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Abdallah Hasna

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Sustainability and Engineering Philosophy: The Paradigm

Abdallah Hasna, Central Queensland University, Queensland, Australia

Abstract: As part of a process towards developing a yard stick for sustainability management of engineering technologies (SMET). The division between sustainability and philosophy of engineering, in theory and in practice, is absolutely artificial. In essence there are complementary characteristics with a common objective that it is to contribute to the development and the progress of the human being. However in regards to engineering philosophy, where philosophy is in its true and disciplined sense, is as important to the engineering profession as an engineering mission statement is to an engineering firm. Like a company's mission statement, philosophy of engineering provides a direction for development and a professional identity. This paper examines the definitions, relationships and essential connections between sustainability and engineering philosophy.

Keywords: Sustainability, Philosophy, Engineering Design, Implicit Sustainability, Curriculum

Introduction

SUSTAINABILITY REQUIRES A new philosophy to spirit a new set of broad knowledge to nurture a sense of connection between people [Stegall, 2006]. Given that engineers have key roles in wealth creation and in innovation [Johnston, 1997, p80]. Let us consider engineering's commitment to the real world pragmatism, utility, practical know-how [fox, 2005]. Mitcham [1998] Philosophy has not paid sufficient attention to engineering. Nevertheless, engineering should not use this as an excuse to ignore philosophy. Why is philosophy important to engineering? Ultimately and most deeply it is because engineering is philosophy - and through philosophy engineering will become more itself. Engineers of the world philosophize! You have nothing to lose but your silence [Kroes, 1998].The argument here is that philosophy is important to engineering for at least three reasons.

1. Philosophy is necessary so that engineers may understand themselves. For example Snow, [1959] portray that engineering and philosophy do not have much to do with each other. They are, as it were, giant islands separated by a large body of water, as indicated in Figure 1. That is engineering and philosophy as two mutually exclusive domains.

Figure 1: The Great Divide between Engineering and Philosophy

2. Philosophy, especially ethics, is necessary to help engineers deal with professional ethical problems. These examples can range from situations in which companies try to cheat one another to those in which human health and safety are jeopardized, hence the engineer must be equipped with a philosophy to steadfast the tide.
3. Philosophy may actually function as a means to greater engineering self-understanding, Because of the inherently philosophical character of engineering. For example the largest exporter uranium, Australia has 40 per cent of the world's reserves. The Australian of the Year Flannery [2007] the challenge for all Australians, I believe, is to conduct our export of uranium at the highest ethical and moral level.

Hence Engineering Philosophy addresses the relationship/connections between philosophy and engineering. It reflects on the connections and overlap of premise.

A Systems Perspective Principles of Sustainability

The human connection to the physical and natural worlds is defined by the understanding that humans are a part of nature, and must live in harmony with natural systems [Cortese, 2005]. It was Tolstoy who wrote that the greatest threat to life is habit. Habit, he argued, destroys everything around us, because it familiarises us to the point that we no longer really see things. We become incapable of bringing the fa-

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miliar furniture of our lives into focus. A similar argument can be made about ideas and concepts, and about the intellectual frameworks that shape ideas and concepts [Martin, 2005]. Concepts such as the environment, nature and civil society are familiar and we often take them for granted. Yet they are often difficult to define, partly because they carry with them a variety of implicit assumptions, which influence the way we think about them [Martin, 2004].

Advances in modern technology have provoked dramatic changes in contemporary society namely information and communication technology, nanotechnology, and genetic engineering. For example global positioning system (GPS) technology originally developed for military use-is now used in civilian car navigation systems. Common catch phrases like, digital age, information society, global world, global warming, carbon trading fast becoming part of every day language. Fox [2005] reports that fundamental concepts that underpin the engineering profession are ever widening for the discipline, These are mainly interdisciplinary concepts which have led to a crisis of identity, the nature of professionalism - rigour, process, practicality, ethics, responsibility, function, form, elegance, ingenuity and creativity. Such changes imply the need for a new engineering philosophy a holistic approach to sustainability.

