ENGINEERING CHANGE LAB USA

For more information on Engineering Change Lab-USA, contact Executive Director Mike McMeekin at mike.mcmeekin@lamprynearson.com and visit our website www.ecl-usa.org

THE ENGINEERING IDEAS INSTITUTE

SESSION 1:

TECHNOLOGICAL DRIVING FORCES - SOCIAL IMPACTS OF TECHNOLOGY

Summit 9 Report
July 29, 2020
Session 1

Technological Driving Forces - Social Impacts of Technology

Summit 9 • Session 1 | July 29, 2020

Introduction

Engineering Change Lab – USA (ECL-USA) Summit 9, the initial Engineering Ideas Institute, took place utilizing a virtual format on July 29 and 30 and August 5 and 6, 2020. The Engineering Ideas Institute continued the work of ECL-USA in catalyzing change within the engineering community that will assure the highest-level contributions to meeting the challenges of the future.

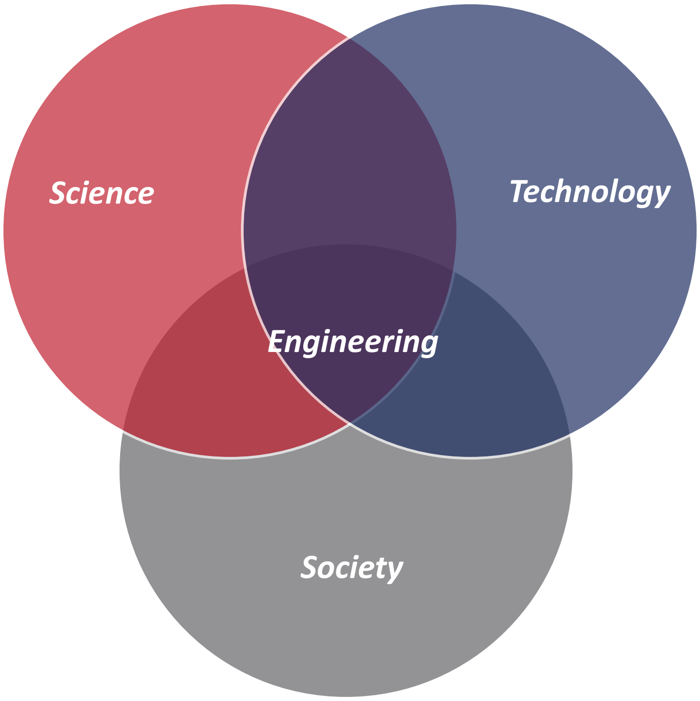
The summit kicked-off with a virtual check-in. Several highlights emerged from the check-in.

- Continued and increased interest in the stewardship role of engineers.
- Belief in the need to focus on improving equity, diversity and inclusion across the engineering community.
- Opportunities to stretch intellectually, while interacting with other leaders from a variety of backgrounds and perspectives.
- Interconnection of the themes of the summit.

Session 1 Overview

"Society and technology are entangled together" according to Thomas P. Hughes, the great historian of technology. Engineers and the engineering community, as creators and stewards of technology, are inextricably woven into this knot.

Session 1 of the Engineering Ideas Institute sought to better our understanding of the nature of this complex relationship and explore, through best-practice examples, the role that engineers and the engineering community can play in an emergent future to help society anticipate, untangle (where possible), and adapt to these entanglements.



PROVOCATEURS

Guru Madhavan
NORMAN R. AUGUSTINE SENIOR SCHOLAR &
DIRECTOR OF PROGRAMS
NATIONAL ACADEMY OF ENGINEERING

Guru Madhavan is the Norman R. Augustine Senior Scholar and senior director of programs of the National Academy of Engineering. A systems engineer by background, he received his M.S. and Ph.D. in biomedical engineering and an M.B.A. from the State University of New York. He is author of "Applied Minds: How Engineers Think" (W.W. Norton), and is an elected fellow of the American Association for the Advancement of Science and the American Institute for Medical and Biological Engineering

Iana Aranda
DIRECTOR, ENGINEERING FOR CHANGE PROGRAMS
AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Iana Aranda is the Director of the Engineering for Global Development Department at the American Society of Mechanical Engineers (ASME) where she sets the business strategy of a portfolio of programs and platforms that advance knowledge, workforce and hardware-led social innovation to improve the quality of life of underserved communities. Iana also serves as the President of Engineering for Change, LLC (E4C)- a knowledge organization and global community of over 1 million individuals dedicated to design and delivery of essential technologies advancing sustainable development.

