Engineering and Social Justice

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In the University and Beyond

by

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Purdue University Press
West Lafayette, Indiana

Printed in the United States of America.

Library of Congress Cataloging-in-Publication Data

Engineering and social justice : in the university and beyond /
[edited by] Caroline Baillie, Alice L. Pawley, and Donna Riley.
p. cm.
Includes bibliographical references and index.
ISBN 978-1-55753-606-8 (pbk.) -- ISBN 978-1-61249-156-1
(epdf) -- ISBN 978-1-61249-157-8 (epub) 1. Engineering ethics. 2.
Engineering--Social aspects. 3. Engineering--Study and teaching. I.
Baillie, Caroline. II. Pawley, Alice. III. Riley, Donna (Donna M.)
TA157.E546 2012
174'.962--dc23
2011036984

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Foreword

Reflections on engineering and social justice in teaching, learning, and research

Karl A. Smith

Engineering and engineering education in the United States have undergone tremendous changes since Thomas Jefferson signed the legislation establishing The United States Military Academy in 1802. Colonel Sylvanus Thayer served as Superintendent from l8l7 to l833 and made civil engineering the foundation of the curriculum. The first civilian engineering school, Rensselaer Polytechnic Institute (RPI), opened in 1824 and granted the first engineering degrees in 1825. Many of the changes are documented in a long series of reports conducted under the auspices of the Carnegie Foundation for the Advancement of Teaching, the American Society for Engineering Education, and the National Academy of Engineering. An early, notable report was the 1918 Mann Report, and the most recent is the 2009 Jamieson/Lohmann Report. Until recently these reports focused primarily on the curriculum. The Jamieson/Lohmann report focuses on student learning outcomes and a scholarly approach on the part of faculty.

Changes in engineering and engineering education are driven in part by the fundamental nature of engineering that is advancing the state-of-the-art through progressive refinement (Koen, 2003) and the evolutionary nature of technology (Arthur, 2009; Kelly, 2010). Technology, according to Arthur (2009), is defined by three principal features:

1. A means to fulfill a human purpose
2. An assemblage of practices and components
3. The entire collection of devices and engineering practices available to a culture

The question of purpose, especially whose purpose and who gets to choose, is solidly located in the engineering and social justice realm.

Changes are also driven by broader technological, social, political, economic, environmental, global, and other influences. Some current drivers for change are documented in the National Academy of Engineering Grand Challenges report (NAE, 2008) and include:

- Make solar energy economical
- Provide energy from fusion

- Develop carbon sequestration methods
- Manage the nitrogen cycle
- Provide access to clean water
- Restore and improve urban infrastructure
- Advance health informatics
- Engineer better medicines
- Reverse-engineer the brain
- Prevent nuclear terror
- Secure cyberspace
- Enhance virtual reality
- Advance personalized learning
- Engineer the tools of scientific discovery

Conspicuously missing from this list is an emphasis on engineering and social justice. While nearly 200 years have passed since the first engineering degrees were granted in the United States, there are still huge discrepancies among groups and individuals who are served by and benefit from engineering and technological developments, which have provided for some clean water and air, safer products (automobiles, for example), and better services. This book is an important contribution in raising awareness and increasing emphasis on social justice in engineering. As noted by the editors, "we see huge potential in engineering to serve society—all of society."

The adoption of ABET Engineering Criteria 2000, which embraced student learning outcomes, has dramatically changed engineering education (Lattuca, Terenzini, & Volkwein, 2006); however, the ABET a-k outcomes only vaguely emphasize social justice. Elements of the *Desired Attributes of a Global Engineer* (Lewis, 1997) list began to embrace social justice more directly.

