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Reading Like an Engineer in 1960s America

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> *Engineers are the chief revolutionaries of our time. . . . When engineers in greater numbers come to know explicitly what they are doing, when they recognize their dedication, they can join with alert humanists to shape a new humanism which will speak for and to a global democratic culture.*
>
> **— Lynn White**[1]

By its very nature, engineering is a normative practice. Engineers distinguish themselves from scientists and—as this essay investigates—perhaps also from humanists by building their imaginary world—the *ought* of technology—into the real world.[2] But the mind's eye of the engineer sees not

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1. Lynn T. White jr., "Engineers and the Making of a New Humanism," *Journal of Engineering Education* 57 (1967): 375–76.

2. Bruno Latour, *Aramis, or, the Love of Technology* (Cambridge, Mass., 1996). See also Walter G. Vincenti, *What Engineers Know and How They Know It: Analytical Studies from Aeronautical History* (Baltimore, 1990); Eugene S. Ferguson, *Engineering and the Mind's Eye* (Cambridge, Mass., 1993), 153–68; and Louis L. Bucciarelli, *Designing Engineers* (Cambridge, Mass., 1994).

only diagrams, equations, and models of things. What engineers know is also formed by malleable assumptions about how society works, how it worked in the past, and how it will or will not change as a result of their interventions. How they know, moreover, comes not simply through cultural osmosis, on the job acculturation, or from the various familial relations, private organizations, and media that contribute to an individual's worldview; rather, since the turn of the twentieth century, to a significant degree engineers' social knowledge has been designed. Like diagrams, equations, and models, it has been instilled through credentialed training in the reading of social texts, sometimes guided by engineering faculty and at other times by specialists in the humanities and social sciences. Even among engineering educators, the normative dimension of this training often fails to attract serious deliberation. Engineering faculty consider the humanities and social sciences a necessary, but comparatively small, time commitment for fostering communication skills, good citizenship, and cultural finishing, while students often view such knowledge as irrelevant to their future careers.

Nonetheless, for almost as long as engineering careers in the United States have begun in the academy, reformers have targeted the humanities and social-science elements of their curricula to reinvent who engineers should be. The Mann report of 1918, *A Study of Engineering Education*, the first national study of engineering education, called for "humanistic" coursework, particularly the study of writings by prominent engineers, to instill "humane intelligence" and the "professional spirit."[3] Similarly, during the Great Depression, Robert Doherty developed his social-relations curriculum to mold engineers as agents of change.[4] As David Noble has shown, the strongest call for enhanced social knowledge in the curricula of the 1920s and 1930s came from corporate employers who were convinced that a "liberal education gives power over men."[5] Yet another wave of reform, initiated by H. P. Hammond's reports of 1940 and 1944, produced a new humanistic-social division within the American Society for Engineering Education (ASEE) to promote coursework that would help the young engineer "reach his own decisions in meeting the problems of his study, his work and his life; and, equally important, skill in learning from doing this."[6] Educators in the

3. Charles Riborg Mann, *A Study of Engineering Education* (New York, 1918), 63–66, 88, 92–94, 106–8; Frank Aydelotte, *English and Engineering: A Volume of Essays for English Classes in Engineering Schools*, 2nd ed. (New York, 1923).

4. Bruce Seely, "SHOT, the History of Technology, and Engineering Education," *Technology and Culture* 36 (October 1995): 739–72; *Selected Readings in the Study of Technology and Society*, 2nd ed. (Pittsburgh, 1941); Lawrence P. Grayson, *The Making of an Engineer: An Illustrated History of Engineering Education in the United States and Canada* (New York, 1993), 138–42.

5. David F. Noble, *America by Design: Science, Technology, and the Rise of Corporate Capitalism* (New York, 1977), 32.

6. Elliot Dunlop Smith, "Can Humanistic-Social Study Be Made Engineering Educa-

burgeoning cold war research university—some trained in engineering disciplines, others in English and history—modulated these claims into "general education" for democratic citizenship.

This half-century of pedagogical change altered the manner in which engineering students encountered Plato's *Republic*, Marlowe's *Dr. Faustus*, and the like. But to the consternation of reformers, most engineers—preoccupied by an explosion in the scale and scope of scientific research—retained the view that the nontechnical was noncritical, and hence students followed their lead. Then, in the late 1960s, business-as-usual threatened to be upended as America's culture wars challenged engineers' foundational assumptions about technology and society.

A shake-up in engineering curricula began unassumingly when design advocates during the early 1960s responded to what they saw as an overemphasis on scientific training and a consequent loss of professional identity. Humanistic-social pedagogy appeared to be entering yet another turn in the cycle. But, sparked by the profession's transformation in the cold war military-industrial complex and a flourishing of cultural criticism that gave the system its name, by 1967, reform had taken on an encompassing urgency. Engineers across the profession came to fear that they were losing authority over technology, and that this had as much to do with language and philosophy as it did with technical complexity.

To gauge the difference in tenor, one need turn no further than the pages of *Technology and Culture*. Founded in part to enhance engineering's luster, the journal's January 1969 issue gave space to a dispute being carried on by the nation's engineering educators. Were engineers responsible for assuring that "*technology is for man, and not man for technology*," and, if so, could liberal education be responsibility's motor?[7] The scale of reform was as large as its normative ambition. A survey by Henry Knepler of the Illinois Institute of Technology (IIT) documented over 200 engineering programs crafting "more meaningful" liberal arts courses to demonstrate that "neither in basic nor applied science is there a decision devoid of value judgment."[8]

This essay interrogates such philosophical engineering, analyzing engineers' attempts to reconstitute beliefs about technology and self by reading their critics in the classroom. Doing so brings into focus the intersection of three lines of inquiry. First, it highlights a period of cultural and intellec-

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tion?" *Journal of Engineering Education* 36 (1946): 134–38. The Society for the Promotion of Engineering Education became the ASEE in 1946. "Aims and Scope of Engineering Curricula," *Journal of Engineering Education* 30 (1940): 555–66; "Report of Committee on Engineering Education After the War," *Journal of Engineering Education* 34 (1944): 589–614.

7. W. E. Howland, "The Argument: Engineering Education for Social Leadership," *Technology and Culture* 10 (1969): 6 (emphasis in original).

8. Henry Knepler, "Engineering Education and the Humanities in America," *Leonardo* 6 (1973): 305–9.

tual upheaval in the history of engineering that was at least as significant as the appropriation of progressive ideology in early corporate America. Second, it demonstrates how methodologies in the history of reading can aid historians of technology in their interpretation of how meaning in technology is made. And finally, it offers contemporary educators—engineers, humanists, and social scientists alike—cautionary observations and a possible direction amid renewed enthusiasm for reform.

Engineering Education for an Era of Revolutionary Change

Longstanding tropes in engineering culture already had begun to show cracks amid the technological optimism and patronage contests of the Eisenhower years. Job specialization, the consolidation of engineering labor into workforces in the tens of thousands, and the cultural ascendancy of science challenged engineers' self-image as creative individuals responsible for technological progress. Engineers lamented that scientists took credit for engineering achievements; at the same time, they were drawn to science's aura. Individually and collectively, they also worried about falling behind what they viewed as the rapidly accelerating pace of technological advance.

Gary Downey and Juan Lucena have argued that "the greatest passion in engineering reform movements is found in efforts to redefine the contents of engineering education, especially the forms of knowledge that make engineers maximally appropriate for the time and place."[9] In Sputnik's aftermath, few were content with engineering education. Critics attacked the narrow-mindedness of the "organization man"; the National Science Foundation (NSF) projected manpower deficits; employees warned of obsolescence; and corporate, professional, and political elites wondered aloud how American institutions would meet cold war demands.

For reformers in the late 1950s and early 1960s, the humanities and social sciences again became candidates for relevance. In 1961, the Engineers' Council for Professional Development (ECPD) requested that the ASEE conduct a national review of engineering curricula to follow up on its Grinter Report of 1955. The six-year study, *Goals of Engineering Education*, emphasized the challenges of fulfilling the aims of engineering science.[10] It

9. Gary Lee Downey and Juan C. Lucena, "Knowledge and Professional Identity in Engineering: Code-Switching and the Metrics of Progress," *History and Technology* 20, no. 4 (2004): 395.

10. Bruce Seely, "The Other Re-engineering of Engineering Education, 1900–1965," *Journal of Engineering Education* 88 (1999): 285–94. The interim report was criticized by industry for ignoring "the inability of engineers to express themselves in clear, concise, effective, and interesting language." The final version thus emphasized the vocational aspects of the humanities. Still, it concluded that an engineering education should convey "an understanding of the evolution of society and of the impact of technology on it; and acquaintance with and appreciation of the heritage of other cultural fields; and the development of both a personal philosophy which will ensure satisfaction in the pursuit of a productive life and a sense of moral and ethical values consistent with the career of

portrayed the profession as caught in a bind that required new pedagogical approaches. Scientific and technical knowledge was expanding, while its useful lifetime contracted; new social and technical problems necessitated integrating scientific knowledge with creative design. Published in 1965, the preliminary *Goals* report asserted that in "a world of accelerating technological change," the engineer was a "builder of bridges between the world of science and the world of man" who must be "sensitive, farsighted, responsible, and dynamic." Meeting these ambitions would strain curricula to the breaking point, however. The *Goals*'s major and most controversial suggestion was to designate the master's degree as the "first professional degree." But it also stressed that humanistic-social training could help set the "genuine engineer" apart from the technician and the abstruse scientist as a man who could see the "system of the future as a whole."[11] In short, humanistic-social studies would give the engineer a clear identity, enhancing the profession's power with respect to science and the state.

