AC 2011-1117: LIBERAL LEARNING REVISITED: A HISTORICAL EXAMINATION OF THE UNDERLYING REASONS, FRUSTRATIONS, AND CONTINUED PROSPECTS FOR ENGINEERING AND LIBERAL ARTS INTEGRATION

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Liberal Learning Revisited: A Historical Examination of the Reasons, Frustrations, and Continued Prospects for Engineering and Liberal Arts Integration

Abstract

In December of 1968, the American Society for Engineering Education issued a report, *Liberal Learning for the Engineer*, directed by Sterling P. Olmstead. However, the Olmstead Report was just one in a series of organized studies, carried out within the society's well honed investigative tradition, which sought to bring about greater integration between engineering and liberal education. One subsequent study was the 1975 O. Allan Gianniny Report—which blunted the critiques found in the 1968 Olmstead Report—while earlier studies included the 1956 Burdell-Gullette Report and the 1944 "Conference on the Humanities," organized by William Wickenden, whose efforts were instrumental in the founding of the Liberal Education Division's precursor, the Humanistic-Social Division of ASEE.

This paper revisits the history of our own society's efforts to "broaden" engineering education, and does so in a way that allows us to reflect on the changes associated with ABET's EC 2000. A careful study of the past unveils the long history of our own attempts to bring liberal education to engineers and how these efforts fit within and contribute to the distinct professional configuration of engineering. It also reveals how engineering educators possess a distinct body of practice for adapting their knowledge to "changing times and needs," and how this body of practice evolved from the early voluntary traditions of this society to the more centralized, administrative direction of policy as represented by ABET's EC 2000 and other related initiatives. While some of the closing, policy-relevant remarks of this paper may tread upon terrain that will be more familiar to those who experienced the latest efforts firsthand, I nevertheless use the historical perspective gleaned from this paper to revisit the question of the relevance of engineering and liberal arts integration in the context of an outcomes oriented approach to engineering education.

Introduction

This paper offers a historical and analytical introduction to the long history of attempts to integrate liberal content into engineering curricula. The underlying aims of this talk are several-fold. They are to document and demonstrate:

a) The long history of attempts to bring liberal education to engineers,
b) How these efforts fit within, and contributed to the distinct professional configuration of engineering,
c) That engineering educators possess a body of practice for adapting their knowledge to "changing times and needs," and

d) How this body of educational reform practice evolved from the early, voluntary traditions of this society to the more centralized, administrative traditions marked by ABET's EC 2000.

The paper then employs the historical perspective gained from this analysis to revisit the question of the relevance of engineering and liberal arts integration in the context of the outcomes oriented approach to engineering education represented by ABET's EC 2000. This paper also serves as a historical introduction to a new initiative and educational research network assembled by Deans Cherrice Travers and J. Douglass Klein at Union College for contemporary explorations in engineering and liberal education integration. Their efforts are also being presented at this year's conference.

While the material presented here is also intended for publication in a historical journal, it is written up here in a way so as to provide practical policy insights for engineering educators—including humanities and social sciences faculty. Partly to uphold the necessary demarcation between the two venues, what follows will be presented in an analytical, non-chronological style built around the four themes outlined above, with the third and fourth themes combined into one section.[1]

The Recurring History of Engineering & Liberal Arts Integration

Efforts to integrate engineering and liberal education go back to the beginnings of the formal training of engineers, and owe their heritage to the liberal political ideologies that gave shape to modern institutions of higher education.[2] In the United States, the 1862 Morrill Act, which gave rise to our system of land grant colleges, was particularly instrumental in placing engineering education on a four-year undergraduate model that combined technical training with liberal education. This actually meant that for a short while engineering had a curricular structure that was more advanced than medicine. As contrasted against the high degree of variation in standards found in medicine at the start of the 20th century—which attracted adverse attention in the famous 1911 Flexner Report—by the turn of the century private engineering colleges had already begun to emulate the basic curricular structure laid down by the state colleges.[3]

As pointed out by historian Bruce Seely, another important consequence of the land grant act was its creation of a confident group of engineering educators whose professional identification, as educators, rivaled their engineering disciplinary identities. One outcome of this broader professional identification was our society—then the Society for the Promotion of Engineering Education, as organized during the 1893 World Columbian Exposition. It was these educators' commitment to what historian Edwin Layton Jr. referred to as an orientation towards professionalism, as opposed to bureaucracy, that made the continued focus on liberal education and breadth possible within the engineering education community.[4]

This commitment is documented in the long history of studies produced by our society. The 1918 Mann Report, originally conceived of back in 1907, focused one part of its investigation on the humanistic portion of the curriculum. It took note of the contraction in this segment in the face of the perennial problem of new knowledge and increased specialization, exacerbated, specifically, between the 1870s and the 1910s by the pace of U.S. industrial growth. Mann also endorsed the model of combined liberal-professional training that had taken hold in the nation's engineering schools.[5] The 1923-1929 Wickenden Investigation gave even greater emphasis to humanistic training, providing, in effect, a sustained forum for discussing what elements were most valuable for the general education of engineers. Wickenden also concluded that there ought to be a continuous band of humanistic courses extending throughout an engineering student's undergraduate years.[6]

In 1940 and 1944 there were then the two Hammond Reports, the first on the "Aims and Scope of Engineering Curricula," and the second for planning the postwar reconversion of engineering education at the end of World War II.[7] The 1940 report was responsible for giving articulation to the notion of there being parallel scientific-technological and humanistic-social "stems" in engineering education. As important, it defined a specific set of objectives for the humanistic-social portion of the curriculum (as well as for the scientific-technological portion), establishing a learning outcomes based model of education within the engineering education community that would be picked up again in subsequent decades. (It's most recent incarnation is the learning outcomes and assessment regime established by ABET's EC 2000, as discussed further below.) The 1944 Hammond Report is regarded by most to be a reiteration of the 1940 report. Indeed it was a call to reverse the changes necessitated by the war, in a way that was similar to other academic policy statements of the era. However, there were other implications of the 1944 Hammond Report that will be considered later on in this paper.