- A multidisciplinary, systems perspective, along with a product focus
- A basic understanding of the context in which engineering is practiced, including:
    - Customer and societal needs and concerns
    - Economics and finance
    - The environment and its protection
    - The history of technology and society
- An awareness of the boundaries of one's knowledge, along with an appreciation for other areas of knowledge and their interrelatedness with one's own expertise

- An awareness of and strong appreciation for other cultures and their diversity, their distinctiveness, and their inherent value
- A strong commitment to team work, including extensive experience with and understanding of team dynamics
- Good communication skills, including written, verbal, graphic, and listening
- High ethical standards (honesty, sense of personal and social responsibility, fairness, etc)
- An ability to think both critically and creatively, in both independent and cooperative modes
- Flexibility: the ability and willingness to adapt to rapid and/or major change
- Curiosity and the accompanying drive to learn continuously throughout one's career
- An ability to impart knowledge to others

The United States has been guided recently by calls for increasing competitive advantage, most prominently in the National Academies' report *Rising Above the Gathering Storm* (National Academy of Sciences, 2005), which cautioned: "Without a renewed effort to bolster the foundations of our competitiveness, we can expect to lose our privileged position." The follow-up report, *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5*, (National Academy of Sciences, 2010) reinforces this claim and highlights a sense of extreme urgency.

I argue in a recent chapter, "Preparing Students for an Interdependent World: Role of Cooperation and Social Interdependence Theory" (Smith, 2011), for increasing emphasis on global collaborative advantage and developing students' knowledge, skills, and habits of mind that support developing collaborative approaches to challenges and opportunities. The argument is based on social interdependence theory and Lynn and Salzman's (2006, 2007) work on collaborative advantage. Lynn and Salzman argue that globalization is permeating the US economy at multiple levels, and therefore, continued support of "techno-nationalism" is not in our best interest. They claim in their 2006 *Issues in Science and Technology* article, "Collaborative Advantage," that:

> The United States should move away from an almost certainly futile attempt to maintain dominance and toward an approach in which leadership comes from developing and brokering mutual gains among equal partners. . . . Such "collaborative advantage," as we call it, comes not from self-sufficiency or maintaining a monopoly on advanced technology, but from being a valued collaborator at various levels in the international system of technology development. (p. 76)

Among their three goals for the United States, they argue that "the United States needs to develop a science and technology education system that teaches collaborative competencies rather than just technical knowledge and skills" (p. 81). Their research indicates that cross-boundary skills (working across disciplinary, organizational, cultural, and time/distance boundaries) are needed more than technical skills. Lynn and Salzman (2007) note that "In collaborative advantage, mutual gain comes from the strength of interdependencies" (p. 13).

One place where cooperation and competition have enormous influence on students in engineering programs is in grading systems, which until recently have been primarily competitive (norm-referenced) grading systems. Grave concerns about justice emerge when we examine grading systems (Deutsch, 1979, 1985; Smith, 1986, 1998). Several researchers have challenged the default grading-on-the-curve (norm-referenced) system:

> It is not a symbol of rigor to have grades fall into a "normal" distribution; rather, it is a symbol of failure—failure to teach well, to test well, and to have any influence at all of the intellectual lives of students. (Milton, Pollio, & Eison, 1986, p. 225)

Additionally, Ben Bloom, famous for many things, including "Bloom's Taxonomy," states:

> If we are effective in our instruction, the distribution of achievement should be very different from the normal curve. In fact, we may even insist that our educational efforts have been unsuccessful to the extent that the distribution of achievement approximates the normal distribution. (Bloom, Madaus, & Hastings, 1981, p. 52)

Engineering faculty are slowly changing from norm-referenced to criterion-referenced grading systems (Astin, 1993; DeAngelo, Hurtado, Pryor, Kelly, & Santos, 2009), and it is in this spirit of challenging assumptions and prevailing norms that the authors of *Engineering and social justice: In the university and beyond* compel us to think more deeply about who is in our classes (and who is not) and whose interests are being served, or as Ursula Franklin asks of any engineering project, "who benefits and who pays?"

The dismal progress in advancing the state-of-the-art of thinking and action on engineering and social justice will require modern approaches, such as embracing complexity theory and complex adaptive systems (Axelrod & Cohen, 2001; Miller & Page, 2007). Page (2009) claims that a "system can be considered complex if its agents meet four qualifications: diversity, connection, interdependence, and adaptation" (p. 4). Furthermore, he argues that "the attributes of interdependence, connectedness, diversity, and adaptation and learning generate complexity" (p. 10). In terms of diversity, Page (2007) argues that "progress depends as much on our collective differences as it does on our individual IQ scores" (p. xx).

I encourage you to immerse yourself in the stories, narratives, claims, arguments, and evidence in *Engineering and social justice: In the university and beyond*, and I am hopeful that together we can embrace our interdependences and help engineering make for a more just world.

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