Questions of self-definition, however, were exacerbated and ultimately overshadowed by a broader conceptual breakdown. While critiques of technology generally become more prevalent amid social or political catastrophe, in this case the perceptual shift began at the height of America's economic affluence and global power.[12] During the late 1950s and early 1960s, a confluence of events from Sputnik to the publication of Rachel Carson's *Silent Spring* challenged dominant narratives of material progress. Technology came to be cast even by its designers as an autonomous agent of social change, revolutionizing and integrating society in a complex system with unintended consequences. As emphasized in the *Goals* report, this ambivalent progressivism identified human agency—including that of engineers—as secondary to the logic of technology.

By the end of the 1960s, disparate criticisms coalesced into an interrogation of the technological foundations of modernity. Aided by an expansion in paperback publishing, Jacques Ellul, Lewis Mumford, and scores of other intellectuals, policymakers, and social theorists produced a new genre of "technology and society."[13] This ideological debate about the nature and control of technology offered a host of concepts—the mega-machine, the

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a professional engineer." "Summary of the Report on Evaluation of Engineering Education," *Journal of Engineering Education* 46 (1955): 25–60.

11. *Goals of Engineering Education: Preliminary Report* (Washington, D.C., 1965), 11, 20, 21. For further background, see Jonathan Harwood, "Engineering Education between Science and Practice: Rethinking the Historiography," *History and Technology* 22, no. 1 (2006): 53–79; Bruce Seely, "Research, Engineering, and Science in Engineering Colleges, 1900–1960," *Technology and Culture* 34 (1993): 344–86.

12. Jeffrey Herf, "Belated Pessimism: Technology and Twentieth-Century German Conservative Intellectuals," in *Technology, Pessimism, and Postmodernism*, ed. Yaron Ezrahi, Everett Mendelsohn, and Howard P. Segal (Amherst, Mass., 1995), 115–36.

13. On publishing, see Marshall Best, "In Books They Call It a Revolution," *Daedalus* 92 (1963): 30–41; on technology's critics, see Langdon Winner, *Autonomous Technology: Technics-out-of-Control as a Theme in Political Thought* (Cambridge, Mass., 1977), 133.

technostructure, the technological society—that provided commonality among the countercultural, environmental, civil rights, and antiwar movements in what Theodore Roszak dramatized as "a cultural constellation that radically diverges from values and assumptions that have been in the mainstream at least since the Scientific Revolution of the seventeenth century."[14]

Confronted with charges of technology's failure, engineers could have chosen quiescence or defensiveness; instead, many became surprisingly vocal in questioning their role in social change. In member societies and alternative organizations, professional journals and underground newspapers, engineers debated, refuted, and appropriated critical texts in an effort to discern their societal obligations.[15] It was in the academy, however, where engineers engaged most visibly with a technological worldview defined not by engineers, but by cultural critics and political partisans. This was due in part to the proximity of critical intellectuals, often just on the other side of the quad, and to the receptiveness of self-reflective engineering faculty members; but it was also because educators identified humanistic-social pedagogy as an area in which the future of engineering was at stake. Advocates of directed social change viewed such pedagogy as vital to reform, while engineering educators more generally recognized the power of controlling social knowledge. Whether or not one agreed that society was experiencing a *technological* crisis, beyond debate was its present *intellectual* crisis in which technology was circumspect. Engineers needed a framework for operating in a harsh intellectual environment.

Reading Like an Engineer

What are the advantages and disadvantages of civilization?

—Engineering 96A midterm exam, UCLA, 1963

Humanistic and social-scientific training present unique challenges to engineering educators that subjects such as circuits or thermodynamics do not. As previously mentioned, social knowledge is rarely valued as a part of engineering pedagogy. Compounding this perennial problem, in the "federal grant university" of the 1950s and 1960s, research was paramount, and there were few mechanisms for faculty to gain credit for innovative instruction.[16] But humanistic-social pedagogy also presented an intellectual problem: for most engineers, it was outside of their control and beyond their

14. Theodore Roszak, *The Making of a Counter Culture: Reflections on the Technocratic Society and Its Youthful Opposition* (Garden City, N.Y., 1969), xiii.

15. My book in progress explores this spectrum of activity. For initial conclusions, see Matthew H. Wisnioski, "Engineers and the Intellectual Crisis of Technology, 1957–1973" (Ph.D. diss., Princeton University, 2005).

16. Clark Kerr, *The Uses of the University* (Cambridge, Mass., 1963).

formal competency—taught, they opined, by professors who often knew nothing about engineering and were hostile to its purposes; on the other hand, if engineering educators could direct such pedagogy, they could make it serve their goals.

Irrespective of their varied intentions, engineers' efforts to apply the humanities were first and foremost about reading books.[17] Their reading in the humanities and social sciences was a process of acquiring new ideas and of making new meaning. In their *The Intellectual Appropriation of Technology*, Mikael Hård and Andrew Jamison show how intellectuals in the early twentieth century borrowed technical terms from scientists and engineers to "come to grips with modern technology by taking it out of a frightening and strange world of mechanized relations and placing it in a more familiar world of tradition and linguistic convention."[18] Engineers' reading during the 1960s was appropriation in the opposite direction: they were seeking to implement ideas formed by intellectuals into a new grounding of engineering practice.

Historian Robert Darnton has argued that when examining the spread of subversive ideas, "there is little use in asking whether a particular theme appeared first in gossip or in print, because themes originated from different points and traveled in different directions, passing through several media and milieux."[19] One finds engineer Samuel Florman making a similar claim in 1969: "In this age of mass communications, every moderately educated person knows about alienation, pollution, overpopulation, and the rest. For simple awareness of these problems one needn't read Plato and Dostoyevsky; a TV set and a newspaper will do."[20] Despite the ubiquity of media, however, it mattered a great deal how engineers came to talk about the *technological society* or the *megamachine*. The ability to cite Ellul or Mumford held for the literate engineer an epistemological worth greater than mere pessimistic grumbling. Moreover, the meaning engineers acquired was shaped by how they engaged with texts; debating Herbert Marcuse's *One-Dimensional Man* in an after-work reading group, for example,

17. Scholarship in the history of reading has demonstrated that this practice is far from transparent. See Roger Chartier, *The Order of Books: Readers, Authors, and Libraries in Europe between the Fourteenth and Eighteenth Centuries* (Stanford, Calif., 1994), 1–23; Robert Darnton, *The Kiss of Lamourette: Reflections in Cultural History* (New York, 1990), 154–90; Carlo Ginzburg, *The Cheese and the Worms: The Cosmos of a Sixteenth-Century Miller* (Baltimore, 1980).

18. Mikael Hård and Andrew Jamison, "Conceptual Framework: Technology Debates as Appropriation Processes," in *The Intellectual Appropriation of Technology: Discourses on Modernity, 1900–1939*, ed. Mikael Hård and Andrew Jamison (Cambridge, Mass., 1998), 15.

19. Robert Darnton, *The Forbidden Best-Sellers of Pre-Revolutionary France* (New York, 1996), 190.

20. Samuel C. Florman, "Comment: Engineers and the End of Innocence," *Technology and Culture* 10 (1969): 14–16.

mirrored the experience of readers of forbidden novels described by Darnton.[21]

Engineers were poachers. In contrast to the systematic analyses of social theorists, they approached technology and society texts as amateurs, making decryption errors and willful misapplications.[22] The process of reading rarely leaves traces, especially in a milieu that ascribes little worth to nontechnical knowledge. What limited accounts we do have of engineers' reading practices, however, indicate that the act could be transformative, if not transgressive.[23]

Reading social theory in a classroom was an experience of a different order: it gave texts authority. It was an effort to normalize the humanities and social sciences as relevant knowledge to the student who was not yet initiated into engineering culture. For educators, it could embody libratory possibilities for helping students view engineering anew, or it could foreclose speculation and uncertainty about technology's ill effects by contextualizing problems through the lens of the status quo. It could also entail teaching nonengineering students the true meaning of technology. Whatever the case, it was a process of *disciplining*, the aim of which was to make learning systematic: to turn poaching into social theory. Herein lay the power of pedagogical reform.[24] As one ASEE study stressed: "Whatever the kind of integration, success involves a rethinking of subject matter on the conceptual level. It is not enough just to throw things together in new combinations. There must be some kind of intellectual framework which will give meaning and continuity to the whole experience."[25] That framework almost always took the form of epochal thought that explained the engineer's role in the past, present, and future of technological society. Furthermore, educators' efforts went beyond crafting syllabi; they sought to remake social theory by composing their own classroom texts and having students address the nature of technology in written assignments.

