Mobilizing and Equipping the Technical Workforce for the SDGs through platforms for Interdisciplinary and Multi-stakeholder Collaboration

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Abstract

A shortage of engineering professionals engaging in the development and delivery of solutions for the SDGs threatens their realization. This brief seeks to share lessons learned from four years of implementation of a workforce development program focused on mobilizing and equipping engineering students and early-career engineers worldwide to solve sustainability challenges.

The global engineering workforce is not equipped to integrate the values and objectives of sustainable development to tackle systemic socio-technical challenges addressed by the 2030 Agenda for sustainable development [1]. Additionally, employment and career opportunities in sustainable development are affected by a disconnect between academia and industry [2]. Active participation of engineers, technologists, and scientists is recognized as a lever for delivering the SDGs [3]. Upskilling and reskilling initiatives are needed to better equip rising engineers to tackle current and future global challenges.

Since 2014, Engineering for Change (E4C) has been evolving a workforce development program serving to activate and empower engineering students and early-career engineers (within 10 years of their most recent graduation) worldwide to solve local and global challenges.

E4C Fellowship: a model for multi-stakeholder collaboration

The E4C Fellowship is a workforce development program at the intersection of technology and social impact. Sponsored by mission-aligned organizations, E4C Fellows are matched with a project partner to work remotely for five months with diverse, interdisciplinary, multi-sector teams and develop professional and technical skills by investigating or designing to advance the SDGs. Alongside the projects, the program offers management support and targeted training that includes tailored lectures, workshops, and interfaces with E4C's Solutions Library[1] - designed to increase awareness of the evolving relationship between the engineer and the world and advance knowledge to promote a Sustainable Development practice at the individual, local, and global levels.

As an intermediary organization powered by its digital platform, E4C convenes a worldwide engineering community. To date, E4C has awarded 205 Fellowships to Fellows from 46 nationalities and has completed 102 projects with organizations ranging from academia, non-profits, multi-laterals, private sector, and government agencies from more than 20 countries in Eastern, Central and West Africa, Middle East and Northern Africa, Southeast Asia, and Latin America and the Caribbean.

The Fellowship program is an example of a model to **mobilize an Engineering for Sustainable Development community,** leveraging a digital platform to increase the geographical reach of organizations or Small and Medium Enterprises in LMICs seeking technical assistance and early-career engineers seeking opportunities to apply their technical skills in challenges aligned with their values.

Engineering for Sustainable Development is the broad *interdisciplinary practice of engineering to improve the quality of life of society and the environment worldwide*, which aims to be inclusive of all sub-disciplines and philosophies of engineering and design [2].

Identified engagement pathways for early-career engineers

The collaborations enabled by the E4C Fellowship Program showcase research and design projects aligned with the SDGs occurring across several sectors and further highlight opportunities for engineers to engage in this sector, as shown in Figure 1. As of 2019, E4C established technical assistance pathways for participating organizations within the following streams:

Technology needs and impact assessment: investigating the opportunities and barriers for a technology or range of technologies to scale in a given context or region depending on the needs of the organization.

Product development and validation: assisting in product design, validation, and implementation of organization's technical offerings by integrating design frameworks with the use of digital design and modeling tools.

Technical capabilities enhancement: providing support to improve diverse technical capabilities organizations require to meaningfully implement digital tools for design, process improvement or data management.

[1] Codified database of technology-based solutions designed to be accessible and appropriate for communities living in resource-constrained environments.

Figure 1. E4C Fellowship engagement pathways for early-career engineers

Data source: Engineering for Change

Program outputs for an STI4SDGs Ecosystem

A project-based workforce development program highlights an opportunity to deliver on impact initiatives and innovation priorities of an STI4SDGs while providing an avenue for stakeholder and early-career technical professionals to connect, collaborate and grow as peers.

