Engineers and Development:
The Need for Engineering Studies

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What has it meant to be an engineer working in international development, across different territories, at different periods in time, and in association with different kinds of organizations? How have visions of development and progress contributed to the formation of engineers? How have engineers come to see themselves as engaged in projects of societal service that extend beyond their countries into territories and communities often alien to them? Who has tended to make such moves and who has not? Where and for whom have engineers worked? What has that work comprised, and who has benefited? How, in particular, have engineers come to claim jurisdiction over technological developments, and how have these claims varied across time and territory? At the same time, what has led engineers to be relatively invisible in activities of international development compared with scientists and economists, given that the numbers of participating engineers far exceed the numbers from both other groups? When have engineers achieved great visibility in development projects, and under what conditions? What are likely future trajectories for engineering education and engineering work, both within and beyond projects of development and progress?

These are the types of questions related to development that are of interest to researchers in Engineering Studies. Asking these questions is important because they call attention to the dimensions of development work that extend beyond technical problem solving. Engineers involved in development projects must always deal with both the technical and nontechnical dimensions of such work. Yet the focus on technical problem solving in engineering education may not prepare them to do so well. Indeed, it may actively dissuade engineers from considering anything beyond technical problem solving to be important.

Research and teaching in Engineering Studies can help. Its key contribution to engineers involved in international development is to help them see and understand that technical problem solving always has nontechnical dimensions. It matters, for example, who is involved in decision making, as well as who benefits from the engineers' contributions to development work, or who does not. It also matters how engineers carry their forms of knowledge with them into engagements with co-workers, including both engineers and non-engineers within and beyond project organizations.

Engineering Studies is a diverse, interdisciplinary arena of scholarly research and teaching built around a central question: What are the relationships among the technical and the nontechnical dimensions of engineering practices, and how have these relationships evolved over time? Addressing and responding to this question can sometimes involve researchers as critical participants in the practices they study, including, for example, engineering formation, engineering work, engineering design, equity in engineering (gender, racial, ethnic, class, geopolitical), and engineering service to society.

The lead organization for Engineering Studies research and teaching is the International Network for Engineering Studies (INES; www.inesweb.org). INES was formed in Paris in 2004. Its mission is threefold: (1) to advance research and teaching in historical, social, cultural, political, philosophical, rhetorical, and organizational studies of engineers and engineering; (2) to help build and serve diverse communities of researchers interested in engineering studies; and (3) to link scholarly work in engineering studies to broader discussions and debates about engineering education, research, practice, policy, and representation. The lead research journal in the field is *Engineering Studies: Journal of the International Network for Engineering Studies* (www.informaworld.com/engineeringstudies). It is published three times yearly by Routledge, an imprint of the Taylor & Francis group.

Researchers and teachers in Engineering Studies are sometimes engineers with advanced degrees in the social sciences and humanities. Sometimes they are social researchers and teachers interested in engineering education and practice. Sometimes they are practicing engineers interested in the nontechnical dimensions of engineering work. The work of Engineering Studies researchers can be found most frequently at the annual meetings and publications of the Society for Social Studies of Science, Society for History of Technology, and other outlets for interdisciplinary science and technology studies.

One reason the practices of engineers are important to study is because they constitute examples of knowledge put in service to society. Studying how, when, where, and for whom engineers serve is crucial to understanding how engineering work has contributed to the emergence of key dimensions of contemporary life. To what extent, for example, has engineering education and work been focused on developing, maintaining, and extending the territorial boundaries of countries? Furthermore, studying the formation, everyday work, and career trajectories of engineers in the context of broader societal visions and initiatives offers insights into how evolving forms of engineering knowledge have become linked to varying forms of service. The participation of engineers in development work constitutes a case in point.

Over the past half-century, the participation of engineers in international development has expanded dramatically.[1] Engineers have participated in the full range of development activities, including large infrastructure development and small-scale community development, state-led development and non-governmental humanitarian work, and, most recently, emergent forms of sustainable development. How have engineering practices working within visions of development contributed to transformations in communities, societies, and landscapes? What are the implications of such transformations? To what extent, for example, has engineering development work achieved development?

Publication of this volume as the "first ever world engineering report" is stark testimony of the fact that millions of engineers working in the world today serve in relative obscurity. This is true not only for arenas of international development, but for all areas of engineering work. Science has long been understood in popular thinking as the key site of knowledge creation, with technology the product of its application. In this way of thinking, engineers have been located downstream of scientists, between science and technology. Engineering is the product of applied science.

In the case of development work, engineers have often appeared to be mere technicians of larger intellectual and societal projects imagined and run by others. The relative obscurity of engineers is especially pronounced as political leaders have often defined the goals of

development projects while scientists have gained responsibility for defining their means and economists their metrics, leaving engineers to implement what others have conceived. The absence of engineers is striking, for example, at the Science and Development Network (www.scidev.net). One of the largest online resources on development work, the Network "aims to provide reliable and authoritative information about science and technology for the developing world." Engineering, although a key dimension of every topic covered by the network, is rarely discernible. The relative invisibility of engineering in development vis-à-vis science perhaps reached a new low in 2007 when a *Science* magazine editorial announced that, in October 2007, "more than 200 science journals throughout the world will simultaneously publish papers on global poverty and human development—a collaborative effort to increase awareness, interest, and research about these important issues of our time."[2] The editorial did not mention engineers or engineering. No such effort has been attempted by engineering publications.