Still, even the most determined programs started on uncertain ground. Chemical engineer Noel de Nevers, for example, author of the textbook *Technology and Society*, explained that his book was designed for use where neither students *nor instructors* had training in the subject.[26] Moreover, one's ability to inculcate a particular philosophy was never total.[27] Thus

21. "Evolution of the BBN Underground," *Signal/Noise* 1, no. 1 (1970): 1, 5.

22. Michel de Certeau, *The Practice of Everyday Life* (Berkeley, Calif., 1984), 165–76.

23. David Beers, *Blue Sky Dream: A Memoir of America's Fall from Grace* (New York, 1996), 121–24.

24. Andrew Warwick and David Kaiser, "Conclusion: Kuhn, Foucault, and the Power of Pedagogy," in *Pedagogy and the Practice of Science: Historical and Contemporary Perspectives*, ed. David Kaiser (Cambridge, Mass., 2005), 393–409.

25. Humanistic-Social Research Project, *General Education in Engineering* (Washington, D.C., 1956), 25.

26. Noel de Nevers, *Technology and Society* (Reading, Mass., 1972), back cover.

27. De Nevers was dismayed by how off the mark students could be; for example,

understanding how engineering educators employed the humanities requires studying their reading practices, how they systematized knowledge, how they distributed it, how they implemented it in the classroom, how it was received in the university, and how students approached it.

Making Humane Engineers

The first place that engineering educators turned for answers was the ASEE. Its *Journal of Engineering Education* and a series of reports provided guides to pedagogical philosophy, course outlines, and classroom practices abstracted from local experiences. The transformation it documented in the 1960s was dramatic.

In the happier days of the postwar boom, concerned educators advocated the training of engineer-citizens in the service of cold war democracy. Echoing the themes of James Bryant Conant's *General Education in a Free Society*, in 1956 the ASEE conducted a detailed survey of the "humanistic-social stem" of engineering education. Under the direction of George Gullette, head of social studies at North Carolina State University, field workers visited sixty colleges and found that over half had revised or were revising their curricula. His report, *General Education in Engineering*, portrayed incremental change: reasserting that a 20 percent minimum of a student's coursework be in humanistic-social studies, touting general-education courses for nonspecialists as superior to watered-down engineering versions, and recommending that faculty bridge the two-cultures divide by planning jointly with humanists and social scientists. But, the report went on, educators should not overreach nor expect dramatic results.[28] Course summaries outlined how citizenship and professional leadership were to be cultivated by studying European history, Shakespeare, Steinbeck, Plato, Locke, and the history of technology. The majority were surveys of Western civilization, while innovative courses such as Case Institute of Technology's Background of American Democracy addressed the United States' political tradition with an anticommunist tinge "to help create in the student a keen sense of his responsibility as an individual, as an American, and as a member of a free society."[29]

As charges against technology mounted, however, the innovative courses of 1956 seemed less than adequate.[30] Engineers were presented with myriad

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many believed that Aldous Huxley's *Brave New World* was a positive technological future. See Noel de Nevers, *A General Education Course on Technology for the Non-Technological Student* (Salt Lake City, 1970), 10.

28. *General Education in Engineering*, 3–6.

29. Ibid., 94–95. Bruce Seely examines Case Institute's curriculum at length in "SHOT, the History of Technology, and Engineering Education" (n. 4 above), 749–52.

30. Tensions were apparent as early as 1960. Earl McGrath identified engineering as "at the very center" of the problem of specialization in higher education, asserting that

new texts to master. The number of articles, books, and general screeds about technology grew at a confounding rate. Capitalizing on foundations' enthusiasm for funding interdisciplinary innovations, educators hosted workshops that brought together engineers, humanists, and social scientists to define engineering's position in a discordant world. Anthologies attempted to capture the most salient writings for study, and, by 1968, the enlightened engineer could discuss a new canon that included Lynn White's *Medieval Technology and Social Change*, C. P. Snow's *Two Cultures*, and Ellul's *Technological Society*.[31] Nonetheless, the volume and negativity of the critiques destabilized traditional courses at the same time that universities appeared to be falling into social disorder.

In a tenor of crisis, the ASEE followed up on its *General Education* survey. Directed by Sterling Olmsted of Rensselaer Polytechnic Institute (RPI), in 1968 the ASEE sent faculty teams nationally to query colleges.[32] Olmsted, who had taught engineers for three decades, was a Yale-trained literary scholar and Quaker. His report, *Liberal Learning for the Engineer*, depicted engineers as poised either to destroy society or to save it. Technological change and its consequences threatened to overwhelm the engineers, who were their supposed masters, necessitating a new means of understanding and controlling them. Mere introduction to the liberal arts was no longer enough; any investigation could not avoid a fundamental "coming to terms with the larger question of what is the role of technology in the human context."[33]

While ninety-three schools had initiated "major" programs in liberal studies since 1965, the report feared the maintenance of the status quo. It

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it was because of technology that "domestic and international social problems of unprecedented magnitude have arisen"; see Edwin J. Holstein and Earl James McGrath, *Liberal Education and Engineering* (New York, 1960), v.

31. Anthologies designed specifically for or by engineers included: Melvin Kranzberg and Carroll W. Pursell Jr., eds., *Technology in Western Civilization*, 2 vols. (New York, 1967); William Henry Davenport and Daniel M. Rosenthal, *Engineering: Its Role and Function in Human Society* (New York, 1967); Donald P. Lauda and Robert D. Ryan, eds., *Advancing Technology: Its Impact on Society* (Dubuque, Ia., 1971). A brief list of other anthologies includes: Charles R. Walker, *Modern Technology and Civilization: An Introduction to Human Problems in the Machine Age* (New York, 1962); John G. Burke, ed., *The New Technology and Human Values* (Belmont, Calif., 1966); Carroll W. Pursell, *Readings in Technology and American Life* (New York, 1969); John P. Rasmussen, ed., *The New American Revolution: The Dawning of the Technocratic Era* (New York, 1972).

32. They collected surveys from 175 schools and visited 27: Cal-Berkeley, Caltech, University of Cincinnati, Colorado School of Mines, Columbia, Cooper Union, Cornell, Dartmouth, Georgia Tech, HMC, Howard, IIT, University of Illinois, Johns Hopkins, MIT, Michigan, Newark College of Engineering, NC State, Northwestern, Penn State, Purdue, RPI, Rice, SLU, Stanford, Swarthmore, and the Air Force Academy; see ASEE Humanistic-Social Research Project, *Liberal Learning for the Engineer* (Washington, D.C., 1968).

33. Ibid., 4–7.

characterized most curricular revisions as superficial, rather than as a rethinking of engineering in the "total human culture." It offered no definitive models, but stressed the importance of developmental and contextual goals rather than utilitarian skills or content coverage and found hope in curricula co-designed by humanists and engineers. A comparison between exemplary courses in 1968 with those from 1956 demonstrates by just how much conceptions of the humanities had changed: action-oriented courses tackled social problems, general education gave way to student choice, and Western civilization was jettisoned for experimental courses such as Dartmouth's The Crisis of Human Values in a Technological Society, designed to

> examine and discuss the value judgments implicit or explicit in the decisions made by engineers, scientists, and planners in attempting to deal with such problems as local and global pollution, quality of the environment and of life in general, military funding of research, secret work, world food and population problems, nuclear deterrence, genetic control, and the man–machine relationship.[34]

While some canonical texts remained, Marshall McLuhan, Mumford, and technology and society anthologies now dominated syllabi. Olmsted concluded his report with an extensive reading list, with fifty-nine of its seventy-two texts published in 1964 or later.

Despite the often tenuous relationship between engineering and liberal arts faculties, the role of humanists stands out in these efforts to reinvent engineers. Classical literary scholars employed in engineering schools and a new breed of historians—including Melvin Kranzberg, Carroll Pursell, John Rae, and Lynn White—acted as advisors and instructors for engineering students and faculty. These humanists were embedded participants in engineering culture, and they assimilated the humanities and social sciences to engineers' sensibilities.[35] In most cases, they were ambivalent about technology's critics. Kranzberg, for example, defended technology as the height of humanistic achievement and chided humanists and social scientists for abandoning it, explaining that "[t]o make up for the failure of others to develop the human dimensions of technology, technologists must perforce educate themselves in what Simon Ramo calls 'the greater engineering.'"[36]

This affinity shaped how humanist mediators guided engineers through texts. Kranzberg and Pursell's textbook, *Technology and Western Civilization*, which was developed at the request of the United Armed Forces Institute and Extension branch of the University of Wisconsin, began in the Stone Age to demonstrate technology's centrality to humanity. But the overarch-

34. Ibid., 35–37.

35. Seely, "SHOT, the History of Technology, and Engineering Education" (n. 4 above), 741.

36. Melvin Kranzberg, "Technology and Human Values," *Virginia Quarterly Review* 40 (1964): 578–92.

ing emphasis of the two-volume work was the rapid "acceleration of technology" that had made the twentieth century the "American Century." Composed of chapters by historians and industrial-relations experts, the volumes were bookended by Kranzberg's and Pursell's reflections. They noted that the "ambivalence of technological change" had tempered the unbridled optimism of the early twentieth century but concluded that technology represented a "continuing promise."[37]