The end of the war brought a series of significant developments, beginning with a conference on the humanities organized by William Wickenden, who by then was the President of the Case School of Applied Science. One of the outcomes of this conference was the decision to create a new Humanistic-Social Division (the precursor to the present Liberal Education Division) as distinct from the English Division already in existence. (SPEE also became the American Society for Engineering Education in 1946.) Indicative of the strong support given to this development by engineering educators from the technical disciplines, a majority of the committee that was assembled to establish this new division were prominent engineering faculty and engineering deans, as opposed to liberal arts faculty. Meanwhile, one of the first actions taken by the new Division was to organize a study on "the characteristics of the humanistic-social studies in engineering education." This was carried out by Robert M. Boarts and John C. Hodges, the heads, respectively, of the Chemical Engineering and English Departments at the University of Tennessee.[8] The principal conclusion of Boarts and Hodges' report was that there was great variation among engineering colleges in terms of their resources, structure, and constraints, and that the objectives outlined in the 1940 Hammond Report had to be reinterpreted in the light of local circumstances in order to produce a coherent and achievable set of objectives. In their view, "Failure to do so can mean only that the faculty has not come to grips with the fundamental issues which confront each school."[9]

The Cold War saw other, broader studies of engineering education, most notably the 1955 Grinter Report, as chaired by Linton E. Grinter from the University of Florida; and the 1968 Goals Report, as coordinated by Penn State President Eric A. Walker. The Grinter Report, which was itself quite controversial in its time, is widely recognized for having given better articulation to the notion of engineering science, and for establishing a more science-based curriculum as the postwar norm for engineering education. The 1968 Goals Report, meanwhile, was an even more controversial document that recommended that the master's degree ought to be the first professional degree in engineering. Both studies placed considerable emphasis on general education, including, quite explicitly, the humanities and social sciences. In fact, it could be said that the most controversial aspects of both reports resulted in part from the need to give a more prominent place to the humanities and social sciences as well as the physical sciences in the engineering curriculum.

From the point of view of advancing the contemporary thinking about engineering and liberal arts integration, the main effect of these studies was that they spawned a parallel set of studies on the liberal portion of the engineer's curriculum. Dubbed the "Humanistic-Social Research Project," the 1956 Burdell-Gullette Report was overseen by a committee chaired by Edwin Burdell, President of The Cooper Union, and directed by George Gullette from North Carolina State. Recognizing, as had Boarts and Hodges, the considerable diversity among engineering schools, Burdell and Gullette chose to emphasize the diversity of possible solutions as opposed to highlighting any particular approach. At the same time, the report took strait aim at the idea of integration, arguing that the objectives of general education had to be defined jointly by engineering and liberal arts faculty for there to be an effective outcome. It also argued that the humanities and social sciences had to be recognized as professional disciplines in their own right; and that engineering, in turn, must be "viewed as a profession with social responsibilities."[10]

The second of these divisional reports, the 1968 Olmstead Report "Liberal Learning for the Engineer," was written during a more radical moment in U.S. history. It was cutting in its criticism in a way that was consistent with the general protest culture of the 1960s. Beginning with the statement that, "Technology has brought mankind to a critical point in history. It is in a position to destroy man; it may even be in a position to save him," Olmstead's committee adopted the stance that it was necessary to completely rethink how schools approached the liberal education of engineers. Students were to be trained to understand the role of technology "within the total human culture," and to control its adverse effects. Considering the task at hand, the committee judged all prior attempts at engineering and liberal arts integration to be a failure, and provided no less than 35 specific recommendations on how to make this possible. The report also blamed not only the engineering faculty, but the humanities and social science faculty for excessive attention to graduate education and research, which occurred at the expense of undergraduate education. In partly misreading the original intent for the distinction, Olmstead's committee judged the separation of the humanistic-social stem from the scientific-technological stem to be a detriment to integration, insofar as it allowed instructors to focus only on the delivery of their specific subject.[11]

Olmstead's report was subject to criticism, both at the time of the study, and afterwards. In 1973, ASEE organized a follow-on study, conducted by O. Allan Gianniny from the University of Virginia (an active member in the history of our division), to assess the impact of Olmstead's report and the merits of its specific recommendations. This included a workshop for performing this assessment. The basic consensus that emerged out of the workshop was that Olmstead's committee was unrealistic in its expectations; while the goals it laid out were meaningful for a handful of institutions, it was said once again that a greater diversity of objectives had to be permitted in considering the resources and interests of different educational institutions. Overall, Gianniny and his contemporaries viewed the high level of integration sought for by Olmstead's committee to represent an impossible ideal; they labeled the report a "product of its time."[12]

However—and this is for better and for worse—this is precisely what was challenged under the ABET's EC 2000 accreditation criteria, as also consistent, at least on the surface, with statements found in the National Academy of Engineering's *Engineer of 2020* reports.[13] Influenced by concerns about "national competitiveness," and more recently, economic globalization, both organizations have turned once again to liberal education as a necessary means for supporting the engineer's professional development. This time, the focus became that of producing engineers who have the skills necessary to compete in a global marketplace. Taking the latest version of ABET's accreditation criteria, and specifically Criterion 3 on curricula, it remains clear, at least to those of us in the liberal arts, that no less than five, and as many as seven of the 11 "a-k" curricular criteria for *all* of engineering education can be best addressed through courses in the humanities and the social sciences—or else through courses and curricula that fully integrate engineering and the liberal arts. The fact that this change has been successfully resisted in many quarters will, on the other hand, be familiar to many.[14]

Liberal Education and the Professional Configuration of Engineering

The specific implications of the above history, including its usefulness in revisiting various developments associated with EC 2000, are considered at the end of this paper. But first, it's necessary to retain a more general focus.

It is clear from the historical account given above that our society has had a long, illustrious history of attempts at engineering and liberal arts integration. This is not necessarily reassuring. The very fact that there have been recurring attempts to "broaden" engineering education suggests, at one level, the frustrations and unattained goals associated with these efforts. Clearly, the changes that have occurred, when they occurred, did so within a context of significant resistance. If it is of any consequence, this problem of resistance is not unique to the liberal portion of the engineering curriculum; it has been a consistent thorn in the side of all those seeking engineering reform and has its origins in professional tensions that are integral to the engineering profession.

I would like, therefore, to shift the conversation for the moment in a more analytical direction. Historians of technology, like myself, have been among those who have pointed to the disciplinary fragmentation and professional frustrations of engineers. Nor is it necessary to view this as external criticism. Engineers themselves have been highly aware of, and according to some, obsessed with this concern. Moreover, the issue of professionalization remains central to any conversation about engineering and liberal education, insofar as a focus on "breadth" has always come accompanied with claims about the professional standing of engineers.[15]

I've always found this concern about the engineer's professional standing to be somewhat puzzling. While it is clear that there were times, historically, when engineers had legitimate reasons to worry about their stature—the early period when engineering training occurred through apprenticeships, or later when engineers were confronted with the ascending ranks of a new breed of professional managers during the rise of American corporations in the early

1900s—engineers, at least since World War II, have been reasonably secure in their professional identities. Still, given the constant pressure to interpret histories of engineering and liberal arts integration within the analytical framework of engineering professionalization, it is important to place more casual remarks about engineering as a "frustrated" profession within a proper, academic context.