Yet engineering work is not captured by the image of applied science. Engineers make only selective use of findings from the so-called basic sciences. The engineering sciences differ from the basic sciences by actively seeking demonstrable gain. Once one begins to think about how engineers use the sciences along with other tools, it no longer makes sense to devalue or ignore the actions and agencies of engineers in not only development work but also technological developments in general.

Furthermore, an increasing number of academic fields are now claiming jurisdiction over technological developments. Consider, for example, all the scientific fields involved in water treatment. Yet few scientific fields frame their contributions explicitly within larger projects of service to society, as engineers have long done. Engineers are playing crucial roles, yet these are frequently hidden.

Judgments about the value of specific engineering projects to the welfare of diverse stakeholders or the health of ecosystems span a broad spectrum. Conflict and disagreement are perhaps more the rule than the exception. Precisely for this reason, it is both important and revealing to investigate the conditions of service under which engineers have contributed to development visions and projects in the past, are contributing in the present, and will likely contribute in the future. Have engineers contributed to their own relative obscurity, for example, when they attempt to enforce boundaries between the technical and nontechnical dimensions of the problems they encounter, claiming exclusive jurisdiction over the former while leaving the latter to others? To what extent have engineers understood their service as blind technical support that assigns larger societal and political responsibilities to others? At the same time, what have been the specific circumstances and conditions through which engineers have successfully achieved great visibility in development work? How have such people understood the connections, or tensions, between the technical and nontechnical dimensions of their identities?

Examining the intellectual and social contents of engineering service as well as the concrete conditions under which engineers have actually worked can also provide crucial insights into how development projects have emerged, including how and why particular forms of engineering design, analysis, and construction have succeeded or failed in specific cases, and from whose points of view. It can be worthwhile, for example, to examine specific efforts such as those by the 1960s group Volunteers in Technical Assistance (VITA). In what ways and to what extent might VITA engineers have brought to international development efforts specific expectations drawn from their education in new science-based curricula and/or employment in newly emerging defense industries? [3]

Engineering Studies researchers tend to ask difficult historical, philosophical, social, cultural, political, rhetorical, and organizational questions. Consider, for example, the construction of a hydroelectric dam, a typical project in the early history of development. Engineering Studies researchers are interested in the specific historical convergences that brought engineers together with other practitioners and stakeholders and put their various forms of knowledge into contact with one another. How did these projects emerge and what contributed to their broader significance? Who had stakes in their development and outcomes? What were the outcomes, and for whom?

It makes a difference to the status of engineering work that many hydroelectric dams in the United States were built during the New Deal as means to revitalize economic growth and employment while many hydroelectric dams in what has been called the "developing world" were built during the geopolitical competitions of the Cold War. In the first case, the focus was on using engineers within the home country to facilitate recovery from the Depression, positioning the engineers as agents of collective welfare, sometimes even granting them heroic status (e.g., Hoover Dam).[4] In the second, the project was often an explicit negotiation between political and economic leaders in two different countries, one agreeing to accept technological assistance in exchange for political and economic commitments and the other using engineering to extend and maintain political and economic influence through assistance. In this latter case, the meaning of engineering work was frequently more ambiguous, depending upon who was making the judgment. Yet even in the first, the dominant accounts of collective benefit and heroic achievement do not take account of the perspectives of those for whom hydroelectric power counted as a loss rather than a gain. It is probably safe to say no development project exists in which every stakeholder wins or finds their interests and identities affirmed. For those who do not benefit or who contest its larger societal missions, the image of development can be a distinctly negative one.

Another type of question is philosophical. How do engineers involved in development projects define and understand the engineering content of their work, whether explicitly or implicitly? And how and why does that matter? For example, the achievement of effective low-cost, low-tech solutions for the removal of arsenic, a more recent type of development project, may be the product of engineers actively exchanging knowledge with members of local communities, non-governmental organizations, and other fields of technical expertise, e.g., chemistry. Might engineers who are trained to see themselves primarily as technical problem solvers find themselves at a disadvantage in effectively engaging groups who understand and define problems differently than they do? Might they be reluctant, if not actively resistant, to critically engaging the larger contexts within which they undertake development work? Would it make a difference if engineers emerged from degree programs and other mechanisms of formation expecting to work with people who define problems differently than they do, including both engineers and non-engineers? Would it make a difference if they emerged with a commitment to engage in collaborative activities of problem definition and solution?[5]