Extending this point of view, sustainability can be implicit, i.e. tacit, or explicit, revamped. Sustainability is not, itself, an implicit, analytic, measurable property. Instead, it must be approached as an overall design goal. Indicators of unsustainable design may not be immediately observable. Hence, the development of engineering design guides for sustainability require systems treatment, including such core considerations as the selection of system boundaries, the design process, the identification of systems stakeholders, and the openness or transparency of this process. When dealing with an organizing design principle for large-scale systems, it also essential to consider the scale for analysis of sustainability and the interrelationships among various major subsystems (e.g., energy, environment, urban form, etc.) [Cutcher et al, 2004]

Implicit sustainability is defined as sustainability that is transferred directly between persons by socialization, i.e. through one's own perceptions, practical experiences and, most importantly, building of own internal mental models.

Implicit sustainability can be made explicit, e.g. formalized, by externalization, i.e. articulation of implicit knowledge by using explicit concepts, metaphors and models. Explicit sustainability is embodied again by persons through internalization. E.g. learning by doing supports the creation or extension of internal mental models of persons. Explicit sustainability is enriched through combination, i.e. by systemizing, categorizing, ordering and combining concepts.

In reality how much of an engineer's technical education is actually used in daily working life compared with non technical decision making i.e. ethics, morality, decision making etc.. i.e. Encourage questioning of assumptions, critical thinking, argument, decision making and moral judgments. Include ideas about aesthetics, form, function, value, and social responsibility, classification of objects and modelling, posing the fundamental question about Relationship between sustainability and engineering practice.

1. Is a longer degree programme needed in order to educate the engineer about sustainability?
2. Should the Philosophy of engineering be a core learning subject in the engineer’s training?
3. Who will pay for the extra training?
4. How will the extra training affect appeal to the engineering discipline?
5. In practice, engineers are employed to design solutions how does the engineer balance the need between development and conservation?
6. What tools/matrix to use in assessment between development and conservation?

Engineers are both in part responsible and subject to changes in their day-to-day work, i.e., the broadening of design criteria to include ethical, contextual, and cultural issues. The basics of sustainability include; equity, culture, ethics, philosophy, management, social alertness, economics, law and globalization. Hence for the purpose of this discussion paper, we question how do we integrate the notion of sustainability into everyday engineering? Do we need to change our existing engineering philosophy? Would we need to define engineering and its constituent parts, for instance engineering effort have been squandered on achieving small energy savings, for example Energy Star compliance on computer equipment represents misplaced engineering effort. Purely incidentally, present flat panel displays use less than half the energy of corresponding CRT displays [McCarthy, 2002]. If the money spent on it had been spent on developing large flat panel displays, maybe we would have bigger ones now. Another example is nuclear energy verses coal fired power station. In terms of engineering philosophy, as elsewhere, this tendency is visible; and it is this lack of direction that developed a culture of squandering resources.

Philosophy and Engineering

Philosophy and engineering are two words that can seem incompatible together. That is, when we regard philosophy in its true sense of the "careful thought about the fundamental nature of the world, the grounds for human knowledge, and the evaluation of human conduct" [Lacey, 1986, pp15] Philosophy frequently assumes the more simplistic meaning of 'a value system'. In many ways these two definitions are related. It is much more common for engineering to be heard in conjunction with philosophy when it means value system. For example, many companies have 'philosophies' that encompass everything that the company sees as important - from the customer, business and management, to ethics. From this the philosophy is little more than a glorified mission statement.

The standard definition of engineering is "the application of scientific principles to the optimal conversion of natural resources into structures, machines, products, systems, and processes for the benefit of humankind. "Modestly" truncates then expands on this definition when it describes engineering as, "Most simply, the art of directing the great sources of power in nature for the use and the convenience of humans [Barker, 1993]. Thereby accusing engineers of building nuclear weapons that could destroy civilization as we know it, manufacturing transportation systems that are a blight on urban culture, designing communication technologies that can enhance central or authoritarian controls by both governments and private corporations, and creating computers that depersonalize human life.