What I say here is neither particularly novel nor unique. At least since the 1970s, sociologists have ceased to regard medicine, law, and clergy as ideal-typical professions, viewing all claims of professionalism in terms of a dynamic relationship among the occupations. In addition to the system theoretical take on the professions promulgated by Andrew Abbott, based on earlier notions about professional competition advanced by the symbolic interactionists, scholars beginning with Magali Larson have come to view professional stature and jurisdictional claims as part of a "professional project" entered into by all occupations that are in a position to claim some socially beneficial form of expertise.[16] Still, this basic "relational" approach that focuses on the social relations among the occupations is of little value, in and of itself, for analyzing differences among the professions, or for understanding how specific professions operate.

From this point of view, Edwin Layton's early analysis of engineering professional societies remains quite useful for thinking in terms of different and distinct "professional configurations." Extracting from what he and others have written, the two most frequently noted features of the U.S. engineering professional configuration are first, its fragmentation along disciplinary lines, and second, its diffuse professional identity resulting from the permeable boundary between engineering and management. For Layton, the latter, again, was expressed in terms of an engineer's dual loyalty to professionalism and bureaucracy.[17] Using this framework, he and others have laid out the historical interplay between the two in revealing, for instance, the different attitudes about membership and certification that emerged among the engineering professional societies based on such factors as differences in knowledge, industrial structure, rate of expansion, and the contingent effects of their earlier professionalization strategies.[18]

The distinguishing characteristics of the U.S. engineering professional configuration do get more subtle. From the above discussion, we can add to this conversation the strength of the engineering deans and land grant institutions, which provided a partially countervailing trend towards professional integration via an emphasis on breadth and fundamentals that cut across the engineering disciplines.[19] The distinctions also operate at an epistemological level. Consider, for example, the engineer's commitment to the notion of "efficiency." Given a professional commitment to efficiency, including the systematic reduction of industrial operating costs, U.S. engineering educators would have found it difficult to pursue the restrictive admissions policy found in medicine, especially during times of economic expansion. This position would have then been reinforced by the permeable boundary between engineering and management, as well as the land grant institutions' public obligation to expand educational access and to promote economic development. While much of what is said here can be inferred from Layton's analysis, the structural-functionalist assumptions underlying the earlier professionalization literature upon which Layton drew, including his emphasis on a structural binary between professionalism and bureaucracy, tends to obscure the full complexity of the U.S. engineering professional configuration. Here, the interactionist approaches that undergird the more recent professionalization literature help foreground these complexities, along with the subtle dynamics that are always at work in refashioning every profession.[20]

To put this in a different way, engineers can be regarded as professionals because others regard them to be such. While this may seem tautological, the concept is useful for highlighting the role that liberal education played in the engineers' professional claims. A direct study of the curricular content that was emphasized in each of the nine reform initiatives and studies described above reveals, quite directly, how liberal content was redefined based on opportunities presented by a change in historical context. Each time, new content selected in such a way so as to strengthen the professional standing of engineers, most always in relation to other professions.

Thus, with the Mann Report, the general emphasis on science and breadth was consistent with late 19th and early 20th century efforts to establish engineering as a profession during the period of the general ascent of American professions. And while Wickenden and the board that oversaw his work were more cosmopolitan in their outlook—the Board of Investigation recommended, in its summary report, that humanistic training beyond engineering economics should be directed "primarily for cultural rather than technical ends"— contemporary conversations stressed how subjects such as engineering economics, management, and corporate finance, as well as subjects such as Engineering English and public speaking, should be essential training for all engineers.[21] The main professional threat to engineers during the 1920s again came from the rapid expansion of a new professional managerial class, who were challenging the engineers' authority with respect to industrial operations.

The Great Depression brought about a reversal in preferred content. During the Depression, the emphasis was no longer on narrow "tool" subjects, which were labeled as such, but a more fundamental knowledge of economics and the social sciences necessary to understand and reign in the social consequences of technological development. Wickenden, who had become President of the Case School of Applied Science (Case Western today) became, along with Robert E. Doherty at Carnegie Tech, one of the most vocal advocates for an expanded program in the social sciences designed to train engineers under a more "organic conception."[22] From the point of view of curricular content, the 1940 and 1944 Hammond Reports reemphasized the directions defined during the 1930s, the former in response to efforts to define the profession too narrowly.[23]

However, the immediate postwar years brought about another reversal in relative emphasis. As contrasted against the strong emphasis on economics and the social sciences associated with the Great Depression, the concern now lay with a broader humanistic understanding of totalitarian regimes, and of the human devastation wrought by the technological implements of war. One of the major conclusions of the 1946 Boarts-Hodges Report, as also reiterated in the 1956 Burdell-Gullette Report, was a call for greater balance between the humanities and social sciences.

By the time of the 1956 Burdell-Gullette Report, those associated with ASEE's Humanistic-Social Division had become sufficiently reflexive about the different possible aims for general education to comment on it. Written in a lucid style that was itself designed to demonstrate the benefits of broader training, the report warned against an overly narrow, utilitarian definition of general education that failed to go beyond the idea that, "an engineer should be able to write well and speak effectively, that he should be able to win friends and influence people"; and against superficial definitions that amounted to a "finishing school" concept of general education in which engineers were given "a cultural veneer designed to make the engineer acceptable in polite society." It also warned against overly ambitious statements that expressed the "faith that a few courses in the humanities and social sciences can provide health and emotional adjustment, personal and social success, clarity of thought, moral integrity, civic responsibility, aesthetic sensitivity, professional vision, and in general a kind of serenity and wisdom we had thought reserved for Providence alone."[24] While casting itself as occupying an objective and measured middle-ground, there was nevertheless a consistent emphasis in the Burdell-Gullette Report on approaching the humanities and social sciences on a broadly utilitarian basis. Its position was that the humanities and social sciences were, "in a deeply serious sense, practical and useful," and that this utility could be maintained through "the stubborn insistence that contemporary relevance is the standard by which to judge any humanistic-social program."[25] This emphasis on a less narrowly instrumental, and yet more balanced program in the humanities and social sciences was, once again, something consistent with the broader politics of the postwar and early Cold War era.

