/). Engineers, scientists, medical doctors and other professionals all face the same or similar ethical questions about war, ones that have existed for thousands of years. Whether engineers are working within or outside the parameters set by society is a matter of debate but at the very least no individual can claim to be unaware of the various contexts associated with military operations and war.

Finally, engineering is an infuriating topic to some, for the field of endeavor that is engineering almost defies description. It involves mathematics, science, craft and various technologies in a mix that appears amoeba-like and having no clear boundaries. Carl Mitcham has claimed that engineering is philosophically weak when compared to other professions (Mitcham 2008). There is substance to this claim but in some respects it misses the point, for engineering to succeed it cannot afford the luxury of being soundly philosophically based as, say, mathematics. Its purpose lies elsewhere. It is the curse and blessing of engineering that it is both open-ended and forced to be a profession of everything (Williams 2002). As a result engineering is all too susceptible to failing to meet the heavy demands made of it, trying as it does to satisfy diverse and complex requirements. It would be ridiculous to claim that engineers have helped create the best of all possible worlds. But it is unthinkable that humanity could have developed to its current position or contemplated new developments without the direct involvement of engineering in one form or another. This chapter set out to show whether engineers are sufficiently context-aware and responsive. What the chapter shows is that through a multiple of means context is addressed at first during the educational formation of engineers and second throughout the professional life of an engineer. The means exist but whether the end-result is satisfactory is itself another and different question. Suffice to say that there is a realization within the engineering community that context is vitally important and deserves a rounded attention. And Samuel Florman's view that it is not the engineer's responsibility to impose their morals on their practice, considering that they are not responsible for the initial requirements, seems, at least to this author, nothing more than a convenient excuse for 'hand-washing' (Florman 1976).

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