The consequence of such conceptions can be viewed by the following opinions "Engineering is the scientific art by which a particular group of human beings destroys nature and pollutes the world in ways that are useless or harmful to human life" [Lewis, 1947]. Engineers have, in general, so the critics contend, been polluting the natural world with toxic chemicals and greenhouse gases while flooding the human world with ugly structures and useless consumer products [Ellul, 1954] [Mumford, 1970].

Design requirement is a compilation of information necessary to allow the creation of a design. Engineers face situations that cannot be resolved simply with engineering methods and technical expertise alone. This is in reference primarily to professional ethical issues. For example, Australia is a major exporter of primary energy products and currently experiencing a mineral mining boom and a drought. This drought is the worst in 1,000 years. Our major energy reserves are in coal, natural gas, and uranium. This presents some dilemmas relating to water consumption. I was personally involved in the commissioning of many coal preparation plants and the predicament I faced was, on one hand this is my job, as well as the very industry that employs some 30, 000 people, with direct effects on Australia's GDP, however these coal washeries used vast amounts of water whilst Australia's capital cities water supplies were dwindling to record lows. These sorts of ethical issues go beyond the appropriate behaviour of individual engineers more so to the appropriate behaviour of the engineering profession.

Engineering design is an activity extensively relying on designer's knowledge and experience. Ethical issues arise in this design process, for example in the formulation of requirements and making trade-offs between requirements [Ibo,2002]. Dym [1995] methodologically excludes aesthetics and by extension ethics - from his analysis of design, in order to keep his discussion "bounded and manageable," he also grants that ethics often has a serious role to play in engineering design. Questions of safety, risk, and environmental protection are only the more obvious manifestations of variables that call for ethical judgment in assessing their proper influence on design decisions. Philosophy especially ethics is an internal practical need of engineering summarized again by means of schematic diagram in Figure 2. The situation has been transformed from two mutually exclusive circles.

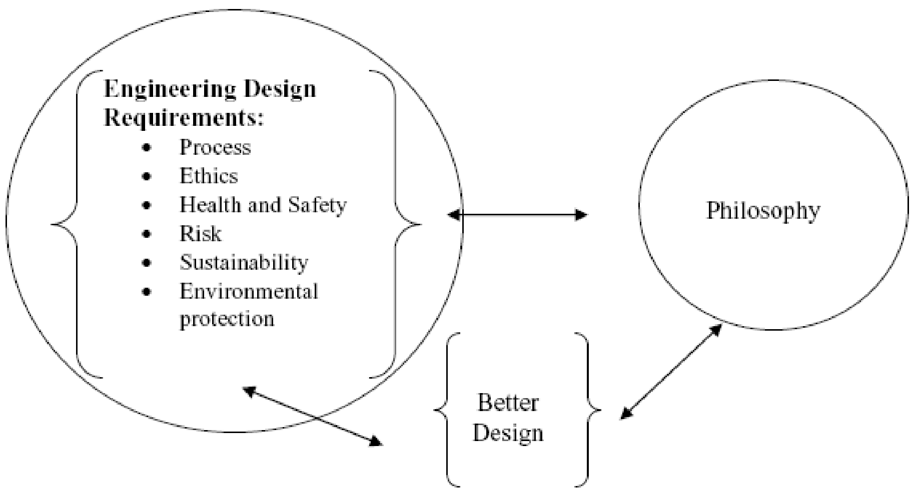

Figure 2: Engineering Connection to Philosophy

Philosophy of Engineering

The engineer must respond to the problems of society with responsibility, following the professional code of conduct. This demands a suitable preparation. Educational institutions consequently must integrate the social and anthropological contents (ethical, moral, human) in the engineering studies. Additionally, the preoccupation to conserve the nature, respect, solidarity and international cooperation must be a manifestation in the work of the engineers. Philosophy of engineering forms an ideological structure so that engineers know where they stand in relation to issues of economic and moral importance that they may face and, more importantly, to make sensible judgements when presented with issues. Definitions of philosophy can be thought of as related, an engineering philosophy could include elements of many other different philosophies. A mosaic of philosophy types in order to achieve the best result.