The curricular content emphasized in the 1968 Olmstead Report, and its relation to historical context, has already been discussed above. Clearly, this was also an attempt to refashion the liberal content of an engineer's education in response to historical circumstance, and an opportunity, in turn, to refashion the engineer's professional identity. And despite Olmstead's committee's disregard for history, their report did call for a new level of integration, one that cast liberal education, whether realistic or not, as something that was not simply of occasional use to engineers, but as something central to the core competency of what engineers did in their professional life.

These frequent, unending reversals in the underlying aims of liberal education for engineers—including the latest changes associated with EC 2000—should give us pause. No doubt there was validity to some of Olmstead's critiques of U.S. higher education, and some of those critiques remain valid today. Nevertheless, from the standpoint of department heads and regular faculty members alike, these discontinuities represent significant changes in intellectual orientation. Such discontinuities affect faculty hiring, and present considerable demands upon the faculty for curriculum revisions and redevelopment. It is little wonder that faculty members and administrators not affiliated with ASEE have learned to resist such changes when they occur. This is, of course, a problem (if indeed it is a problem) found not only with regards to liberal education, but engineering curricula as a whole. The skepticism found in O. Allan Gianniny's 1975 study, and the call for diversity expressed by Gianniny's workshop participants, should be interpreted in this light.

Still, what history reveals, especially when viewed at the level of curricular content, is how liberal education so often holds the key to the professional aspirations of engineers. There is no easy way to separate the motives behind each call to "broaden" engineering education—at certain times they were driven by a sense of civic obligation and the move to define professional identity in terms of social responsibility—but in nearly all cases they were informed, simultaneously, through matters of professional jurisdiction that goes back to the complex professional configuration of engineering. Whether in response to the ascent of the managerial profession during the 1920s; or efforts, amidst postwar "physics envy," to differentiate engineering from science by embracing a new ethic of professional responsibility (even as engineers turned, simultaneously, to science to compete more directly with physicists); or yet again, during the late 60s and the 1970s, to lay claim to even broader claims of social responsibility through direct utilization of liberal knowledge, liberal education has served as a preferred means for the "reconversion strategies" of engineers, at least among those committed to the cause. The "vision" that ABET and the National Academy of Engineering have created for the engineer of the future is part and parcel to the same general drive.[26]

A Body of Practice for Adapting Engineering Knowledge to "Changing Times & Needs"

Allow me to turn to another "analytic" angle. Engineering educators do in fact possess a body of practice for adapting their knowledge to "changing times and needs." Consider, for instance, the following quote by Thorndike Saville, ASEE President in 1949-1950. Saville was one of Grinter's contemporaries, who along with Cornell Dean of Engineering Solomon Cady Hollister, oversaw the rise of the new engineering science ideology during the 1950s.

> "Times change men and men with them": So also must education change to prepare men to cope with changing times. … Engineering education is the most complex and the most sensitive to social and political considerations of any of the professional disciplines. … this Society has always been prompt to relate the basic premises and curricula of engineering education to realistic appraisals of changing times and needs.[27]

Taken at face value, this statement suggests that engineers situate their knowledge claims somewhat differently from other professions. Instead of claiming simple jurisdiction over an esoteric domain of knowledge, engineers inextricably link their professional identity to an obligation, and indeed a practiced responsibility for adjusting their knowledge in response to a change in social and historical context.

This has significant bearing on a rather classic problem in the sociology of scientific knowledge.[28] While it has been argued that it is difficult to establish a direct connection between estoteric knowledge and historical context in the sciences, engineering educators appear to do so on a routine basis. From the Perry Movement described by historian Larry Owens[29]; to the Mann Report, Wickenden Investigation, Grinter Report and Goals Report mentioned above; to each of the liberal education studies discussed in the previous two sections, engineering educators have repeatedly turned to educational reform as a means of reconsidering the fundamental basis of engineering expertise. They have embraced embodied knowledge, specialization, and a focus on fundamentals and breadth, at different times and in different combinations. And they did so repeatedly to reposition engineering professional identity amidst historical changes in the context for their work.

It should also be clear, even from the discussion so far, that engineering educators possess a distinct if also evolving body of practice for reexamining the epistemological foundations of their discipline. Put more formally, this is to say that engineers possess an ethnomethodologically “accountable,” which is to say identifiable and describable body of practice for adapting their knowledge to a change in social and historical context.[30]

The larger body of historical research upon which this paper is based is working to identify the historical origins and evolution of this practice. It is clear, for instance, that the early investigative practices of this society were directly connected to the educational reform movements of the Progressive Era. The Mann Report, as supported by the Carnegie Foundation for the Advancement of Teaching, was issued as Bulletin #11 in a series of reports issued by the Foundation. Bulletin #4 was the famous Flexner Report, which had catalyzed a major change in U.S. medical education. Moreover, taken together, these reports were part of the Foundation’s efforts to systematically study the professions as a new social force in American society. It is clear that the very pattern of investigation established for the Mann Report had its origins in Progressive Era reforms—Charles Riborg Mann was an “applied scientist” at the University of Chicago enlisted to carry out an independent investigation.[31] It is also clear that other elements of the Progressive Era affected engineering educators directly, especially via civil engineers and certain mechanical engineers who were also educators. These segments of the engineering profession had explicitly adopted progressive ideologies as a core part of their professional identity during the early part of the 20th century. Appeals to professional standing rooted in claims of efficiency and civic responsibility, including discussions about the curricular implications of these claims, fit squarely within a body of Progressive Era reform strategies.[32]

The Wickenden Investigation, initiated only several years after the Mann Report was issued, has on the other hand been cast as a break away from the independent investigative traditions of the Progressive Era. While the study was financed by the Carnegie Foundation, the foundation accepted SPEE’s claim that engineering was the only profession with a society dedicated to the study of its educational system, and therefore that the society itself was most qualified to conduct this work.[33] Nevertheless, there were significant continuities. SPEE, via the Wickenden Investigation, internalized many Progressive Era reform practices, which included the use of surveys and field work to elicit best practices, and for introducing them back to the membership as a means of establishing a regime of accountability. Compliance was kept voluntary. More unique to the SPEE investigation was its use of “institutional committees” at each member college, which were set up both to contribute to and to implement the recommendations derived from the investigation.[34]

The 1940 and 1944 Hammond Reports were smaller studies, and were produced through the efforts of an appointed committee. However, the 1955 Grinter Report, and the 1968 Goals Report were both full-fledged investigations carried out in the tradition of the Wickenden Investigation. Both employed surveys. Both made use of institutional committees. The 1968 Goals Report established, as well, a board that oversaw the efforts of teams assembled to conduct separate studies for the undergraduate and graduate “phases” of the overall study. In fact, by mid-century, many within ASEE had a reflexive understanding that their society possessed a body of practice for educational reform, and fully understood their organization to be a society dedicated to changing engineering education to meet “changing times and needs.”