Technology and Western Civilization, however, was a transitional text between Gullette's *General Education* and the chaos portrayed by Olmsted. In the late 1960s and early 1970s, radical critiques moved from the endnotes to the front page. Electrical engineer Richard Dorf's textbook, *Technology and Society*, began simply: "Technology takes over."[38] Dorf used philosophy, economics, history, ecology, and political theory to address engineers' responsibilities for technological change. The book's first chapter alone reprinted excerpts from Gene Marine, Paul Goodman, Ivan Illich, and John Kenneth Galbraith. Critical of the "technological imperative," Dorf concluded that technology could not solve every problem. Like Kranzberg and Pursell, however, he viewed technology as the primary agent of historical change. But where *Technology and Western Civilization* chronicled the heritage of engineering and the nature of change, *Technology and Society* and textbooks like it tried to generate solutions. Putting his hope in liberally educated engineers, Dorf asserted that "[a] truly educated person must understand the technological forces present in the world and thus control them."[39]

Three Paths to New Meaning in Technology

Surveys, workshops, and textbooks are useful for locating social networks and common knowledge, but the desire for reform met institutional reality and actual students on the local level. Moreover, every local pedagogical experiment had an internal impetus for reform in addition to a national one. Reform took place in schools across the country, from MIT to Columbia, Dartmouth, IIT, and Vanderbilt. Southern California's engineering schools—the University of California, Los Angeles (UCLA), the California Institute of Technology (Caltech), and Harvey Mudd College (HMC)—deserve special attention.

I want to examine in detail these institutional peaks, in what Clark Kerr hailed as the "California mountain range," for four reasons.[40] First, they

37. Kranzberg and Pursell, "Technology's Challenge," in *Technology in Western Civilization* (n. 31 above), 704.

38. The book was the culmination of pedagogical experiments dating at least to 1968; see Richard C. Dorf, *Technology, Society, and Man* (San Francisco, 1974).

39. Ibid., 21.

40. Kerr (n. 16 above), 92.

represent three varieties of engineering school: a comprehensive state university, an elite, private research institute, and a unique experiment in "liberal engineering." Second, as a consequence of California's emergence as the cold war engine of science and technology, change at its colleges and universities was especially stark. Third, pedagogical innovations at UCLA and HMC in particular had a national impact on reform. And last, these examples demonstrate how institutions within close geographic proximity, and even close faculty interaction, could reach quite different views on how to apply the humanities.

UCLA'S EDUCATIONAL DEVELOPMENT PROGRAM

Founded in 1945, UCLA's College of Engineering offers a parable of engineering education in the postwar era. It owed its existence to Southern California's aerospace boom, in-migration, and a baby boom that tripled the state's population between 1940 and 1970, transforming UCLA from a commuter school into a central node in the multiversity.

In 1944, Professor L. M. K. Boelter was sent from Berkeley to create and head the new college. He brought with him a neoclassical vision in which education was "the catechism of engineering," meant to impart technical skill with moral content.[41] Privileging undergraduate education, he created a unified curriculum in a single department to train professional leaders rather than specialists. Students received a degree in general engineering, with freshman and sophomore years devoted to the physical sciences, mathematics, and graphics; followed by advanced training in materials, mechanics, circuit analysis, engineering design, thermodynamics, and engineering economics; and electives in a major concentration.

But California's demand for technical manpower and its desire for the research funding that supported it pulled UCLA in new directions. By 1955, the original faculty of seven had grown to eighty-six. Undergraduate instruction expanded from twenty offerings in 1945 to eighty-five in 1955. Initially, the college offered only two graduate courses, but by 1955 there were twenty-four.[42] The college's development prompted it to reexamine its purposes, and in 1957 it won a $1,200,000 grant from the Ford Foundation to undertake systematic curricular review.[43] Extending over twelve years and resulting in forty-one reports and fifteen textbooks, UCLA's Educational Development Program (EDP) would become the largest local evaluation of engineering pedagogy in the postwar era. Its "most startling discovery" was

41. L. M. K. Boelter, *Education for the Profession*, Department of Engineering, UCLA (1963), 2.

42. Statistics gathered from UCLA's catalogs from 1945 to 1955.

43. Carl W. Borgmann, *The Ford Foundation's Role in Engineering Education*, 1964. UCLA's grant was one of three awarded by Ford's new engineering-education program; MIT and Case Institute of Technology were the other recipients.

the "recognition that *expertise* in the applied humanities represents both the outstanding *need* of the professions and the most exciting challenge of professional education."[44]

The EDP's motive force was Allen Rosenstein, a magnetic-systems engineer who had been one of the first recipients of an engineering doctorate from UCLA. Rosenstein's vision of engineering incorporated engineering-science techniques, but he stressed that *design*—the professional ability to analyze, construct, and manipulate a system—was the "essence of engineering."[45] For Rosenstein, curricular planning was itself a systems problem subject to mathematical analysis.[46] The EDP contrasted engineering with science, arguing that in science, "values are deliberately excluded," whereas they "figure prominently in any statement of an engineering problem." Engineering was a process of "making the future" that required an "operational value system."[47]

The humanities thus became central to the EDP plan. Rosenstein believed that "liberal education had failed the professions," because humanists had abandoned relevance as a learning criterion. Therefore a new "applied humanities" was required to teach "the functional role of the humanities in the professions." The student had to learn that judgment was the essence of professionalism, and that he had a special responsibility for "generating new values for the society of his design objects."[48]

44. Allen B. Rosenstein, *A Study of a Profession and Professional Education: The Final Publication and Recommendations of the UCLA Educational Development Program*, School of Engineering and Applied Science, UCLA (1968), II-13 (italics in original). The EDP had an inauspicious start. The University of California System's Committee on Educational Policy challenged its necessity, suggesting that pedagogical studies detracted from scholarship, which was the mark of a "first-class university." It delayed accepting the grant and suggested using the funds to recruit faculty. Frustrated by the treatment, co-Principal Investigator Myron Tribus left to become dean of Dartmouth's Thayer School. See Committee on Educational Policy, "Ford Foundation Grant," 12 February 1960, and Myron Tribus, "Dear President Kerr," 27 January 1960, both in box 8, RS 401, UCLA university archives.

45. Allen B. Rosenstein, "Engineering Science in EE Education," in *Proceedings of the International Conference at Syracuse and Sagamore*, ed. Norman Balabanian and Wilbur R. Page (Syracuse, N.Y., 1961), 95–98.

46. D. Rosenthal, A. B. Rosenstein, and G. Wiseman, *Information Theory and Curricular Synthesis*, UCLA (1963). The process also figured prominently in Rosenstein, *A Study of a Profession and Professional Education*, III-1–22.

47. D. Rosenthal, A. B. Rosenstein, and M. Tribus, "How Can the Objective of Engineering Education Be Best Achieved?" *Data Link* 10, no. 4 (1961): 8–15. Their argument drew on insights from Lynn White, Alfred N. Whitehead, Henri Le Chatelier, and Norbert Weiner.

48. Rosenstein, *A Study of a Profession and Professional Education*, II-11, II-14. Rosenstein found inspiration in an essay by Lynn White (the source of this article's epigraph) that called for an erasure of the two-cultures divide and for the aristocracy of humanism. See also Lynn White jr., "Humanism and the Education of Engineers," in *Studies of Courses and Sequences in Humanities, Fine Arts and Social Sciences for Engineering Students*, Department of Engineering, UCLA (1963), 39–54.

A subcommittee led by engineers Bonham Campbell and Jacob Frankel worked with William Davenport, a professor of English at HMC, to rethink humanistic-social studies for UCLA's engineers. As it stood, such courses constituted less than 20 percent of the curriculum, with minimal integrated elements. The College of Engineering offered a senior capstone on the ethos of engineering and Engineering 96: The Engineer in Civilization, an introductory course with readings by prominent engineers. In 1962, at a conference attended by professors from seventeen UCLA departments and external visitors George Gullette and Howard Bartlett, Davenport reported with dismay that students took fewer humanities classes than required and often chose them based on proximity to their dorms.[49] The group argued that a required humanities course needed to be taught by the College of Engineering itself, and, in 1963, a revised Engineering 96 became Introduction to the Humanities. This new class chronicled civilization's path from Plutarch to Allen Ginsberg and was ordered around human drives to "not simply endure," but to "organize," "worship," "order," "defy," and "prevail." Faculty members from the humanities, social sciences, and performing arts gave guest lectures, and assignments written by engineering faculty prompted students to draw connections to contemporary problems. Final exams for the course included essay questions such as the following:

> Write an organized essay, beginning with the characteristics of Rome just before its "fall" as described, for example, by Muller, Hamilton, and several of our lecturers, continuing with a description of modern-day life such as given by Eliot and Arthur Miller and your own ideas and observations, leading to a set of analogies between Rome then and US society today, and conclude with a discussion of the likelihood or certainty of an impending "fall." (1963 exam)
>
> Admittedly many aspects of technology have adversely affected civilization. Can one meaningfully assign professional and individual engineering responsibility for these happenings? Present your arguments pro or con using examples where they apply. (1966 exam)[50]

Additionally, the EDP integrated history into design exercises through studies of the Wright brothers' airplane and the Hoover Dam.[51]

Materials engineer Daniel Rosenthal described the EDP's curricular changes as a Hegelian synthesis of past reform: report writing and its cul-

49. Bartlett was MIT's director of humanities. Bonham Campbell, ed., *Proceedings of the Conference on the Humanities in the Engineering Curriculum*, UCLA (1963), 3, 37.