Darshan Karwat
ASSISTANT PROFESSOR, SCHOOL FOR THE FUTURE OF
INNOVATION IN SOCIETY
ARIZONA STATE UNIVERSITY

Darshan Karwat is an assistant professor in the School for the Future of Innovation in Society and The Polytechnic School at Arizona State University, where he runs re-Engineered, an interdisciplinary group that embeds peace, social justice, and environmental protection in engineering. He studied aerospace engineering and sustainability ethics at the University of Michigan. Darshan then spent three years as a AAAS Fellow in Washington, D.C., first at the U.S. EPA on the Innovation Team, where he worked on climate change resilience and low-cost air pollution sensors; and then at the U.S. DOE helping design and run the Wave Energy Prize.

Synopsis of Provocations

DO IT YOURSELF PANDEMIC MODELS

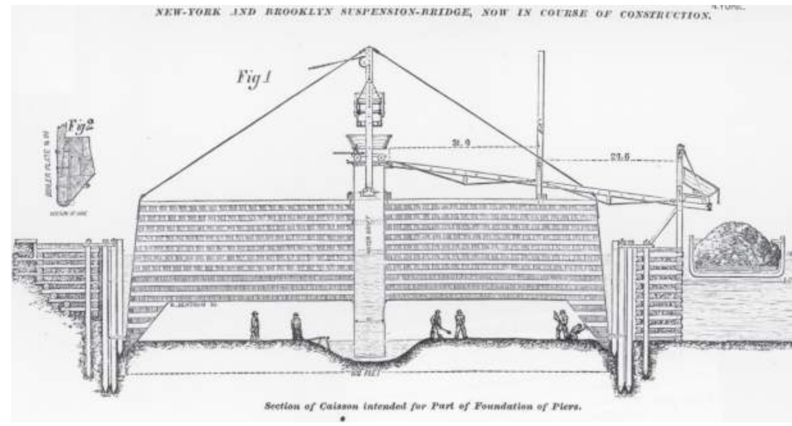
Guru Madhavan
NORMAN R. AUGUSTINE SENIOR SCHOLAR & DIRECTOR OF PROGRAMS
NATIONAL ACADEMY OF ENGINEERING

One form of engineering and scientific technology with major societal impacts is modeling. Engineering and scientific models often form the basis of planning and policy. The COVID-19 pandemic has brought epidemiological modeling to the front pages of public communication regarding the potential impacts of the pandemic. Our first provocateur, Guru Madhavan, challenged participants to examine all aspects of accountability in how models are developed and used.

EFFECTS ACCOUNTABILITY. Effects accountability includes taking a broad approach to the understanding all the physical and behavioral side effects of the phenomenon being modelled. In the medical field, a lack of effects accountability can result in healing turning into harm. In military applications, a lack of effects accountability results in collateral damage and civilian deaths.

EXPLANATION ACCOUNTABILITY. Explanation accountability entails understanding the intent and ultimate usefulness of the model. Post-event modeling of the World Trade Center collapse following 9/11 included a massive evidence-reconstruction effort that led to significant design improvements for high-rise buildings.

ENTERPRISE ACCOUNTABILITY. Enterprise accountability results from institutionalizing the knowledge gained from practical experience into models. During the early phases of construction of the Brooklyn Bridge, workers constructing the underground caissons experienced debilitating physical effects later determined to be decompression sickness. Washington Roebling and Emily Roebling experimented and ultimately adapted their construction practices to protect the workers.



With respect to the “buffet of epidemiological models” cited during the COVID-19 pandemic, Madhavan cautioned that many, including many of those that are visually appealing, are being used “without warning labels.”

Models are entangled with society through their use to shape, influence, and inform public policy and opinion as well as personal choices. Models bring with them both micro- and macro- ethical choices and dilemmas that are too often not acknowledged and considered. Given that “models are incomplete and uncertain abstractions of the real world” a key responsibility of engineers as modelers is accountability for “not just applying rigor (in developing the model) but transparently communicating to the public the assumptions and limitations that undergird even the best models and intentions.” *

The engineering community needs to contribute to a culture of modeling that replaces

“Garbage In – Garbage Out” with
“Accountability In – Accountability Out.”

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* Do It Yourself Pandemic: It’s Time for Accountability in Models, Guru Madhavan, Issues in Science and Technology, July 1, 2020, https://issues.org/real-world-engineering-pandemic-modeling-accountability/

ENGINEERING FOR CHANGE

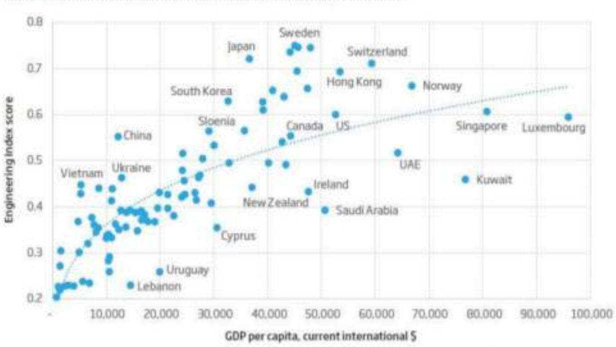
Iana Aranda
DIRECTOR, ENGINEERING FOR CHANGE PROGRAMS
AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The mission of ASME's Engineering for Change initiative (www.engineeringforchange.org) is to ***"prepare, educate and activate the international engineering workforce to improve the quality of life of under-served communities around the world."*** E4C seeks to close the gap between the between the opportunities offered by new technologies and the needs in developing countries.