The investigative traditions of ASEE also spread to different parts of the organization, including its Humanistic-Social Division. The 1946 Boarts-Hodges Report made use of survey methods as did the 1956 Burdell-Gullette Report. In the case of the latter, the Humanistic-Social Research Project was also overseen by a committee, while the investigations were conducted by a project director in a manner modeled after the Wickenden Investigation.

Still, it should be noted that the educational reform practices of the society remained quite adaptable, both with respect to its liberal education component as for the engineering curriculum as a whole. Thus, it was the organizational improvisations carried out by Cornell's Dean of Engineering, Solomon Cady Hollister, which enabled ECPD to develop new quantitative standards of accreditation that significantly displaced the regional, peer-based system of accreditation that had prevailed within the ECPD. Whether by chance or manipulation, Hollister served simultaneously as the chair of the ECPD Committee on Education (ECPD's accreditation arm at the time), and as ASEE President. This shift to quantitative standards was really the most significant outcome of the Grinter Report, although this has attracted relatively little historical attention. Meanwhile, it was perhaps in response to the standardizing effects of this new accreditation regime that Burdell's committee chose to emphasize the inherent diversity among U.S. engineering colleges. This would have been a common response among the ASEE divisions. Recognizing as well that the humanities faculty at many institutions had limited authority in the face of a more powerful engineering faculty, Burdell's committee decided at the outset of their study that Gullette should document best practices not as a means of asserting a single standard, but to work subtly to alter local negotiations by offering different models of integration that the humanities and social science faculty could use to push back against their engineering colleagues' often naïve and singular attitudes towards general education. This was itself a variation in the society's prevailing reform practice. It had its roots in older claims about the inherent variability of U.S. engineering schools, and the position would continue to reverberate within liberal education circles, as demonstrated in the 1975 Gianniny Report's stance that it was necessary to support diverse approaches to integration.

Another significant procedural innovation by Burdell and Gullette was their increased reliance on fieldwork—itself a Progressive Era practice. Beginning with the same argument employed earlier by Boarts and Hodges, Burdell and Gullette insisted that liberal education for engineers, and the diversity of approaches taken to it, required qualitative assessments compiled through site visits conducted by field workers. (ECPD accreditation committees, incidentally, were set up on a similar basis, as justified by similar rhetoric.) While this is a point more relevant to the my colleagues in the history of technology, and for the envisioned historical article in *Technology and Culture*, it was this work that allowed one of the key founding figures in my field, Melvin Kranzberg, to cut his teeth on engineering education pedagogies. As pointed out by historian Robert Post, Kranzberg as a consequence shifted his academic attention from French History to the History of Technology.[35]

The more significant historical shift in engineering education reform practices occurred not within the sphere of liberal education, but in the realm of engineering education as a whole. This also occurred as a result of the limitations of the voluntary approach to reform that the society continued to embrace as crucial to the society's own identity. So long as the preliminary findings of every major investigation had to be aired before the membership, and the membership had strong expectations that the investigating team would respond to their criticisms, the investigative committees organized by the society remained substantially accountable to their membership. This in turn was based on broad based democratic traditions—which is to say, a describable body of practice—that were embedded into the makeup of voluntary organizations like the ASEE.[36] This limited what individuals such as Grinter and Walker could accomplish within the framework of the ASEE. In the case of Grinter, he was forced to rescind a key recommendation of the committee favoring the functional bifurcation of engineering education into professional-scientific and professional-general curricula. Arguably, it was only the behind-the-scenes negotiations carried out by Hollister that served to preserve the report's broader focus on engineering science, which was then codified, more or less through fiat, by the ECPD into quantitative standards of accreditation as described above.[37] Meanwhile, in the case of the 1968 Goals Report, Walker's insistence on re-embracing the Progressive Era traditions of independent investigation, specifically by refusing to concede to the opinions expressed by the ASEE membership, wound up revealing institutional and disciplinary rifts within the organization that, in the words of historians Bruce Seely and Terry Reynolds, dismantled ASEE's ability to serve as "the voice of engineering education." As Seely and Reynolds note, ASEE never pursued another investigation of engineering education of a similar scale: One of the major conclusions of the 1977 study by our society's Ad Hoc Committee for the Review of Engineering and Engineering Technology Studies (REETS) was that another general investigation of engineering education was neither desirable nor warranted.[38]

This shift away from a voluntary tradition of educational reform to the more centralized, administrative control over engineering curricula was of course part of a broader trend in engineering education, and of higher education at large. The early, professional schools that focused on specific engineering disciplines had given way to unified schools and colleges of engineering by the 1930s. And while engineering deans still had to grapple with autonomous faculties during the interwar years (which contributed to the continued emphasis on specialization), the 1930s nevertheless saw an increasing influence on the part of engineering deans within the administrative structure of the SPEE—this is a change documented in other historical accounts of the society.[39] Some of these changes were resisted, but the crisis of World War II, which made necessary many accelerated and specialized war training programs in engineering schools, gave engineering deans further control over their schools, including, quite explicitly, control over curricula. The key difference between the 1940 and 1944 Hammond Reports, therefore, is that the latter reflected the new administrative confidence of the engineering deans. As contrasted against the focus on curricular content and structure found in the 1940 Hammond Report, the 1944 report focused primarily on matters of implementation. Under the heading, "Means of Achieving the Purposes of the Curriculum," the committee provided no less than thirteen specific recommendations on how to go about teaching and transforming the humanistic-social and scientific-technological portions of the engineering curriculum. The 1944 Report was also the first study to put forward an explicit, quantitative standard for engineering curricula. This was the 20% requirement for humanistic-social study.[40]

