Global Engineering for a Small Planet

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Recommendations

The engineering community should embrace global engineering as the professional and academic complement to the fields of global health and development economics.

Global engineers are needed to address a multitude of global issues faced by humanity today and in the foreseeable future.

Global engineers need to be able to make decisions across technical and socioeconomic and political sectors while operating in a multicultural and increasingly challenging world.

Engineering education and practice should include introductory training in health, economics, policy and governance as relevant dimensions of engineering's contribution to achieving the Sustainable Development Goals.

Abstract. Meeting the United Nations Sustainable Development Goals by 2030 is impossible without the full input of the engineering profession. Global engineers are needed to address a multitude of global issues faced by humanity today and in the foreseeable future. To do so, they need to acquire, during their formative years and professional careers, the approaches, skills and knowledge necessary to operate in a global world. This approach responds to increasing global needs as well as demands within the engineering profession, as students desire more meaningful opportunities to apply what they learn. This chapter advances the view that global engineering functions as

overarching goal of forming *global engineers* capable of making decisions across technical and socioeconomic and political sectors while operating in a multicultural and increasingly challenging world.

To quote Albert Einstein, ‘the significant problems we face today cannot be solved at the same level of thinking we were at when we created them’. The education of a new generation of global engineers able to work across disciplines, cultures and community needs does not come without its own share of challenges. However, these challenges have precedents in previous changes that have shaped the engineering profession and its relationship to society over the past 200 years. For example, during the first part of the nineteenth century the dominant view held that engineering should develop apart from society and that technology was nothing more than applied science and economeu (s)-1 e do wasTcieaa(e (o)]T4*Td[((o)4 (4 (w)e1 7F wcw02 (p)5 ( )7 c5e)-1 (nc)4s7/TT(d)]TJ0.2 (a)A

The second quantum leap that changed the dynamic between technology and society and shaped demand by 80 per cent and water demand by 55 per cent (Ferroukhi et al., 2015). This growth will occur in an already existing context of uneven resource scarcity in which the consumption of water, energy and food resources are interconnected. In addition to meeting the demands associated with population growth and providing the necessary infrastructure, other issues affecting human and economic development include increasingly competitive demands for water, energy and food resources, both within and across various sectors (domestic, industrial and agricultural), and demands from groups of consumers who may or may not be on different sides of a geopolitical border (*The Economist*, 2019). If resource allocations are not adequately addressed, compromises in the development, management and allocation of natural resources across groups and sectors have the potential to create unintended negative consequences, risks and uncertainties that could adversely affect large populations, especially those living in poor and marginalized communities.

Climate change is another critical factor for human and economic development, as it exacerbates inequity and accelerates poverty in some regions of the world. The World Health Organization conservatively projects over 250,000 additional deaths each year between 2030 and 2050 attributable to climate change-driven increases in temperature (heat waves), diarrhoea, malaria and malnutrition (crop failure) (WHO, 2018). An additional 100 million people could be pushed back into poverty by 2030 because of climate change (Haines and Ebi, 2019). Most of these deaths and hardships will be experienced in developing countries – those least equipped to manage climate change and least responsible for its causes. Engineers have a critical role to play in developing solutions for climate change mitigation and adaptation and to contribute to disaster risk reduction.

In general, the role of engineers will be critical in fulfilling the above-mentioned demands at various scales and settings, ranging from small remote communities to large urban areas such as megacities. A key task at the heart of the SDG agenda is to identify what needs to be done, now and in the immediate future, for all humans to meet their basic ne d toHu r fos pn.haati atkto 7]TJ0.002 Tc -0.01

Global engineering

Guiding principles

As noted by Weingardt (1998), ‘engineers are probably the single most indispensable group needed for maintaining and expanding the world’s economic well-being and its standard of living’. Today, the quality of life of many societies is built upon a complex and highly productive set of technological, industrial and municipal systems and structures (see Chapter 1). Continuing discoveries in electricity, mechanics, materials, processes and testing have resulted in thousands of new products and services, all contributing to increased levels of health, comfort and productivity that were previously unthinkable. Moreover, over the past 50 years, these advances have been accomplished with surprising ease that people, specifically those living in the developed world, have been conditioned to expect solutions for any new problem or need to appear almost immediately.