Capacity building:

Stakeholder collaborators **highlight levers of action for sustainability challenges** and **tackle unmet technical needs.** Organizations understand longitudinal perspectives of real-world challenges and have a unique opportunity to provide engineers insights into the ecosystem complexities where the products or services are introduced and expose them to confront the complexities of systemic social challenges. However, due to a lack of financial resources, time, or capacity, organizations addressing social impact challenges through hardware or infrastructure services experience diverse gaps in technical capabilities. A project-based collaboration allows stakeholders to answer questions at the intersection of STI and sustainability through a dedicated resource that is limited, time-bound, and addresses a specific need.

Early-career technical professionals **understand the intersection between technology and sustainable development** and **cultivate a mindset to participate in an evolving global economy.** The targeted training accessed through the program equips engineers with skills and competencies to create and implement solutions that consider broader historical, socio-technical, and environmental perspectives. While individual projects expose them to well-rounded STI approaches on the ground and provide an opportunity to apply the acquired sustainability skills. Additionally, remote project-based experiential learning is an avenue to develop digital and project management skills due to the practice of navigating diverse layers of communication, organization, and planning.

Facilitating innovation and implementation:

Stakeholder collaborators **access science-based evidence for action and systems change.** In most cases, the focus of impact organization is at the systems level and fills out roles as ecosystem-building actors and market facilitators. Obtaining targeted support through an engineer who can translate science advice into accessible language delivers a technical complement to an organization's development efforts.

Early-career technical professionals **broaden their perspective on the role and responsibilities of an engineer.** Through the immersive experience of the projects, target learning opportunities, and knowledge exchange with their peers, engineers are exposed to all aspects and disciplines required to develop and implement sustainable solutions as well as professional pathways and ecosystems defined and enabled for engineers to participate.

Mobilizing engineers for an urban metabolism

Looking at projects conducted by Fellows that showcase the opportunity for engineers to create an urban metabolism, defined as the "sum of the technical and socio-economic process that occurs in cities"[4], demonstrates that there is a fundamental role engineers can play and a need for them to be equipped to tackle today's systemic socio-technical challenges. This section provides insights into 27 projects conducted between 2019 to 2022 (Annex I) that contribute to spatial sustainability (11.1, 11.2, and 11.a) and environmental sustainability dimensions (11.5, 11.6, 11.b and 11.c) of the New Urban Agenda. Although access to services is promoted by SDG11.1, for this revision, we excluded projects directly addressing access to energy, water, and sanitation.

Projects completed by E4C Fellows address urgent priorities such as climate action, agriculture, energy, and habitat. Projects are sourced from mission-aligned organizations, particularly those funding social impact organizations such as the Autodesk Foundation. E4C Fellows with professional backgrounds ranging from Industrial Engineering, Mechanical Engineering, Architecture, Civil and Environmental Engineering, Bioengineering, Electrical and Electronics Engineering, to Engineering for International Development successfully delivered on impact initiatives and innovation priorities of diverse stakeholders. Three trends prevailed that highlight the value of engaging early-career engineers in the provision of technical assistance:

Digitization opportunities are opening a window for technical assistance to improve the uptake of Computer-aided Design (CAD) or Building Information Modelling (BIM) modeling or managing digital assets through custom data analytics tools. We have recognized an opportunity for the *provision of hardware development support* and *improving digital capabilities* of stakeholders with examples such: as the development of a digital design and manufacturing package for a 3-wheeler e-mobility solution for Powward Mobility to advance the development of context-appropriate transport vehicles **[SDG 11.2],** design and development of a digital platform to monitor an e-bike's KPI metrics such as state of charge or distance traveled for M-KOPA to assist in the maintenance of the vehicle **[SDG 11.2],** processing of GIS data of 65 sites intervened by Bridges to Prosperity in Rwanda and Uganda to visualize the impact of trail-bridges on adjacent paths and roads **[SDG 11.2 & 11. a]**

Standardization of infrastructure solutions enabled by digital tools can serve as an opportunity to create bridges between infrastructure development, evidence-based policy recommendations and standards development for low-resource settings. We have recognized an opportunity for the development of *repositories of standard designs, templates, and digital toolkits* with examples such as the development of a design package of standard assessment reports and drawing templates for the United Nations High Commissioner for Refugees (UNHCR) to advance spatial design frameworks of humanitarian settlements **[SDG 11.1],** and design of a digital BIM tool integration to automate the design of structural retrofits for different housing typologies for Build Change to advice and improve technical capabilities of Colombia's Ministry of Housing to retrofit households vulnerable to natural disasters **[SDG 11.5]**.