Thus, although Seely and others are correct to point out that the major changes in engineering education occurred as a result of postwar federal research expenditures and the associated emphasis given to science and scientific methods, the means by which this change occurred involved subtle shifts in the practice of educational reform. Thus, although Grinter's Committee on Evaluation of Engineering Education, and the teams assembled by Walker to produce the 1968 Goals Report represented, in one sense, the high point in ASEE's investigative tradition, the actual outcomes of these studies depended on negotiations carried out by engineering deans who operated behind the scenes. In considering Hollister's inter-organizational manipulations described above, it is worth noting that the ECPD was an organization more specifically dedicated to the *professional development* of engineers. Set up as a "conference style organization" comprised of delegates from its member organizations, ECPD was set up as an organization to enable more centralized administrative decision making. Its practices, moreover, were more attuned to the goals of professional development, as opposed to the voluntary traditions and a vaguely articulated ideal favoring the collegial exchange of ideas, which characterized ASEE's institutional identity and mode of operation. It can also be added that towards the end of the work on the Grinter Report, Hollister organized a private meeting of engineering deans to help determine the final form of the report. With the 1968 Goals Report, engineering deans simply turned away from ASEE as the principal site from which to develop new standards in engineering education.[41]

Additional historical research is needed to establish how the authority for overall curricular matters shifted from ASEE to ECPD (ABET from 1980), along with the National Academy of Engineering and the National Science Foundation's Engineering Directorate. Even further research would then be needed to document the changes in the practice of educational reform that were associated with this shift.

There are, nevertheless, some valuable clues. For instance, it was the declining engineering enrollments of the 1980s, as conjoined with the perceived crisis over "national competitiveness," that prompted the NSF Director, Erich Bloch, and the former ASEE Executive Director and NSF assistant director, F. Karl Willenbrock, to organize a workshop on formulating a new vision for engineering education. Drawing also on NSF's general move towards more targeted funding strategies, which was itself a product of the national competitiveness debate, NSF shifted its funding priorities away from small educational research grants, which were described as "evolutionary—not revolutionary," towards bolder initiatives. This included NSF's decision to support a half dozen Engineering Education Coalitions (EEC) that were given $15 million a-piece to innovate, demonstrate, and disseminate new approaches to engineering education.

While the EECs were not a failure, neither were they a resounding success. From what evidence is openly available, traditional disciplinary barriers, including the barrier between engineering and the liberal arts, prevented radical pedagogic innovations of the sort that NSF's new head of the Engineering Directorate, Joseph Bordogna, hoped to see. Already by 1993, Bordogna began to refocus his vision under the specific slogan, "innovation through integration," where he argued that knowledge-based approaches to engineering education had reached its limits, and that an engineer's potential to innovate, and therefore contribute to the national economy, lay with integration rather than the sheer quantity of knowledge they acquired while in college.[42] This emphasis on integration implied a shift away from the quantitative approach to accreditation developed by ECPD, and enforced by its successor ABET, insofar as quantitative standards encouraged faculty to teach their particular subject without attention to a student's ability to retain, let alone utilize and integrate this knowledge in any meaningful way.[43] While I have not yet established a direct connection, it is worth noting that Bordogna's emphasis on integration, and his critique of quantitative standards for accreditation, were identical to the critique put forward by earlier ASEE studies of liberal education, most notably the Olmstead and Boarts-

Hodges Reports, respectively. The endpoint of this dialogue was ABET's EC 2000, in which an outcomes assessment model, based on a taxonomy of learning that placed learning on a scale ranging from initial exposure to cultivated ability and mastery—this taxonomy was circulating within engineering education circles at least since the 1970s—replaced the former quantitative approach to accreditation.[44] Clearly, all this also involved changes in the practice of engineering education reform that requires further reflection and analysis.

Conclusions and Implications

In summary, the history of attempts to integrate engineering and liberal education goes back to the beginnings of this society, and the origins of formal engineering education at large. Not just many, but all of the efforts described above also occurred within the context of a dialogue about the engineer's professional image and responsibilities. Liberal education content proved particularly germane to these dialogues. This was as true for the 1918 Mann Report, as for the latest version of ABET's EC 2000 criteria. The historical excerpt presented here also makes it quite evident that engineering educators possessed a distinct body of practice for reexamining the content and structure of engineering education—the epistemological foundations of engineering as a field of study—and that this practice had its origins in Progressive Era educational reform traditions. It then evolved towards a more centralized, administrative model with the historical ascent in the authority of engineering deans and university administrators. The shift in general curricular authority, from ASEE to ABET and other organizations, should be viewed within this context. While the research with regards to this point about a historical shift in engineering education reform practices remains incomplete, there nevertheless appears to be substantial evidence that engineers, unlike scientists, possess an ethnomethodologically "accountable" (identifiable and describable) body of practice for adapting their knowledge in response to "changing times and needs."[45]

In turning to the more practical implications of this history, it is important to keep in mind the ever present gap between rhetoric and reality when dealing with matters of educational reform. Without question, there were always detractors to each of the investigations and studies described above. At least until the end of World War II, the vision for engineering education put forward in the major ASEE reports represented the views only of a subset of engineering educators, and increasingly, that of engineering deans and administrators. At least through the interwar years, at a time when research remained secondary to teaching, specialized knowledge and instruction, along with remunerative industrial consultancies and contracts, remained an important component of a faculty member's identity and prestige. In many quarters, the interwar years in fact saw a continued drift towards increased specialization, to which the national dialogue was a response.

However, historic developments of World War II transformed the playing field. New levels of federal research expenditures, and the status accorded to science as opposed to engineering provided the necessary context for finally executing the reforms that were mostly put up only as an ideal during the previous decades. Transformations to the scientific-technological stem were effected as an outcome of the Grinter Report, even as the multiple studies by the Humanistic-Social Division and its successors contributed to a somewhat more gradual transformation in the liberal education of engineers. Still, there remained unresolved tensions—in both "stems" of engineering education, really, but certainly with respect to the liberal education component. In this respect, both the Olmstead and Gianniny reports point, though in different ways, to the limitations of past attempts at engineering and liberal arts integration. Bordogna's "new vision," as reflected in ABET's EC 2000 accreditation criteria, simply invited us to reopen this issue.[46]

But as mentioned above, this is clearly a history that ought to give those of us in the liberal arts some pause. It is hardly in the interests of any liberal discipline to have the principal focus of instruction, let alone research, shift so easily in response to the professional aspirations of another discipline. It suggests, if nothing else, that the liberal disciplines that have built their reputations on their utility to the engineering professions retain vestiges of a "service" relationship to engineering departments, despite the maturation of their discipline. At the same time, the sustained ties to engineering education have clearly been a double edged sword. The origins of fields such as the history of technology (which occurred during the time of the Burdell-Gullette Report) or Science and Technology Studies (which occurred during the time of the Olmstead Report) clearly demonstrate that these wild swings in the curricular desires of the engineering profession have given rise to highly productive areas of liberal inquiry. The more recent concerns about national competitiveness and economic globalization (which, as a historian, I consider part of the same historical moment), and the associated interest in professionally and "globally-oriented" standards for accreditation, have provided yet another round of opportunity for developing new liberal education programs that are synergistic with the needs of the engineering profession, imagined or real.