50. William Henry Davenport and Jacob P. Frankel, *The Applied Humanities*, School of Engineering and Applied Science, UCLA (1968), 44, 75; Gershon Weltman, "Final Exam," 1 June 1966, personal papers of Gershon Weltman.

51. Educational Development Program, "The Wright Brothers' Airplane: A Case History in Engineering Design," UCLA (1964); Educational Development Program, "The Hoover Dam: A Case History in Engineering Design," UCLA (1964).

tural finishing antithesis would be superseded by applied humanities, which would make engineering "more creative and human."[52] To that end, he and Davenport co-designed an upper-division course, Engineering: Its Role and Function in Human Society, intended for both engineering and humanities students. Taught for the first time in 1966, it confronted technology's critics by asking: "Are engineers on trial?" "Are humanists on trial?" and "For what?" Its reader, which became a nationally published textbook, reprinted excerpts from Herbert Hoover to Rachel Carson and Ellul to explore the consequences of a technological society. It concluded with a set of writings under the category "hopes for the future" so that engineering and liberal arts students could see their joint path.[53]

When the Ford grant expired, the EDP released a flurry of publications. Its final report, *A Study of a Profession and Professional Education*, concluded with a discussion of the EDP's origins. "Our initial premise," wrote Rosenstein, "held that Engineering Education was in a period of crisis." Twelve years of study had convinced the EDP that engineering education's problems were symptomatic of a "massive" societal crisis, and that, if steeped in the design of optimal human value systems, engineers could combine analytical skill with scientific and humanistic knowledge to alleviate society's ills.[54]

Desires aside, the EDP's goals were at variance with UCLA's direction. When Chauncey Starr, president of the Atomic International Division of Rockwell, succeeded Boelter as dean in 1966, he implemented swift changes. The college became the School of Engineering and Applied Science to stress graduate training, divisions were formed by specialization, and freshman and sophomore courses were eliminated in favor of a pre-engineering curriculum.[55]

The integrated humanities courses were discontinued. Nonetheless, Starr liberally employed their rhetoric in support of a cost-benefit analysis, asserting that engineers needed to take "a lead responsibility for the guidance of our social development."[56] Lynn White welcomed the change, as engineering students would now encounter humanists "in their own haunts." The instructors of Introduction to the Humanities argued otherwise; engi-

52. *Studies of Courses and Sequences*, 37.

53. William Henry Davenport and Daniel M. Rosenthal, "Engineering: Its Role and Function in Human Society," UCLA (1966); a year later, their reader became a textbook in Pergamon Press's new Humanities and Social Sciences series for engineers.

54. Rosenstein, *A Study of a Profession and Professional Education* (n. 44 above), xii.

55. The trend toward graduate research was pronounced. In 1963, graduate students outnumbered undergraduates for the first time; by 1969, there were 168 faculty members, 135 undergraduate courses, and 163 graduate courses (statistics gathered from UCLA's catalogs from 1955 to 1969).

56. Chauncey Starr, "To the Prospective Engineering Student," in *Announcement of the College of Engineering* 7, no. 11 (1967): 5. On technological assessment, see Starr, "Social Benefit versus Technological Risk," *Science* 165, 19 September 1969, 1232–38.

neers needed courses oriented to their "particular psychological set," because outside a professional setting they might discount them and simply "mark time."[57]

While its plans faltered at UCLA, the EDP had a marked impact on engineering educators elsewhere. It exhausted its 3,500-copy supply of *A Study of a Profession*, and its humanities reports circulated widely; the applied humanities program at IIT was formed in conversation with the EDP; and J. Herbert Hollomon described the EDP method as the only logical means of curricular reform.[58] Still, Rosenstein's unfulfilled plan is instructive of reform's challenges at any institution competing for grants, personnel, and students in a system where success is measured in terms of quantifiable technical virtuosity.

CALTECH'S AIMS AND GOALS

A decidedly different sort of engineering institution lay just a short drive inland from Westwood Village, the home of UCLA. By the 1960s, the words *engineer* and *engineering* rarely appeared in official literature at Caltech, with 60 percent of its students majoring in physics or math. Where UCLA's student body grew rapidly, Caltech's remained consistent and small. Its faculty expanded during the cold war era, but not nearly at UCLA's pace. Finally, Caltech traditionally dedicated a quarter of its curriculum to humanities coursework.

Caltech's size, prestige, and homogeneity helped it sustain a mission of fundamental research. However, it was not immune to challenges to its vision. By the mid-1960s, faculty members worried about student unrest and a national backlash against science and technology. Drug use and attrition were rising, as students bemoaned Caltech's alienating culture.[59] In seeking solutions, "humanizing" Caltech became entangled with making social-scientific experts.

Among the largest differences between education at Caltech and other technical institutes when compared to universities like UCLA was that humanists were an institutional minority. Its humanities division began as a nondegree-granting service division devoted to teaching future scientists and engineers. For most of Caltech's history, students took a required core in literature, U.S. and European history, classical economics, and public affairs.[60]

57. Gershon Weltman and Julia B. Kessler, "How Relevant Is the Incidental? An Experiment in Engineering Education," *Engineering Education* 60, no. 10 (1970): 964–66.

58. Correspondence with IIT, unprocessed papers of Allen B. Rosenstein; J. Herbert Hollomon, *An Engineering Education Report: System Response to a Changing World*, Center for Policy Alternatives (Washington, D.C., 1973), 51.

59. Ad Hoc Committee on Potential Campus Disruptions, box L1.2; "Drugs and the Caltech Students," box X2.6; and Committee on the Freshman Year 1964–1967, box 1.1, all in California Institute of Technology archives (hereafter Caltech archives).

60. Caltech cast the humanities as a source of imagination for technical work and as

In the 1960s, however, the division's role changed. Caltech eliminated its humanities core in favor of electives, requiring only freshman English. It introduced a B.S. in economics, English, and history. This new degree served two purposes: ideally, it would produce scientifically literate graduates for political leadership, but it was also a safety valve to retain students who dropped out of science and engineering majors. The biggest change in Caltech's humanities division, however, was the expansion and composition of its faculty. New hires were interested in scholarly research, and MIT's high-profile economics and political-science programs were a source of envy. Historian Robert Huttenback was hired in 1958, economist Robert Oliver in 1959, geographer Edwin Munger in 1960, and anthropologist Thayer Scudder in 1964. In 1967, RAND economist Burton Klein joined the division, which was renamed Humanities and Social Sciences (HSS), and two new undergraduate courses were offered: Klein taught New Technology and Economic Change, and Huttenback, Oliver, Munger, and Scudder co-taught Science and Technology in Developing Areas. In short, changes in Caltech's undergraduate curriculum to some degree reflected national pedagogical trends, but faculty members viewed themselves as establishing a foundation of excellence in social-scientific research, rather than as updating their role as a service division.

For Caltech, 1967 was a turbulent year. Student president Joseph Rhodes Jr., one of the institute's few minority students, took the reform initiative. Rhodes believed that Caltech had lost its essence and was "producing highly skilled technicians."[61] He wanted to reinvigorate scientific and engineering progressivism through "alternatives to traditional methods of structuring education and organizing research," and he was successful in securing funds for a student-run air-pollution study.[62] President Lee DuBridge employed more tempered rhetoric when, in November, he embarked Caltech upon an $85 million development campaign under the banner "Science for Mankind." He explained that science had always served mankind, but in the past it had done so "haphazardly." Maximizing science and technology's "good and helpful impacts" and minimizing "adverse and painful ones" now required direction through interdisciplinary research in the social and behavioral sciences, humanities, and environmental engi-

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valuable knowledge in its own right: "Literature is taught as literature, history as history, and philosophy as philosophy"; see *Bulletin of the California Institute of Technology* 46, no. 4 (1937): 8.

61. Joseph Rhodes Jr., "Letters: Crisis at Caltech," *California Tech*, 16 April 1967, 2. Rhodes went on to graduate study in history at Harvard and served on President Nixon's Commission on Campus Unrest.

62. Associated Students of the California Institute of Technology, *Air Pollution Project: An Educational Experiment in Self-Directed Research*, California Institute of Technology (1968), 322.

neering.[63] Finally, in 1967, dissent in a faculty meeting prompted an institute-wide review of Caltech's societal obligations. For the next two years, a Committee on Aims and Goals explored plans to humanize the institute. Proposals included converting the Jet Propulsion Laboratory to an environmental-science laboratory, admitting women, having aerospace students investigate why Boeing sought to make the SST, and creating a College of Arts and Humanities.