Science advice to decision-makers can be provided at different levels (industry, civil society, academia) by early-career technical professionals who can identify opportunities for the regulatory environment of technologies and translate science to inform policy for a given context. We have recognized an opportunity for the *development of decision-making tools and frameworks* and *evaluation of the applicability of technologies and methods* with examples such as: developing a contextualized framework for MASS Design Group to improve fire safety engineering best practices for architects, designers, and engineers in Rwanda [**SDG 11.1**], mapping the ecosystem and opportunities for circular housing solutions for low-income communities in Mexico, Kenya, India, and the Philippines for Habitat for Humanity's Terwilliger Center for Innovation in Shelter (TCIS) [**SDG 11. c**].

Recommendations

Increase post-educational training for early-career engineers providing avenues to access relevant skills training to participate in an evolving global economy, highlighting the need for better links between academia and the industry to formalize and accredit training.

Promote digital ecosystems to evolve the practice of technical assistance, making it more accessible, and engage more non-traditional stakeholders such as intermediary organizations that have access to cross-generational and interdisciplinary networks.

Strengthen regional and local ecosystems to bridge the gap of participation of early-career technical professionals such as language, digital literacy and computer and internet access by creating avenues for collaboration between academia and industry to address sustainability skills gap.

Engage non-traditional technical assistance stakeholders in policy and regulation setting through platforms that promote knowledge exchange and allow them to share their insights on evidence for action and proposed approaches to achieve changes at a systemic level.

Create avenues for engineers to engage in more traditional frameworks for decision-making, with a particular priority on training for early-career engineers, providing opportunities to engage in science-policy initiatives.

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- Esther Obonyo, Associate Professor and Director – Global Building Network, Pennsylvannia State University
- Tilly Lenartowicz, Director – Environmental Engineer, MASS Design Group

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[2] ASME, EGD Stakeholder Summit Whitepaper: Engineering Workforce Advancing Sustainable Development, 2022

[3] Independent Group of Scientists appointed by the Secretary-General, 2019, The Future is Now – Science for Achieving Sustainable Development, Global Sustainable Developing Report

[4] Kennedy C., Cuddihy J. and Engel-Yan J., 2007, The changing metabolism of cities, *Journal of industrial ecology* 11.2, 43-59.

[5] Engineering for Change, 2021, Annual Research Report

[6] Engineering for Change, 2022, Annual Research Report

Annex I [5][6]

Stakeholder	Need	SDG	Output	
UN Habitat	Inform the Affordable and Dignified Housing Plan of Kenya's government	11.1	Performance-based review of emerging construction technologies and materials	TECHNOLOGY NEEDS AND IMPACT ASSESSMENT
Habitat for Humanity	Understand the opportunity for circular housing solutions in Mexico, Kenya, India, and the Philippines	11.c	Landscape analysis of circular solutions, including methods, technologies and materials, and enablers and barriers for innovation for each given context	
MIT D-Lab	Increase awareness, use, and barriers to adoption of Evaporative Cooling Technologies (ECTs) in the Embu and Machakos Counties of Kenya	11.a / 2.3	Technology priorities assessment and analysis of contextual factors for adoption of ECTs	
Institute of Food Technologists	Identify technologies to reduce post-harvest losses for mango production in Kenya	11.a / 2.3	Landscape analysis of technologies across the value chain for mango processing	
Guyana Economic Development Trust	Identify technologies to scale the offering of micro and small agro processors in Guyana	11.a / 2.3	Landscape analysis and scenario planning of technologies for the transformation, preservation and preparation of agricultural production for intermediate or final consumption	
Bridges to Prosperity	Assessing impact of trail bridges on adjacent paths and roads in Rwanda and Uganda	11.2	Processing of GIS data and visualization of impact of 65 sites intervened	
MASS Design Group	Improve fire safety engineering for architects, designers, and engineers in Rwanda	11.1	Contextualized framework and policy recommendations	
Vartega	Obtaining a Global Recycled Standard (GRS) certification for a carbon fiber recycling business	11.6	Research and planning for GRS certification process	
Pennsylvania State University	Identifying opportunities for resilient affordable housing for flood risk reduction in East Africa	11.5	Analysis of contextual factors related to flood-impact in urban areas and identifying different solutions/measures addressing the physical vulnerability	
	Assesses the barriers preventing effective application of housing solutions for improving flooding resilience for housing within the context of Dar es Salaam, Tanzania	11.5	Mapping of barrier cause-and-effect factors to improve flood resilience	
WASE Ltd.	Further commercial validation of a containerized wastewater treatment solution that can recover	11.6 / 6.3	Pilot system for a modular containerized wastewater treatment solution	