In her provocation, Iana Aranda summarized the global forces driving the need for E4C – a worldwide lack of critical infrastructure and unevenly distributed technical talent around the world. Aranda emphasized the need for engagement of the engineering community to address this problem. She cited the existence of "engineering deserts" and research that demonstrates that access to engineering correlates with increases in GDP per capita. Other important forces relevant to E4C's work include the rise of investors that are prioritizing purpose (purpose-based entrepreneurship as examined in ECL-USA Summit 6) as well as millennials and Generation Z who, as employees, see the primary purpose of business as improving society (versus generating profits).

Technical Talent Gaps

Figure 28: Correlation between GDP per capita and the Engineering Index



Source: The World Bank, Cebr analysis

Study by the Centre for Economics and Business Research (CEBR)

IMPACT

1% increase in a country's score on its engineering index correlates to a 0.85% increase in GDP per capita

Engineering "deserts": Kenyan Board of Engineers estimates that there are presently 7,000-8,000 engineers in the country and ~700 receive undergraduate engineering degrees annually. To meet their goals, they will need an engineering workforce of about 20,000 within a decade.

ENGINEERING FOR CHANGE CONTINUED

Engineering for Change has built a community of over one million people that is engaged collaboratively in upskilling local people to fill these gaps and achieve the UN Sustainable Development Goals. E4C does this through the growth of knowledge communities, solutions libraries, training programs, fellowships, technology incubators, and other events and initiatives.

Aranda described a key learning from the E4C's work- ***technology does not work on its own***. She described common problems in the application of technology in the developing world.

- Flawed assumptions of how communities function.
- No plan for operation and maintenance.
- Unintended consequences.
- No consideration for community context.
- False security.

As an example of flawed assumptions, Aranda cited the example of a water system in Africa that relied on a pump driven by children playing on playground equipment. $60 million was invested in these systems, only to find that to meet water supply demands, children would need to be playing non-stop for 27 hours each day.

Working at the intersection of technology and global development requires the right complementary strategies. ASME, through the E4C initiative, continues to build this technical capacity in the engineering community.

ACTIVIST ENGINEERING

Darshan Karwat
ASSISTANT PROFESSOR, SCHOOL FOR THE FUTURE OF INNOVATION IN SOCIETY
ARIZONA STATE UNIVERSITY

Darshan Karwat's work is centered around the concept of Activist Engineering. According to Karwat, an activist engineer is one who is willing to step back from their work and examine the question, ***"What is the real problem, and does this problem require an engineering solution?"***

The need for activism in engineering stems from an acknowledgement of the realities of some types of current engineering practice. Engineering practice, by its nature, embodies not just technical problem-solving, but also political realities. In some cases, we justify the work we do as engineers even when there are negative consequences, often by stating that we are only responding to government policy or directives from others. Karwat asserts that many working engineers have little sense of purpose. In the engineering education sector, research suggests that engineering students' concern for public welfare decreases as they proceed through their education.

For the activist engineer, values matter, and values drive why engineering is practiced. The activist engineer has a strong interest in impacting the policies that drive engineering and applying engineering to benefit communities.

According to Karwat, building skills in critical thinking and instilling the practice of self-reflection can lead to a broader perspective and reinforce value-driven engineering practice. Karwat has developed a set of questions that can guide this self-reflection. The questions are intended to help engineers address basic questions about their practice.

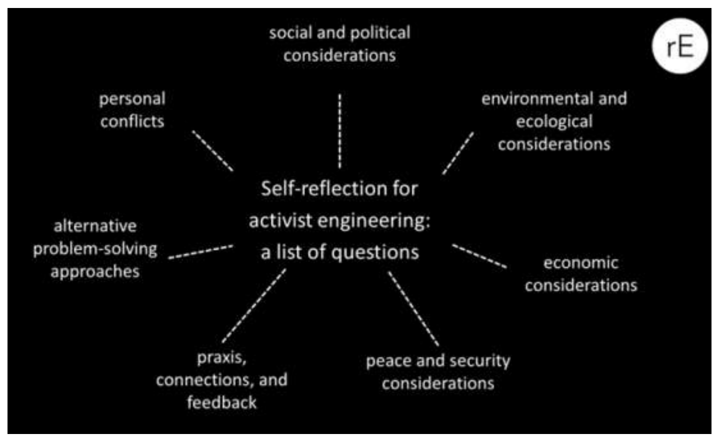
"Why am I an engineer?"