Challenged to put Caltech in mankind's service, the faculty expressed reservations. They feared the institute would drift from its mission and dilute its excellence.[64] Attempts to attract first-rank humanities students would fail. Federal funding was declining and new programs might divert resources from science and engineering divisions. Finally, pursuing knowledge for its own sake was the essence of intellectual inquiry, and one should not be forced to be "relevant."

The social sciences offered a contentious though mediating position. Fredrick Thompson of the Department of Philosophy and Applied Science argued that Caltech should avoid action-oriented studies such as smog control or educating the "culturally deprived"; instead, it could investigate the underlying theory of problems "caused by the increasing rates of technological and social change."[65] Caltech's social scientists asserted that they could provide the institute's normative vision: science, they claimed, "recoils from the wished-for or the what-ought-to-be," and technology was not "good or bad in a social or moral sense," thus its values depended on "whom the engineer hires himself to serve"; economics and political science could address "use-judgments," because those fields had become the "applied sciences" of greatest relevance, but achieving success required a graduate program.[66]

Between 1967 and 1972, reform at Caltech took four paths: 1) Rhodes's student project, which was not repeated; 2) an expansion of environmental sciences; 3) "humane" endowments of a resident poet, an art gallery, and

63. Interdisciplinary efforts would make it "especially attractive for many individuals, corporations, and foundations to make new and generous investments in the future of Caltech"; see Lee DuBridge, "Report of the President," *Bulletin of the California Institute of Technology* 76, no. 4 (1967): 3–4. In preparation for the campaign, Caltech hired consultants to examine its reputation among corporate and civic leaders. Respondents were "vitally concerned" about social problems demanding solutions "in human terms," and viewed Caltech as weak in the humanities; see Fry Consultants, Inc., *California Institute of Technology (An Image Study)* (1967), box K4.4, Caltech archives.

64. Ad Hoc Faculty Committee on Aims and Goals, *Aims and Goals of the California Institute of Technology II: General Problems of Growth and Change of Caltech*, California Institute of Technology (1969), 45.

65. Ibid., 41.

66. Ad Hoc Faculty Committee on Aims and Goals, *Aims and Goals of the California Institute of Technology III: Introducing the Social and Behavioral Sciences at Caltech*, California Institute of Technology (1969), 71.

noncredit art classes; and 4) the institution of a Ph.D. program in the HSS division that emphasized the application of economic and political theory to "social problems inherent in change."[67] These outcomes did not please everyone. The Aims and Goals committee had questioned whether a Ph.D. program and undergraduate pedagogy were "compatible or competing," and in addition to opposition from science and engineering faculty, retiring HSS chair Hallett Smith called for "emancipating" the humanities into a separate division.[68]

The debate over humanities and social sciences thus became a debate *between* the humanities and the social sciences. Social scientists saw Caltech as uniquely poised to create expert policymakers for a technological society; critics warned against propagating scientism and defended the humanities as a source of value judgment that provided "not only a counterbalance but a valuable complement in the Caltech educational process."[69] While pedagogical philosophies were at stake, scholarship was the dominant factor in decisions about staff, direction, and curriculum. The division that emerged made concrete the tension between human values and instrumental reason at the heart of any effort to create a normative humanities curriculum.

LIBERAL ENGINEERING AT HARVEY MUDD COLLEGE

As the nation's engineering schools labored to retrofit their curricula, in 1957, the first new engineering college in three decades opened its doors, with liberal learning as its mission. Comparing itself to experimental colleges of the 1930s, a third of HMC's curriculum would be devoted to the humanities so that its students could "assume technical responsibility with an understanding of the relation of technology to the rest of society."[70] While their rhetoric was not as exceptional as HMC's founders might have imagined, their devotion to making it a reality was, and the college's progress was carefully followed by reformers elsewhere.

In 1958, HMC's president, Joseph Platt, its seven-member faculty, trustees, and consultants gathered to formalize a curriculum. A strong base in science and mathematics was essential to modern engineering, but HMC did not want to produce applied scientists; the humanities and social sciences would foster "intellectual penetration," "analytical ability," and "val-

67. Lester Lees helped found the Environmental Quality Laboratory, and the Environmental Health Sciences program became the Environmental Engineering Science Program; see *Report of the Caltech Art Program, 1968–1971*, box J1.2, Caltech archives.

68. *Aims and Goals of the California Institute of Technology II*, 52.

69. Ad Hoc Faculty Committee on Aims and Goals, *Aims and Goals of the California Institute of Technology VI: The Humanities at Caltech*, California Institute of Technology (1969), 2.

70. Harvey Mudd College, *Bulletin, 1958–1959* (1958).

ues," rather than serving as mere inputs for systems engineering. Still, the engineer was supposed to draw on them "just as he draws on Mathematics, Physics and Chemistry." Not fully resolving the liberal/instrumental divide, HMC concluded that students would learn to view engineering problems "beyond strictly technical considerations."[71]

At the start, William Davenport, former head of the English department at the University of Southern California, was chairman of a faculty of two that included himself and George Wilkes, an assistant professor of English. Like general education elsewhere, HMC's curriculum consisted of expository writing, literature, and Western civilization, with electives available in other colleges in the Claremont system of which HMC was a part. With John Rae's arrival in 1959, HMC added a history of technology course that stressed engineering's growth as a profession.

But HMC was an early innovator of cross-disciplinary and interdisciplinary coursework. In 1960, Warren Wilson replaced the freshman graphics requirement with a project-oriented design course: an open-ended problem was chosen yearly by engineering faculty in consultation with humanists and social scientists, and students were divided into teams that were required to consider nontechnical factors in their solutions. In the first year, students designed survival colonies for the preservation of culture in the aftermath of a nuclear holocaust, a task that forced them to interview faculty from across the Claremont colleges to first define "culture." In 1961, HMC also introduced Science and Man's Goals—a problem-oriented senior seminar, co-taught by a humanist and an engineer or scientist. In the fall, students examined man's individual relationship to science and technology, and in the spring, the impact of technology on society.

After a decade of instruction, however, faculty and students wondered if HMC was meeting its goals. By 1966, it had attained operational stability: faculty reached critical mass, the physical campus took shape, students enrolled in an expanding array of courses, and graduates were either accepted to top graduate programs or gainfully employed;[72] on the other hand, attrition remained high, students were grade-driven, and social knowledge seemed to have fallen into a secondary role.

HMC's crisis of confidence came to be framed as a struggle at the core of its mission—to identify "the relation of technology to the rest of society." There was broad consensus for further integrating the humanities with the technical curriculum. Proposed reforms included creating nontraditional majors to train students capable of "managing, coordinating, interpreting,

71. Harvey Mudd College, *Curriculum Study: Harvey Mudd College, June 30–August 9, 1958* (1958), 47–50.

72. In its first ten years, HMC's faculty grew from 7 to 37, and its student body from 48 to 283; see Joseph B. Platt, *Harvey Mudd College: The First Twenty Years* (Santa Barbara, Calif., 1994), 194–207.

and *criticizing* technology"; teaching new technology and society courses that would bring together engineering and liberal arts students from other Claremont colleges; and overhauling the entire curriculum.[73]

Initial reforms mirrored the evolution of Davenport's own understanding of technology. In the summer of 1968, he had visited Britain where he met Eric Ashby and C. P. Snow. He then spent his sabbatical year as a fellow at the Harvard University Program on Technology and Society. Directed by Emmanuel Mesthene, this IBM-funded program was a prolific generator of reports, books, articles, and congressional testimony in support of a position best characterized as an "ideology of technological change." Mesthene argued that technology was creating positive and negative externalities at an accelerating pace, and that social-scientific analysis could help U.S. institutions adjust. Davenport described his time at the program as constituting his "maturation as a person and as a 'scholar.'" He wrote a book titled *The One Culture* that tried to reconcile Snow's divide under the premise that technological change was the great challenge for all members of society. "Progress has its own tyranny," Davenport claimed, and the only way to master it was for humanists, sociologists, and engineers to come together "in a unified program."[74] He set the syllabus for a new required freshman course at HMC, Man, Science, and Society, with this orientation:

> Humanities II TEXTS, First Semester, 1968–69
>
> Bronowski, J., *Science and Human Values*
> Brown, Harrision, *The Next Ninety Years*
> Fromm, Erich, *The Sane Society*
> Heilbroner, R. L., *The Making of Economic Society*
> Matson, F. W., *The Broken Image*
> Mesthene, E. G., *Technology and Social Change*
> Snow, C. P., *The Two Cultures and a Second Look*
> Taylor, Philip, *The Industrial Revolution in Britain*
> White, Lynn, "Historical Roots of Our Ecological Crisis"[75]

With a grant from the Sloan Foundation, in 1969 HMC planned even deeper changes. President Platt argued that the nation's priorities had

73. *Projection '67: The Goals of HMC*, box 1, folder 6, George McKelvey Papers, Special Collections at the Libraries of the Claremont Colleges (emphasis added).

74. While in Cambridge, Massachusetts, he met Lewis Mumford, with whom he struck up a twelve-year correspondence. He also initiated correspondences with J. Bronowski and Joseph Wood Krutch; see William H. Davenport, *The One Culture* (New York, 1970), xi–xiv, 87–120. See also "William H. Davenport: Founding faculty, chairman of the Humanities and Social Sciences, Willard W. Keith, Jr. Fellow in Humanities, 1957–1973: Oral history interview," conducted by Enid Hart Douglass (1990), 113.