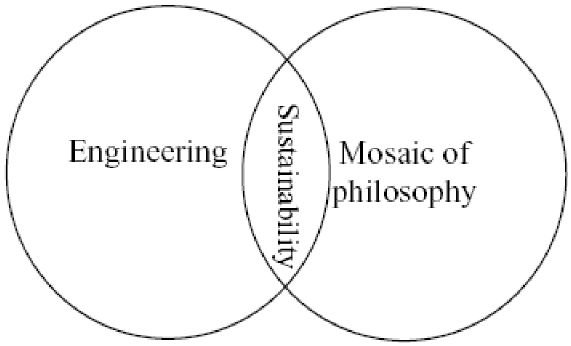

Figure 3: Merger of Entities with Hypothesis by-Product

Figure 3 shows an abstract view of living life with only many types of philosophy. Engineers especially, who must deal with several different types of individuals in many varied situations, engineering philosophies need to be mutually inclusive of other philosophies. Therefore, for engineering to facilitate a healthy relationship with technology and the wider community we must break out of the cycle and focus on a balance of many of these philosophies that would make a good engineering management, but mostly in the way that they would simply make us a good human being since the purpose of technology is to provide a better standard of living. Thus, through the function of this philosophy engineers will be better equipped to deal with the external values placed upon them and turn them into an acceptable engineering solution.

An early and important division of philosophies developed between Empiricism, which professed the importance of practice and knowledge gained through experimental observation, and Rationalism, which said that theory was the most important aspect of knowledge [Lacey, 1986]. Post-Modernism's focus is on human understanding as only interpretation. This calls into question how we interpret the world around us [Johnston et al., 1999]. It is impractical for an engineer to call into question his interpretation of a project situation on such philosophical grounds alone. Science is a major discourse in engineering. Therefore a philosophy of science may hold many keys to what may best describe a philosophy of engineering. Elements of a philosophy of science may feature in a philosophy of engineering. However, an important difference between the scientist and the engineer is the application of scientific knowledge necessary in engineering. Therefore, there is a practical element to engineering which is not necessarily present in science Figure 4.

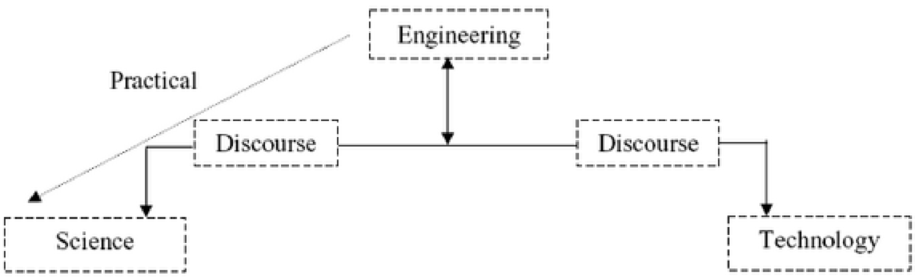

Figure 4: Engineering Discourse of Science

Engineering is known for its ability to produce solid results, in combination with the commonalities of science and technology as both are based on the gathering of knowledge. However, the most important aspects of this philosophy for an engineer lie in the discussion of what is called 'discourse'. This is, as Foucalt (1970) explains, “a set of possible statements which produce the meaning and values of a cultural formation" [Johnston et al., 1999, p.493]. This is useful in describing the ‘discourses’ which act to make up engineering, as Figure 5 Figure 4 illustrates the flow pattern of this relationship. That is, as engineering is partially socially constructed, we as engineers and members of society are bound to act within our cultural form, made up of meanings and values.