	useful products from waste streams.			
Sanergy	Enhance design of a greenhouse that converts organic waste into useful agricultural outputs such as insects and organic fertilizer	11.6 / 6.3	Improved design of the air handling system for the greenhouse	PRODUCT DEVELOPMENT AND VALIDATION
Fresh Life	Enhance design of a black soldier fly (BSF) larvae production greenhouse	11.6 / 6.3	Improved design of the airflow control of the greenhouse	
Moving Health	Further a design of a tricycle ambulance prototype serving the Sissala East District in Ghana	11.2	Identified design considerations from field research, digital model of proposed prototype design and suggestions for a manufacturing and assembly manual.	
Powward Mobility	Further develop the design of an electric 3-wheeler, making it adaptable for three transportation modes (passenger, cargo, and mobile shop mode).	11.2	Improved digital design for suitability to rough terrain and a manufacturing package for local assembly	
EarthEnable	Improve housing conditions leveraging the use of locally sourced clay	11.1	Catalog of design details for an adobe house solution	
TAM Associati	Validate the use of 3D printing to print on-site for a use case in Sudan or Uganda	11.1	Identified constraints to print from foundation to roof through a digital model and simulation	
The Industrial Commons	Optimizing an integrated process for inventory management or products developed from textile waste	11.6	Digital system to streamline workflows and visualize inventory information	TECHNICAL CAPABILITIES ENHANCEMENT
M-KOPA	Monitor an e-bike's KPIs to provide maintenance assistance in East Africa	11.2	Digital platform to monitor KPI metrics such as state of charge or distance traveled	
Hometeam Ventures	Improve processes for scouting potential construction technologies to fund that address affordable housing bottlenecks	11.1	Digital workflow to streamline and increase funding for innovative construction startups	
BuildX Studio	Enhance technical capabilities to quantify the environmental footprint of Cross Laminated Timber (CLT) housing designs	11.b	Carbon calculator enabled by BIM design and analysis tools Revit and Tally	
	Further develop and validate a carbon calculator for sustainable infrastructure designs in Kenya	11.b	Defined carbon analysis approaches and benchmarks for traditional design typologies	
Build Change	Advice and improve technical capabilities of Colombia's Ministry of Housing to retrofit households vulnerable to natural disasters	11.5	Digital BIM tool integration to automate the design of structural retrofits for different housing typologies	
BamCore	Enhance technical capabilities to guide contractors in material placement and assembly to reduce material waste	11.b	Software-based automation tool for building panelization of a bamboo paneling system	
	Improve communication channel between the architect and the engineer to simplify a bamboo panel design process	11.b	Define team collaboration workflows through an integration of BIM tools Revit and Robot	
UNHCR	Advance spatial design frameworks of humanitarian settlements	11.1	Design package of standard assessment reports and drawing templates	
Pennsylvania State University	Assess the application of digital toolkits to enhance awareness and uptake of recommendations on design, materials, and strategies for flood and extreme heat-resilient housing among community members in Florida and Pennsylvania in the United States.	11.5	Digital platform providing information on solutions for resilient housing in low-income areas	