In some ways, that expectation is valid. The fields of biology, computers and information technology, materials, nanotechnology and others continue to progress rapidly. New discoveries seem to appear almost every day, lending a sense of boundlessness to possible advances. However, many technological successes in the developed world have lmstvest2 (e)-1 (v (e)-(c)-1 (e)-1 (-1 (s)-22 (i-1 (s)5

On one end of the spectrum, engineers need to address the key challenge facing the developed world of consuming less and more intelligently, while being respectful of human and natural systems. In this context, engineers are being called to develop innovative and more efficient ways of providing services and to reconsider the take-make-waste process in the production, distribution and consumption of goods and services. They also need to contemplate solutions that consider the three Ps of sustainability (people, planet and profit) and how these solutions might significantly impact social, environmental and economic systems far into the future. As discussed further in t0Tw 2r 1(re)1 -2 (o)2(re)1 -2 (ov ( )]TJ0.00-1 (i)-ulo(n)5 a)-3ake population' (ibid, pp. 16). While this situation has been criticized by society for at least three decades, the engineering community has had a limited role in community-based development projects that address the needs of those at the bottom of the economic pyramid. However, as noted by Radjou, Prabhu and Ahuja (2012), traditional engineering practice is not interested in small projects because they are not perceived as financially rewarding. This is unfortunate as there is considerable untapped market for sustainable solutions that can benefit a few billion customers on the planet.

In today's world, what is needed is a new mindset in engineering project delivery, one that addresses the interdisciplinary challenges involved in working in the context of developing communities and at the same time delivering socially, environmentally and economically appropriate and sustainable solutions to all. Such solutions do not need to be low-tech, as Schumacher (1973) noted in his book

Educating global engineers

These possible definitions of global engineering help to shape the discussion around the appropriate body of knowledge for the education of global engineers. However, it is necessary to start with a few preliminary remarks. Firstly, it is important to realize that the full range of global development issues mentioned above cannot be solely addressed by technology. Simply said, if all the world's problems were just technical, they would have been solved by now. Global engineering amounts to more than developing technology to solve humanity's problems. Global engineers must be able to develop solutions that take into consideration non-technical socioeconomic, cultural and political issues that play as much of a role as technical issues in explaining the problems faced by humanity today. These solutions must also be adaptive, consider gender and inclusion issues and be equitable across a wide societal spectrum. In short, global engineers need to be well-versed in dealing with equitable, appropriate and sustainable solutions whose underlying decision-making processes will incorporate both technical and non-technical tools and cross-cultural issues. As

i00tusH2f)1i36.0295 T-5(i)-2 12 Tc 0 Tw d8.001 Tc -Sqp0.004 i (r)-2Ta Tw [(if)-2 (t)-2 (uqousbusbusbusbusbs body of knowledge would have to address a wide range of issues, as mentioned above. At the same time, defining the required body of knowledge is not a random process if the education of global engineers is understood as a T-type of education with both depth and breadth rather than a traditional specialized I-type of education (Manning and Reinecke, 2016). The depth aspect of T-type education deals with technical competency and professional competency (i.e. the rigorous technical tools and professionalism commonly expected of engineers in practice). The breadth aspect concerns global competency and cross-disciplinary tools from the non-technical disciplines of health, economics, policy, ethics, governance and peace studies (see Chapter 7) that engineers must be aware of in order to address the global problems mentioned above. These tools are mostly taught in non-engineering departments and colleges.

Out of the ‘why’, ‘what’, ‘how’ and ‘who’ of a T-type engineering education, the first two are generally better defined. Regardless of the global engineering emphasis, global engineers must have acquired at least the following core competencies:

sustainably; to minimize the environmental impact of projects, wastes and emissions; and to use their influence to ensure that their work brings social benefits which are equitably distributed'.

Global engineering should work to understand and address the unequal and unjust distribution of access to basic services and envision a world where everyone has access to safe water, sanitation, energy, food, shelter and infrastructure, and can live in health, dignity and prosperity. As much as any other profession, engineers have an opportunity to contribute to a more just and equitable world. Human development requires a humanization of the engineering profession and the realization that engineering in that context is above all – as it has always been – about people.

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