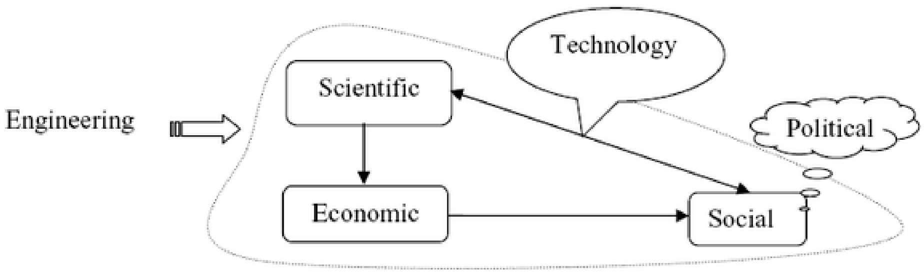

Figure 5: Pythagoras of the Engineering Dimensions

Engineering is largely made up of an economic, scientific and social (political) discourse with technology being the resultant vector, as shown in Figure 5. Although it is not necessary to change this method of thinking necessarily, it is important to know that our human understanding is based upon interpretation which is filtered through these discourses. It is up to the responsible and competent engineer to suitably prioritise these filters to gain a balanced human understanding of the situation which requires an engineering solution.

As technology is another primary discourse making up engineering, venturing into the philosophy of technology may also be appropriate in discovering a philosophy of engineering. An important trend amongst those who have looked at technology from a philosophical viewpoint, is that of recognising technology as more than a value-free accumulation of industrial science. Instead these philosophers emphasise the purpose of technology, and note that it is merely a tool for the improvement of society and, as such has very great social implications. Johnston et al. [1999] explains it so; Martin Heidegger (1889-1976) saw the belief that technology was value-free as the principal danger in the way technology was used in modern industrial societies. He argued that we were so caught up in technique, and besotted with the technology itself, that we missed the point, the essence, of the technology. He feared that this focus on the instrumental and quantifiable clouded our awareness and blinded us to questions of social values. As a result we failed to recognise that the essence of technology was to enhance the quality of life, to support beauty, poetry, creativity and delight [Heidegger 1993]. That is, that regarding technology as value-free is perpetuating because this belief becomes accepted by the community and so technology is increasingly applied without social consideration, and then we get back to a stage where the community can only regard technology as value-free because that is what the evidence suggests.

Discussion

There is a difference in recognition between occupations that provide service to individuals and those that provide service to the wider community. While there is plenty of overlap between a medical doctor and an engineer, the central difference is one of purpose, for instances a medical doctor offers a service to the patient, whilst the engineer design/builds the tools which are used to treat the patient. The engineering profession still has a long way to go in reconciling our present approaches to technology with the competing demands of economic development, social equity and sustainability [Johnson, 1997]. Hence, the Engineering profession holds its own risk assessment; judgment is at the core of engineering philosophy. Sustainable assessment includes risk and uncertainty studies as risk and uncertainty are normal ingredients of engineering work, thus the assessment of risk becomes important in all aspects of engineering work.

Risk management is: to recognize the potential for things to go wrong, reduce high risks from known hazards, and control activities such that low risks remain low. Equally safe means an acceptable level of risk, there is a fine balance between the risks in any action or inaction. However all risk assessment is biased, because all situations contain objective and subjective elements. These factors, judgment and human fallibility, interact at the human technology interface, therefore there is an inherent choice in the tradeoffs between risk and cost. Ultimately this is funnelling into the sustainable engineering philosophy, where professionalism in engineering is highlighted however it is simple in definition, professionalism = technical competence + ethical behaviour. Although there is a difference between unethical and incompetent conduct, hence to be ethical it is part of being professional. According to Tenets of The Institution of Engineers, Australia, Chartered

Professional Engineers 2000 code of ethics, it expresses, practice being in accordance with sustainability and environmental principles.

Continuing social change is influenced by developments and shifts in economic political ideologies. The Social Contract between society and professionals is based on the concept that a professional is a guardians of public trust, with an implicit, unstated agreement which exists between the professional and society. Hence society subsidizes training of professionals through funding of educational institution as well professional institution, in return for ethical and professional service/conduct.