75. Joseph B. Platt and J. P Frankel, "A Proposal to the Alfred P. Sloan Foundation" (9 October 1968), unprocessed papers of George McKelvey, Special Collections at the Libraries of the Claremont Colleges, appendix E. Lynn White's article had appeared in the March 1967 issue of *Science*.

shifted. While Sputnik had directed resources toward space, the United States now faced fundamental problems on earth. Accordingly, HMC students were concerned with "methods for optimizing the humane use of new knowledge."[76] Stressing HMC's flexibility and its problem-oriented method, Platt borrowed language from a recent student workshop to declare that "[i]n all cases it is our society's needs, our society's uses—*and often its abuses*—of technology which dictate and will measure the value of our proposals."[77]

In 1970, HMC implemented a common freshman year divided into three fields: mathematics; natural philosophy, which included physics and chemistry; and the Quest for Commonwealth, a course "concerned with fundamental problems that modern man encounters both as an individual and as a member of a society." Quest was the vision of Theodore Waldman, who had spent a two-year leave of absence working in Cal-Berkeley's experimental Tussman College. It presented a different direction than Man, Science, and Society, which hewed closer to the social theory guiding Caltech. The goal of Quest was to introduce students to "the sources and nature of humane values" and to explore their relevance to technology. Themes included "war and peace" and "freedom and authority." All freshmen read the same texts, discussing them first in an assembly of the entire HMC community and then in small seminars. Daniel Rosenthal, recently retired from UCLA, joined with eight members of the humanities faculty as a lead instructor.

Quest taught students that "understanding the political, legal and social problems that men had dealt with was as important as suggesting a solution to them." Students read great books, from Thucydides' *History of the Peloponnesian War* to contemporary social theory. One theme—that certain tensions endured through recorded history—conveyed the perspective that some complex social problems lay beyond any solution, even scientific or technical answers. Waldman described Quest's ideal exercise to be a model of "a legislative body deliberating over a public issue" in which competing values were ever-present.[78]

On the heels of its newfound social energy, in 1972 HMC introduced a revised mission statement that served it well into the 1980s. It stressed the similitude between sonnet and equation, the human basis of all technical problems, and the cultivation of humility. "Insist that tools take you only so far," it admonished, "then apply what you know to making a better life for

76. Ibid.

77. Ibid. For the source of the language borrowed by Platt, see Associated Students of Harvey Mudd College, *The Uses and Abuses of Technology—Choice and Change* (24–27 April 1968), unprocessed papers of George McKelvey, Special Collections at the Libraries of the Claremont Colleges (emphasis added).

78. Theodore Waldman, "Quest for Commonwealth, an Applied Humanities Course," in HMC's "Applying Humanities to Engineering" (1971).

yourself—a better world for others."[79] The Quest for Commonwealth, however, was discontinued in 1974, as overtaxed faculty returned to research, the imperatives of tenure, and the comforts of disciplinary practices.

Pedagogy and the Meaning of Technology

Engineering institutions across a spectrum of prestige, size, and geography during the 1960s used the humanities and social sciences to instill the social meanings of technology to students. Variants of Southern California's pedagogical innovations and tribulations could be found in almost any engineering college in the United States as it entered the 1970s. Most replaced general education with liberal learning; most created extracurricular programs in the arts; most experimented with a technology and society course designed in tandem with humanists and social scientists; and all dealt with the question of whether technology was to blame for societal crisis. UCLA's instructors told their students that "aspects of technology have adversely affected civilization." When they asked if one could "meaningfully assign professional and individual engineering responsibility" for those effects, how were students to answer?

The great majority of educators implicitly or explicitly conveyed an ideology of technological change. According to this set of beliefs—fostered by their selection and application of texts—engineers were not primarily to blame for the crisis that technology had produced. The consequences of rapidly accelerating technological change had been unforeseen, but now that its logic had been identified, it could be managed. This was the discursive frame that the EDP used to conclude that "the rising tide of social and technological change" had "engulfed" the professions; it was the basis of Science for Mankind and Caltech's social sciences; and it was the position from which HMC started. "The fundamental fact of modern life is the acceleration of change," Platt asserted. "This fact is so obvious as not to require documentation."[80]

Why then the impulse to document? Engineering students—indeed, all students—needed to learn the "fundamental fact" of technological change in order to know their place in the world, but what that place should be was far from settled. Was the engineer a "conscious agent of social change," as Olmsted had posited, or was he "an instrument of change" to be employed by change's "manipulators," as Daniel De Simone believed all engineering students should be aware?[81] Despite similarities, the humanities stem of a

79. Harvey Mudd College, *Bulletin, 1972–1973* (1972), 1.

80. Joseph Platt, *Profile of Harvey Mudd College, 1952–1972: Prepared for the Ford Foundation* (June 1962), unprocessed papers of George McKelvey, Special Collections at the Libraries of the Claremont Colleges.

81. *Liberal Learning for the Engineer* (n. 32 above), 4; Daniel V. De Simone, "Education for Innovation," *IEEE Spectrum* 5, no. 1 (1968): 83–89, quoted in Davenport and Frankel, *The Applied Humanities* (n. 50 above), 29.

curriculum circa 1969 could encompass a range of assumptions and ambitions about the engineer's societal role: UCLA's reformers wanted engineers to be expert managers of the public good; Caltech's social scientists argued that they, not scientists or engineers, should manage social progress; HMC was founded on the belief that engineers would shape social change, though it came to instruct that engineers should be introspective about the limitations of changing the human condition through technology. In other words, reformist educators worked to create a normative vision that would provide students with the judgment and responsibility to gain mastery over out-of-control technology. In some cases, however, as they struggled to do so, they appropriated social theoretical texts that pushed against the ascending ideology of technological change, toward a vision that emphasized the primacy of norms over autonomous change and an awareness that technological fixes could have diminishing returns.

Conceptions of agency and control were guiding factors in curricular reform, and they manifested themselves in classroom exercises. Even when syllabi were similar, how faculty intended students to read informed the vision they wished to inspire. HMC's Quest, for example, viewed social and technical issues as the responsibility of all citizens. Students were to use classical and modern texts to gain awareness of long unanswered—perhaps unanswerable—questions in order to understand the challenges of technological decision making, which could not be separated from legislative decision making. UCLA had used the same texts to find similitude between ancient Rome and the "likelihood or certainty" of a contemporary fall.

Still, the longer engineers engaged with the humanities, the more they wondered what kind of tool they were trying to wield, and if it were a tool at all. At the ASEE annual meeting in 1971, Rosenthal, drawing on his experiences at UCLA and HMC, identified the challenge in desires to use humanistic-social pedagogy for engineering solutions. On the one hand, the reader of a journal like *The Engineer* would think society to be problem-free; on the other, leading engineers such as Simon Ramo recognized the "great anti-technology wave," but asserted that only engineers could provide solutions. Obviously, the need for a new vision was profound, because society rejected both these positions. Yet humanists justifiably recoiled from the "applied humanities." The ontology of the humanities, Rosenthal quoted from Jacob Bronowski, "is perpetually open because it deals with the human dilemma and because the dilemma is perpetually unresolved." Engineers, he concluded, could not use the humanities functionally as they did the sciences; if there was a way to move between the "human dilemma" and actual solutions, recognizing this "dual point of view" had to be the first step.[82]

Programs that reached or sustained Rosenthal's criterion were not plen-

82. Daniel Rosenthal, "Can Humanities Be Applied in Engineering? How?" in "Applying Humanities to Engineering."

tiful. Olmsted's *Liberal Learning for the Engineer* had identified the obstacles: specialization reigned, students lacked motivation, the multiversity created a deficit of "substantive" communication between engineering and liberal arts faculties, and humanists had turned away from "meaning." These culprits, however, left the systemic problem unnamed. In her study of the racial politics of engineering, Amy Slaton highlights what she calls the "conservative impulse" of engineering. At schools such as the University of Illinois at Chicago and IIT, efforts to raise the institution's technical reputation competed for funding with social-action programs, to the detriment of the latter. This reflected a categorical divide between technical knowledge, which was the purview of engineering, and social knowledge, which was not.[83] Slaton's analysis seems to hold both for UCLA, where Starr's model of engineering progressivism supplanted Rosenstein's, and at Caltech, where social problems were theorized with scientific methods. Even HMC's engineering clinics came to be primarily market-directed. Moreover, despite rare individuals like Joseph Rhodes, even at the height of the student movement most incoming engineering students had already internalized the division.