I have no answer, yet, as to the question of whether the developments associated with EC 2000 have been a welcome opportunity. While I myself arrived too late into ASEE's fold to know the latest developments firsthand, those within the Liberal Education Division report on both the hopes and disappointments that arose in the wake of ABET's new accreditation standard. The historical research related to the most recent development still remains to be done.

Still, from the above historical account, I can point out that much of the constructive relationship between engineering and liberal arts faculty did revolve, historically, around the notion of "integration," as executed under different guises. And it is clear that the new, non-quantitative regime for accreditation did open up new possibilities—a genuine opportunity to approach and define engineering and liberal arts integration on very different terms than have been possible in the past. While such a change seems to have been thwarted in the first pass at many institutions through alternative measures and metrics that have come to stand as substitutes for the effective integration called for under ABET's original vision, there are those who have continued to pursue interesting pedagogic experiments. At Rensselaer, for instance, we have continued to pursue engineering and liberal arts integration through a themed living-learning community dedicated to the study of future energy resources and sustainability; an undergraduate electronic arts program designed to integrate a student's technical and aesthetic sensibilities; an Information Technology (and now "IT and Web Science") program that integrates professionalism with both technical and social-analytical skills; and a product design and innovation program that brings a studio based approach to engineering design via a socially conscientious and more generally socially cognizant approach to the engineering design process. The increasing proliferation of such interdisciplinary undergraduate degree programs and initiatives, at many institutions beyond Rensselaer, offers some hope that the desired changes associated with EC 2000 may still be realized, albeit in specialized programs and venues.

With this in mind, I would like to direct this audience to an educational research network assembled by Cherrice Travers and J. Douglass Klein, the deans, respectively, of Engineering and Interdisciplinary Studies at Union College. Since 2008, Travers and Klein have been organizing an annual symposium on Engineering and Liberal Education. The educators assembled through this network have continued to, and have recently redoubled their efforts to pursue integrative projects that go well beyond what I have been involved with at my own institution. They have, or will be presenting their work during this conference, and they will be describing their proposal to establish an NSF STEP Center focused on engineering and liberal arts integration. I encourage this audience to remain attuned to their efforts, even as they think about the implications of the history presented above in assessing both the promise and limitations of engineering and liberal arts integration.

Notes

[1] The new publish-to-present policies of our society present a novel challenge for historians. History is an empirical discipline, and historical insights are normally conveyed through the careful compilation and weaving together of evidence in the form of narratives that may reach 20-30 pages in length—not the 6-8 pages that may be appropriate for most conference proceedings. While the electronic publication protocols for the ASEE proceedings do allow for longer manuscripts, published proceedings carry little academic credit; having a conference paper block subsequent publication of the same material in a referred historical journal would delay or discourage ASEE conference presentations by academic historians. Fortunately, our society also has a long history of encouraging positive dialogue with liberal arts faculty—as recounted in this paper itself. It is therefore hoped that this paper will be regarded as a synopsis of a longer historical article, excerpted and re-presented in such a way so as to make the material accessible to an audience of engineering educators. The same material is also intended for publication in the journal, *Technology and Culture.*

[2] The general histories of engineering education that inform this talk include Bruce Seely, "Research, Engineering, and Science in American Engineering Colleges, 1900-1960," *Technology and Culture* **34** (1993): 344-386; Terry Reynolds and Bruce Seely, "Striving for Balance: A Hundred Years of the American Society for Engineering Education," *Journal of Engineering Education* **82** (1993): 136-151; Matthew Wisnioski, "'Liberal Education has Failed': Reading Like an Engineer in 1960s America," *Technology and Culture* **50** (2009): 753-782; Bruce Seely, :The Other Re-engineering of Engineering Education, 1900-1965," *Journal of Engineering Education* **88** (1999): 285-294; and the collection of essays in Terry S. Reynolds, *The Engineer in America: A Historical Anthology form Technology and Culture* (Chicago: University of Chicago Press, 1991); as well as the historical accounts found in the investigations of SPEE and ASEE.

[3] This transition has not been documented systematically. However, see histories of individual engineering colleges including Arthur Wilson Tarbell, *The Story of Carnegie Tech* (Pittsburgh: Carnegie Institute of Technology, 1937), and C. T. Martin, *From School to Institute: An Informal Story of Case* (Cleveland: World Publishing Co., 1967), and Thomas Phelan, D. Michael Ross, and Carl Westerdahl, *Rensselaer, where imagination achieves the impossible: An illustrated history of Rensselaer Polytechnic Institute* (Troy, NY: Rensselaer Polytechnic Institute, 1995); as well as the historical assessments found within the investigations of SPEE including the Mann Report.

[4] Edwin Layton, Jr., *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession,* Second Edition (Baltimore, 1971/1986). ASEE's history may be found in Reynolds and Seely, "Striving," (n. 2 above), and Lawrence P. Grayson, *The Making of an Engineer: An Illustrated History of Engineering Education in the United States and Canada* (New York: Wiley, 1993).

[5] Charles Riborg Mann, *A Study of Engineering Education Prepared for the Joint Committee on Engineering of the National Engineering Societies,* Bulletin Number 11 (New York: Carnegie Foundation for the Advancement of Teaching, 1918).
[6] Society for the Promotion of Engineering Education, *Report of the Investigation of Engineering Education, 1923-1929*, Two volumes (Pittsburgh, 1930, 1934).
[7] SPEE, "Report of the Committee on Aims and Scope of Engineering Curricula," *Journal of Engineering Education* 30 (1939-40): 555-66; "Report of the Committee on Engineering Education after the War," *Journal of Engineering Education* **34** (1943-44): 589-614.
[8] Robert M. Boarts and John C. Hodges, "The Characteristics of the Humanistic-Social Studies in Engineering Education: A Report," *JEE* 36/5 (Jan 1946), 339-351.
[9] Ibid., 341.
[10] ASEE, Committee for the Humanistic-Social Research Project, "General Education in Engineering," *Journal of Engineering Education* 46 (1955-56): 619-749 (hereafter, Burdell-Gullette Report), 624.
[11] ASEE Humanistic-Social Research Project, "Liberal Learning for the Engineer," *Journal of Engineering Education* **59** (1968-69): 303-342 (hereafter, Olmstead Report).
[12] Ibid, 305.
[13] See the programmatic statement in Joseph Bordogna, "Entering the '90s: A National Vision for Engineering Education," *Engineering Education* (November 1989): 646-649; as well the National Academy of Engineering's *Engineer of 2020* studies, *The Engineer of 2020: Visions of Engineering in the New Century* (Washington, DC: National Academies Press, 2004), and *Educating the Engineer of 2020: Adapting Engineering Education to the New Century* (Washington, DC: National Academies Press, 2005).
[14] Specifically, Criterion 3 consists of eleven "program outcomes," labeled a) through k), of which,