Social, cultural, and political questions about engineers and engineering often blend together, with different researchers calling attention to distinct dimensions. One common interest is in engineering identities, i.e., how participating in engineering projects contributes to reorganizing and restructuring the identities of engineers. Continuing our examples, one might ask: how did construction of the Aswan High Dam contribute to furthering or transforming the identities of both Soviet and Egyptian engineers? Did the Soviet engineers understand their work as action in

the service of socialism, sharpening a focus on successful completion of the Dam itself? Did completion of the Dam enhance a sense of nationalism among Egyptian engineers, stimulating further interest in engineers and engineering education across Egypt?[6] Or for engineers involved in the El Cajón Dam in Honduras, how might actively engaging members of local communities and possibly selecting European components and expertise have affected the standing and career aspirations of participating Honduran engineers? To what extent did they understand themselves in relation to other engineers, other technical experts, and members of the local communities they were developing their technology to serve?[7] In general, Engineering Studies researchers are interested both in what is included in development projects and what is left out, in whose perspectives gain authority and whose do not, and in what is ultimately emphasized and what remains relatively hidden.

The contents of this volume constitute an excellent case in point. This project brings together engineers from different countries and regions of the world, representing distinct disciplines, working for different types of employers (academia, industry, non-governmental organizations, and national and international organizations), and engaged in distinct types of projects (e.g., water supply, energy, transportation). Engineering for development looks differently when viewed from these distinct perspectives. It could be a useful exercise for advocates of engineering in development to make the differences among themselves more visible. Such could both facilitate more effective coalitions and call attention to the perspectives of others, especially non-engineers in affected communities, whose perspectives may not be formally represented in development projects.

In coming years, a key reason for the relative invisibility of engineers, their location and work as technical mediators, could become a crucial site for the examination of engineering work.[8] The work of mediation between science and technology has long been dismissed as a relatively unimportant process of diffusion or circulation. But if mediation includes translation from isolated worlds of researchers into terms and means of implementation that must fit the conditions of affected communities and lives of diverse stakeholders, such work is a crucial site of creative contribution. In recent years, engineers engaged in sustainable community development have found themselves mediating the perspectives and forms of knowledge of local communities, municipal governments, national government agencies, and international organizations. Is such work external to engineering practice, or an integral component?

Engineering Studies researchers thus call direct attention to the existence and presence of engineers, as well as to the technical and nontechnical contents of engineering work. They seek to increase the visible presence of engineers and engineering work and to contribute to improving the abilities of engineers to both serve and critically analyze the projects they engage. Built into engineering knowledge and engineering work is a sense of altruism that has received relatively little critical analysis or attention. Preserving the work of putting engineering knowledge into service, making more visible what is both included and excluded from that service work, and enhancing the extent to which engineering service benefits widely distributed populations, including those at low-income levels, all depends upon both understanding and critically engaging what engineering is, who engineers are, and what engineers do. Engineering Studies researchers aspire to such contributions, in order both to understand and to help.

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[1] For an overview, see Lucena, Juan C. and Jen Schneider, 2008, "Engineers, Development, and Engineering Education: From National to Sustainable Community Development," *European Journal of Engineering Education* (forthcoming).

[2] Borlaug, Norman E., 2007, "Feeding a Hungry World," Science, 318(5849), 359.

[3] Pursell, Carroll. 2001. "Appropriate Technology, Modernity and U.S. Foreign Aid." Proceedings of the XXIst International Congress of History of Science, Mexico City, 7-14 July: 175-187.

[4] Billington, David P. Big Dams of the New Deal Era; a confluence of engineering and politics. Norman; University of Oklahoma Press, 2006.

5 For accounts of two educational efforts in this direction, see Downey, Gary Lee, Juan C. Lucena, Barbara M. Moskal, Thomas Bigley, Chris Hays, Brent K. Jesiek, Liam Kelly, Jane L. Lehr, Jonson Miller, Amy Nichols-Belo, Sharon Ruff, and Rosamond Parkhurst, 2006, "The Globally Competent Engineer: Working Effectively with People Who Define Problems Differently," *Journal of Engineering Education* 95(April)2:107-122; Downey, Gary Lee, 2008, "The Engineering Cultures Syllabus as Formation Narrative: Conceptualizing and Scaling Up Problem Definition in Engineering Education." *University of St. Thomas Law Journal* (forthcoming; special issue on the formation of ethical professional identities); and Schneider, Jen, Jon A. Leydens, Juan C. Lucena, 2008, "Where is "Community"?: Engineering Education and Sustainable Community Development," *European Journal of Engineering Education* (forthcoming).

[6] Moore, Clement Henry. 1994. *Images of Development: Egyptian Engineers in Search of Industry*. Cairo: The American University of Cairo Press.

[7] Jackson, Jeffery. 2007. The Globalizers: Development Workers in Action. Baltimore: John Hopkins University Press

[8] For elaboration, see Downey, Gary Lee. 2005. "Keynote Address: Are Engineers Losing Control of Technology?: From 'Problem Solving' to 'Problem Definition and Solution' in Engineering Education," *Chemical Engineering Research and Design,* 83(A8):1-12.