"For whose benefit do I work?"

"What is the full measure of my moral and social responsibility?"

The self-reflection questions comprehensively address the broad impacts of the practice of engineering.

- Social and political considerations.
- Environmental and ecological considerations.
- Economic considerations.
- Peace and security considerations.
- Praxis, connections, and feedbacks.
- Alternative problem-solving approaches.
- Personal conflicts.



A key element of the mission of ECL-USA is to help engineers and engineering organizations contribute at high levels to addressing the challenges of the 21st century. In our past summits we have heard these challenges described – the National Academy of Engineering's Grand Challenges and the American Society of Civil Engineers Future World Vision initiative. We have also learned of the leadership skills that are needed in engineers of the future, including systems thinking, macro-ethical thinking, collaboration, inclusiveness, polarity management, and public policy leadership. The critical thinking skills and self-reflection practices that are at the core of Darshan Karwat's philosophy of activist engineering can support the change that is needed in the engineering community and help ensure that we are contributing at high levels to the challenges that the world faces.

GROUP EXERCISE - EXPLORING THE TECHNOLOGY / SOCIETY ENTANGLEMENT

Using the learnings and challenges provided by the session provocateurs, participants moved to a group exercise designed to further explore the entanglement between technology and society and the mind shifts that are needed to ensure that technologies, both emerging and conventional, are applied to the greatest benefit.

Technology & Systems Awareness **Shifts of Mind for Getting Out Ahead**

FROM	TO
Focus on Parts or Entities in Isolation	Systems Awareness
Organization Focus	Social System Awareness
Human-Centered Focus	Whole-Ecosystem Awareness
Technology / Service Focus	Whole-Value-Network Awareness

From Value Redesigned: New Models for Professional Practice, Kyle Davy & Susan Harris

Small groups of participants took on the role of an engineering team responsible for innovating / developing the next generation of a selected technology. Groups were asked to explore the "entanglement" between their technology and the social and environmental systems within which it is nested by reflecting as a group on questions drawn from Darshan Karwat's essay, "Self-reflection for Activist Engineering."

Social and political considerations

- Who has the most to gain and lose directly from the technology/technological capability that you are designing and building? Through what means, and why?
- How quickly--and directly--will the marginalized in society benefit from the technology/ technological capability that you are designing and building?

Environmental and ecological considerations

- How are local, regional, and larger environments and ecological systems affected--both "positively" and "negatively" by your work?
- What environmental and ecological concerns are you leaving out of your consideration?

Praxis, connections, and feedbacks

- How are feedbacks from stakeholders and data from evaluation built into your design and implementation process?
- How do you decide whose voices/feedback are important to consider?

Personal conflicts

- Is there anything that you are doing that is counter to your values or the values of the people you claim to serve?

GROUP EXERCISE - EXPLORING THE TECHNOLOGY / SOCIETY ENTANGLEMENT CONTINUED

Insights and/or potential leverage points that emerged in the small groups were reported out to the entire group. Highlights are summarized below.

1. Consideration of the self-reflection questions immediately broadens the decision-making process.

- Recognition of the need to engage stakeholders, including new voices.
- Users can assist in defining the problem.
- Recognition of the need to build new types of teams.
- Recognition of the need for systems thinking and life-cycle thinking.
- Consideration of unintended consequences.
- Consideration of winners and losers.
- Enhanced innovation.

2. Self-reflection increases our sense of accountability.

3. Reflection results in a macro-ethical approach to problems (see ECL-USA Summit 6).

- Should the engineering code of ethics be broadened to include societal impacts, social justice, and overall benefits?

4. What is the role of regulation in ensuring a broader approach?

- Need to broaden the discussion within the entire engineering eco-system and to policy-makers.

5. Engineers often accept the “givens” that are provided to us by others.

6. We are often constrained by budget and schedule which limits reflective thinking. This type of “self-reflection” tool can, even in a limited time, generate significant, useful insights. This is particularly true when used as a group or team.

7. We cannot always allow the client to define the problem.

8. We need to find ways to get the input of young staff in an engineering organization regarding purpose and processes.

9. There are future opportunities to bring new types of thinking to “problems” and to shift the role of engineers such as in public policy.

KEY SESSION TAKE-AWAYS

1 ***The application of technology in problem-solving, such as predictive modeling, requires accountability at multiple levels – effects, explanation, and enterprise.***

2 ***Addressing the lack of critical infrastructure in under-served countries requires deep understanding that “technology does not work on its own.”***

3 ***The practice of self-reflection can advance the practice of engineering in alignment with the mission of ECL-USA, helping the engineering community to contribute at its highest levels in addressing the challenges of the 21st century.***