However, in addition to the conservative impulse—which technology and society courses could inculcate just as well as progressivism—the efforts chronicled here suggest that reformers struggled with their initial naïveté about using humanist knowledge to bridge the sociotechnical divide and the complexities of doing so in practice. The critical theories of technology that had altered the character of reform attacked the hubris of the "technological imperative." If something were to be gained by reading these texts as their authors intended, it would be a search for alternatives, the cultivation of humility or deep skepticism. Or, if approached as Platt and other champions of liberal education hoped, reading might foster moral reasoning by challenging students to ask: "How should you plan your life? What can you accept? Should you rebel, and if so, against what? What do the successes of our society offer you, and what problems do they pose?"[84]

In the best cases—HMC principally among them—listing the "advantages and disadvantages of civilization" gave way to experimental design projects, communal inquiry into cultural assumptions about technology, and critical reasoning worth a second look by today's reformers. But these were not the conclusions most engineers derived from their reading; instead, in engineering programs nationally, such texts were used as a framework for recontextualizing existing managerial relations. If technology was out of control, who better to discipline it than engineers? Technology abided by its own laws; the task of nascent engineers was to know technological change's nature and accept their responsibility to keep pace.

83. Draft copy of chapter 5, "Research in the Urban University: Engineering and the Conservative Impulse."

84. Joseph B. Platt, "Science, Society, and Student Unrest," in *Science Year: The World Book Science Annual* (Chicago, 1968), 27–34.

Coda: The End of Innocence

> *But we must ask if it serves the nation well to permit the engineering profession and engineering education to lag technology and society, especially as technological change occurs at a faster and faster pace. Rather, should the engineering profession anticipate needed advances and prepare for a future where it will provide more benefit to humankind?*
>
> **—National Academy of Engineering**[85]

As the introduction to this theme issue explains, the articles herein come from the first workshop of the International Network for Engineering Studies (INES). In the draft of my essay for that event, I had commented on the interventionist character the workshop hoped to cultivate. The fine essays that emerged, and the fact that I am writing in the same journal in which humanists, social scientists, and engineers in the 1960s documented their interventions, have only heightened my experience of temporal elision. Indeed, engineering organizations nationally and internationally are again targeting the humanities and social sciences, this time to redefine who engineers should be in a global economy. And, again, their visions range substantially—from the "humanitarian engineer" to the project manager of a multinational corporate team.[86]

The history of humanistic-social learning in the United States presents today's mediators with an ambivalent legacy. A confluence of circumstances in the late 1960s generated alternatives to accepted conceptions of technology—a moment of new possibility that momentarily appeared to alter what it would mean to be an engineer. As the decade struggled to its close, the humanities were a cause célèbre of engineering education. Returning to *Technology and Culture*'s January 1969 issue reveals the movement's hopes and frustrations. In a reprint of his essay "Engineering Education for Social Leadership," W. E. Howland, professor emeritus of civil engineering at Purdue, championed a reconstituted vision of Progressive-Era ideals. With liberal training, engineers would become expert servants, capable of maximizing the "humane potentialities of technological progress."[87] Samuel Florman responded with a rebuke befitting the times: "All of us today are in favor of liberal education for engineers, just as we are in favor of motherhood and the American flag—instinctively, almost mindlessly." It was "false and deluding," he elaborated, to assume that engineers "are not as *good* as they ought to be," and that the liberal arts "will make them *better*—more concerned with their fellow citizens, hence more moral." On the contrary,

85. National Academy of Engineering, *The Engineer of 2020: Visions of Engineering in the New Century* (Washington, D.C., 2004).

86. See, for example, Jane Lehr, Benjamin Cohen, and Jody Roberts, "The Ethical Dilemmas of a Critical Engineering Education: On Teaching Engineers to Not Be (Like) Engineers," unpublished essay from the INES Workshop, Virginia Tech, September 2006; Steen Hyldgaard Christensen, Bernard Delahousse, and Martin Meganck, eds., *Engineering in Context* (Århus, Denmark, 2009).

87. Howland (n. 7 above), 6.

engineers would lose their innocence by reading in the humanities, which fostered "individual sensibility *at the expense* of social responsibility." Still, if the engineer did not succumb to cynicism, he would be strengthened by the poison and would "sally forth into the world, rising through the Establishment to positions of power . . . and the world will be saved."[88] John Burke, professor of history at UCLA and a former metallurgist, doubted even this. Despite editing a technology and society anthology, he was pessimistic about making humane engineers, denying that they possessed unique cures for social ills; rather, those ills derived from "the inadequate studies and methods of engineers in the past."[89]

The world was saved neither by worldly wise engineers nor a technological fix. J. Herbert Hollomon reported in 1973 that "[a] decade of protest and turmoil has left engineering campuses and students only slightly changed. As before, the engineering student is comparatively pragmatic, self-directed, not people-oriented, and desirous of unambiguous situations and structured work."[90] Hollomon's lament signaled the beginning of a precipitous decline in efforts to make sociotechnical problems central to engineering pedagogy.[91]

Universities and technical institutes were left with STS programs, minor increases in humanities curricula, and brochures with an aura of human values. However, these took their place with past reforms: institutionalized, but on the outskirts of engineering culture.[92] The economic recession of the early 1970s made resources for innovative programs scarce, while tenure structures worked to attenuate commitment to pedagogical change. But such constraints do not explain fully the inability of reformers to enroll the human and material resources needed to expand upon their gains, because money and security follow vision—that is the essence of the "conservative impulse." Thus, as I have argued, the relative impact of these programs was also constrained by their participants' knowledge claims.

I certainly do not wish to deny engineering educators a usable past or to dissuade engineering students from formal instruction in social knowl-

88. Florman (n. 20 above), 14–16 (emphasis in original).

89. John G. Burke, "Comment: Let's Be Sure Technology Is for Man," *Technology and Culture* 10 (1969): 12–13; and Burke, *The New Technology and Human Values* (n. 31 above).

90. Hollomon (n. 58 above), 73.

91. MIT's School of Humanities and Social Sciences, for example, which saw student enrollments climb during the 1960s, surging to 16,856 students in the 1968–1969 academic year, shrank to 11,215 students by 1974. See "MIT Department Profiles," Department of Humanities, Records, AC404, Box 4, Folder "Dean's Report," Institute Archives and Special Collections, MIT Libraries, Cambridge, Massachusetts.

92. STS, history of science, and technology programs still pursue liberal learning for engineers, but often at cross-purposes with their own academization. For a survey, see Stephen H. Cutcliffe, "The STS Curriculum: What Have We Learned in Twenty Years?" *Science, Technology, & Human Values* 15, no. 3 (1990): 360–72.

edge; on the contrary, I myself engage in these pedagogical goals, and my enthusiasm for attending the INES workshop and for writing now comes from a desire to introduce students to new ways of seeing. But given the déjà vu, I want to reiterate an inescapable problem, made clear by historical distance. In the wake of America's intellectual crisis of technology, Langdon Winner characterized the search for a new ethic of technology as a process of philosophical engineering. He concluded that the problem with such a position is that "at the level which one seeks to elucidate first principles about man, nature, and being, the world is not a problem set. It is, if anything, a question set."[93] This observation was not lost entirely on reformers, but given their awareness of engineering's inherent normativity, many came to recognize that *no matter how* they approached the world, they were performing philosophical engineering.

Presented with this apparent impasse, making visible the question set seems a better choice than selecting an operational value system or, worse, pretending the questions do not exist. Amid calls for expert assessment, a few chose this path. Olmsted's report, for example, struck tones rarely voiced among engineers. "It is implied here," he wrote, "that a major function of the humanities is an unsettling one—not to solve problems, but to suggest them, to force reconsiderations, to break frameworks, to question assumptions, and to suggest new formulations."[94] It was not the position most educators intended when they set out to apply the humanities during the cold war era, but for today's reformers to assert less is to accede to the longevity of feigned innocence. And yet what gives engineers their power, what convinced Lynn White that they were the revolutionary key to global humanism, is their potential to initiate change and to solve problems. Any contemporary effort needs to recognize this dual point of view.

It may be absurd to champion the notion of a new humanism among engineers in a society in which humanism is so self-evidently moribund and engineering so diffuse. As humanistic mediators, however, to do otherwise is to perpetuate the demise and to ensure the replacement of the "question set" with "soft skills" and "global competencies."[95] That the technological world is constructed is a concept that its builders quickly grasp when presented either with systematic design methods or the lessons of the social construction of technology (SCOT). How engineers contextualize themselves in social and historical terms—how they read social knowledge to read the world—is a harder lesson, because it redirects the question set onto the self. It is one, however, that has more potential to break the frame-

93. Winner (n. 13 above), 133.

94. *Liberal Learning for the Engineer* (n. 32 above), 28.

95. For a survey of such efforts, see Juan Lucena, Gary Lee Downey, Brent Jesiek, and Sharon Elber, "Competencies Beyond Countries: The Re-Organization of Engineering Education in the United States, Europe, and Latin America," *Journal of Engineering Education* 96 (2008): 1–15.

work of an ideology of technological change that efforts such as *The Engineer of 2020* simultaneously embrace and strive to overcome in their ambition to "take the initiative in defining [engineering's] own future." Humanism in engineering is a collaborative project that should not begin with a vision of the world as it ought to be, but rather should foster in students the means to decode the multiplicity of visions that the world—humanist and social-scientist faculty included—seeks to impose upon them in support of myriad normative desires. Then, perhaps, engineering educators might not be so quick to conclude that liberal education is a perpetual failure.