Alistair Cook, Colorado State University

Educating Engineers for International Development Careers: A Pathway to the Future of Engineering Design Education

Our global future require engineers and designers who are defined by their intersectionality, that is, engineers who are technically competent in their field(s) of engineering but also have global and professional skills to practice engineering design as professional global citizens [1, 2].

Skills such as communication, ethics, and cultural and global adaptability enable these engineers and designers to work on transnational teams in different country and local contexts in differing regulatory and socio-economic realities. While there are very few programs that specifically prepare engineers and engineers to work in international development, the few programs that do provide an opportunity to demonstrate how engineering design education is changing through the globalization of the engineering and design fields. This change provides an avenue to overcome a major barrier to the achievement of the United Nations Sustainable Development Goals (SDG's) [3], namely, a lack of appropriate engineering expertise and capacity [4].

Engineers are central to international development [5], and international development projects will dominate engineering design of the future, as recognized by the National Academy of Engineering (USA), Royal Academy of Engineering (UK) and the Chinese Academy of Engineering's Grand Challenges for Engineering program [6]. Each of the SDG's [3] has an infrastructural/engineering component, from clean water needed to promote health; transport infrastructure to support trade and economic growth; reliable and clean energy to allow students to study and economies to function; and genetically engineered seeds to increase crop yield and allow families to be self-sufficient. These hurdles to development exist in different forms in every developing country in the world. Although funding and aid has been poured into development in an attempt to address these issues, an underlying problem is the ratio of engineers to general population. In contrast to the United States, where the ratio is 1:100, the lowest ratio is 1:4800 in Africa; in South Africa and across the continent, the ratio varies up to 1:170,000 in Swaziland [4]. This issue is multiplied because engineers are traditionally trained nationalistically to prepare them to be engineers for their local context and country [7]. This means their skills and knowledge may not be transferable and therefore appropriate for the context of a different country or community. To overcome this barrier, "*engineering needs to promote itself as relevant to solving contemporary problems, to become more socially responsible and to link to ethical issues related to development*" [5].

A solution that has proved successful at organizations such as Engineers Without Borders UK and Australia [8-10] and the Massachusetts Institute of Technology D-Lab [11] is promoting a more holistic engineering education that trains globally competent engineers by including professional skills in balance with technical skills and a focus on the social and economic effect of engineering. This approach of training a global engineer requires "*Going beyond just seeking technical solutions to an understanding of the problems […] to encourage a more critically reflective approach towards addressing problems that need to be tackled, understanding and valuing different perspectives and recognizing that external factors, be they economic, political or cultural, do play a role in influencing the decisions we make [as engineers*]" [12]. Engineers and designers who are taught to develop this utopian thinking [7] provide the capacity for the development of what UNESCO defines as "engineering for development." [5] This approach is also modelled by the organization Engineering for Change, who promote a new interdisciplinary thrust in engineering that "responds to the global need for engineers who understand the problems of development and sustainability, can bring to bear on them their engineering knowledge, are

motivated by a sense of the future, and are able to interact with other disciplines, with communities and with political leaders to design and implement solutions" [5].

Engineering design education has changed dramatically over the last century due to the pressures of rapidly expanding design knowledge and technological development [13, 14]. Engineering design has become an increasingly narrow and technical subject as technical knowledge has expanded, following the path of the engineering field itself which has gone from four to over thirty engineering disciplines in a very short period of time [5] to cope with our expansion of technological solutions and knowledge. While industry has begun to recognize the importance of recruiting engineering graduates with strong global skills, professional skills and interest in lifelong learning in preference to technical knowledge [15], engineering design education is struggling to catch up with this shift in priorities. International Development is a field that necessitates strong global and professional skills such as communication, ethics, and cultural and contextual adaptability, and is at the forefront of new design programs and courses that focus on the development of engineering and design students' professional skills through the introduction of a global development context to the technical concepts of engineering design [16-24]. This will allow engineering to reconnect itself not just to technology as tools, and science as theories – but to technology and science as a response societal and environmental needs, as shown in the engineering design system model developed by the United Nations Educational, Scientific and Cultural Organization UNESCO;

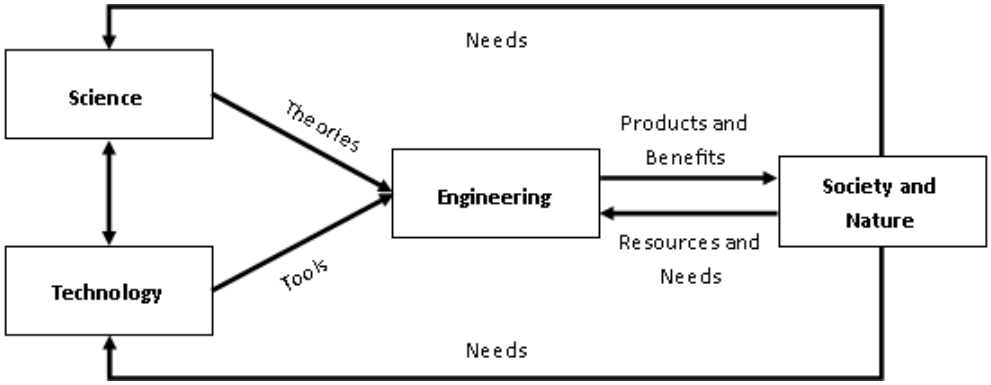

Figure 1 - Engineering System model – adapted from UNESCO [5]

This switch in educational priorities for engineering and design undergraduate students is obviously critical to the availability of appropriately trained, globally focused engineering graduates to work in international development in support of the UN SDG's. However, this change also has two other less tangible outcomes. Western engineering design education is often used as a model by universities in developing countries [5]. Therefore, changing engineering design educational norms in the United States from the current post-colonial, positivist mindset to a critical, human-based educational pedagogy could change the educational norms in engineering design education in developing countries, providing engineering design education that is more appropriate and applicable to the local context. Also, as the world becomes more interconnected, it will not be possible to train engineers and designers nationalistically because all engineers and designers will need the skills to work globally, either on globally located teams [25] or on international projects. Projects, courses, and curricula used in teaching engineering design for international development demonstrate how engineering education can and needs to change from technical-content-focused education towards a more skills-and-application-based future.

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