However in terms of gaining social acceptance for the concept of sustainability, it would be expected to face an initial reaction to change, which is commonly known as resistance to change. However no singular solution can resolve the apparent tradeoffs between the development verses sustainability row, these factors are social objectives, development, reducing unemployment, and achieving environmental sustainability. For example initially pollution control in the process industry was viewed as a hindrance to development, cost impositions, and threats to competitiveness. However given the universal pollution awareness legislation and regulation, implementing control mechanism nowadays is commonly more acceptable and in some instances illegal.

Engineers increasingly need to be educated, sensitive and considerate in matters of environmental awareness and practice [IOE, 1992]. Sustainability ethic recognizes maintenance of ecosystem dependencies and diversity, but any inference that all forms of nature have an inherent value unrelated to any form utility would present new challenges to impact assessment and project evaluation. Conservation and development should be integrated, recognizing their independence. This would require a multi disciplinary approach to decision making, consideration of long term sustainability over short term gains, since what has been destroyed can never be replaced. Similarly engineering design needs to re-evaluate the design criteria by incorporating into the design criteria, Hence, recognizing the concept sustainable yield and capacity notion. Cleaner production and life cycle philosophies are replacing end of pipe methodologies in a progression towards achieving sustainability. Strategically, the drive towards cleaner design and production is critical for industry progression towards sustainability, it basically has stemmed from ever growing need of global awareness of interrelations between ecology and industrial progress. Traditionally this has included focused in achieving sustainable outcomes in non-renewable resources. However, the systematic consideration topics on sustainability such as environmental impacts includes lifecycle methodology such as eco-foot printing, Life Cycle Assessment (LCA) and Material Flow Analysis, Sustainable Consumption and eco-efficiency, environmental systems analysis, green engineering and industrial ecology, Design for the Environment and Eco-design , this underpins a change in attitude in our engineering community .

Due to the prevalence Our Common Future (WCED, 1987) of sustainable policy-making, behavioural engineering methodologies are favouring approaches such as cleaner production and waste minimization, no more end of pipe philosophy. Essentially now engineers integrate social and economic development and conservation, while it is understood that the environment has a finite capacity to accept and assimilate human interventions, responsible engineering work and environmental protection are not mutually incompatible as long as this limitation is acknowledged. Conservation and development should be integrated, recognizing their essential interdependence. Similarly heritage conservation and development need not be mutually exclusive.

Conclusion

Although the micro scale level of sustainability, i.e., any particular engineering project, is as important, in this article I have considered the problem on the macro scale boundary conditions, philosophical in nature that should be presently recognized when approaching any technological endeavor. Some might argue that being too philosophical may be detrimental to being a good engineer. Risks are inherent with innovation [Lloyd, 2005, pp 44]; engineering is synonymous with innovation including the risk of failing to achieve adequate monetary returns to cover the investment in developing innovation. This is where the question of vicarious liability for the sustainable use of our resources. There is a difference between intentional wrong doing and negligence. But in the case where an employee is following company unsustainable procedures, who is at fault here? Given the ongoing issues of industrial reform and lack of job security there is a risk of over looking the liability issues. So the employer and employee sustainability responsibilities need to be a clear cut answers in my opinion, in order to avoid emotional or irrational and unscientific decisions. This can only be achieved by changing the way we educate our engineers. Engineers should be ethically obligated to consider the sustainability in their designs. Engineers should not simply meet consumer demand, but also consider the needs of society as a whole... The government should also offer some monetary incentives for engineering contractors who incorporate sustainability in design. The only obligation of an engineer is to consider sustainability as if it was a specification of the design. Therefore broadening of the design criteria to include ethical, contextual, and cultural issues, in order for sustainability to become be an integral part of an engineer's frame of thinking hence curriculum's and not a mere 'add-on'.

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About the Author

Dr. Abdallah Hasna

I am interested in the political dimensions of global climate change. My doctoral research concerns the sources of influence in shaping national responses to climate change. Dr Abdallah Hasna is Senior Lecturer Faculty of Sciences, Engineering and Health, PO Box 1319 Gladstone QLD 4680.

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