c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethnical, health and safety, manufacturability, and sustainability
f) an understanding of professional and ethical responsibility
g) an ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and social context
j) a knowledge of contemporary issues

are the most relevant. In addition,

d) an ability to function on multidisciplinary teams; and
e) an ability to identify, formulate, and solve engineering problems

imply the humanities and social sciences especially under a fully integrative vision. For the latest version of the accreditation criteria, see ABET, "Criteria for Accrediting Engineering Programs Effective for Evaluations during the 2010-2011 Accreditation Cycle." Available for download at http://www.abet.org/forms.shtml (accessed 1/15/2011).
[15] See for instance Layton (n. 4 above); and Ronald Kline, "Construing 'Technology' as 'Applied Science': Public Rhetoric of Scientists and Engineers in the United States, 1880-1945," *ISIS* **86** (1995): 194-221.
[16] Andrew Abbott, *The System of Professions: An Essay on the Division of Expert Labor* (Chicago, 1988); Magali Sarfatti Larson, *The Rise of Professionalism: A Sociological Analysis* (Berkeley, 1977). For a more recent sociological study whose analysis is much more closely aligned to this paper, see Carroll Seron and Susan Silbey, "The Dialectic between Expert Knowledge and Professional Discretion: Accreditation, Social Control and the Limits of Instrumental Logic," *Engineering Studies* 1(2009): 101-127.
[17] Layton (n. 4 above), xiv-xv.
[18] In addition to Layton (n. 4 above), see A Michal McMahon,*The Making of a Profession: A Century of Electrical Engineering in America, 1880-1980* (New York, 1984); Bruce Sinclair, *A Centennial History of the American Society of Mechanical Engineers, 1880-1980* (New York, 1980); and Terry S. Reynolds, *Seventy-five Years of Progress: A History of the American Institute of Chemical Engineers, 1908-1983* (New York, 1983).
[19] This extends W. Bernard Carlson's observations about the relatively autonomy of engineering schools, found in "Academic Entrepreneurship and Engineering Education: Dugald C. Jackson and the MIT-GE Cooperative Engineering Course, 1907-1932," *Technology and Culture* 29 (1988): 536-567.

[20] On engineers and efficiency, see Thorstin Veblen, *The Engineers and the Price System* (New York: B. W. Huebsch, 1921).
[21] See, for instance, Magnus Alexander, "The Relationship of Engineering Education to the Industries," *Journal of Engineering Education* 15 (1924-25): 459-475, 460; A. A. Potter, "Training for Activity in Non-professional Matters," *Journal of Engineering Education* 15 (1924-25): 469-475; "Preliminary Report of the Board of Investigation and Coordination," November 1926, in SPEE, *Report of the Investigation of Engineering Education, 1923-1929*, volume 1 (Lancaster Press, 1930), 82-119, 87, 91.
[22] William Wickenden, "Engineering Education in the Light of Changed Social and Industrial Conditions," *Journal of Engineering Education* 24 (1933-34): 148-161. See also "Carnegie Plan of Professional Education in Engineering and Science," *Higher Education* **7/7** (December 1950): 73.
[23] Atsushi Akera, "A History of Engineering and Liberal Education Integration and Its Significance for SHOT," draft manuscript intended for publication in *Technology and Culture.*
[24] Burdell-Gullette Report (n. 10 above), 635-636.
[25] Ibid., 636.
[26] Pierre Bourdieu, *Distinction: A Social Critique of the Judgment of Taste* (Cambridge, MA: Harvard, 1987).
[27] Thorndike Saville, "Engineering Education in a Changing World," Presidential address, Annual meeting of ASEE, Seattle, Wash., June 1950. Published in *Journal of Engineering Education* **41**(September 1950): 4-10.
[28] This issue is explored directly in Michael Lynch, *Scientific Practice and Ordinary Action: Ethnomethodology and Social Studies of Science* (New York: 1993).
[29] Larry Owens, "Vannevar Bush and the Differential Analyzer: The Text and Context of an Early Computer," *Technology and Culture* 27 (1986):63-95.
[30] Lynch, *Scientific Practice* (n. 28 above).
[31] As noted by Reynolds and Seely (n. 2 above), 138, Mann did report to a joint committee comprised of representatives from SPEE and the major engineering professional societies.
[32] This is discussed broadly in Layton (n. 4 above), especially in chapters 5-7.
[33] Reynolds and Seely (n. 2 above), 138f.
[34] See especially Chas. F. Scott, "Report of the Chairman," and H. P. Hammond, "Summary of the Fact-Gathering Stages of the Investigation of Engineering Education," in Society for the Promotion of Engineering Education, *Report of the Investigation of Engineering Education, 1923-1929,* Two volumes (Pittsburgh, 1930, 1934), Vol. 1, pp. 1-16 and 17-51.
[35] This basic point is made in articles by Bruce Seely ("SHOT, the History of Technology, and Engineering Education," *Technology and Culture* 36 (1995): 739-772) and by Robert Post, in his more recent biographic essay on Kranzberg, "Chance and Contingency: Putting Mel Kranzberg in Context," *Technology and Culture* 50 (2009): 839-872.
[36] ASEE's rules of membership, for instance, may be compared against those of the engineering professional societies, which during their early history were much more apt to define different classes of memberships in ways that allowed the central determination of policies. See Layton (n. 4 above).
[37] ECPD had its own mechanism for maintaining accountability, and therefore could not, either then or now, establish new accreditation standards simply by fiat. Still, as a "conference type organization" that operated through a small number of delegates advanced by its member organizations, ECPDs policies were more subject to oligarchic control, where a handful of individuals could build consensus around a specific position. This is probably as true with respect to ABET and the development of EC 2000, although I have not yet pursued sufficient historical research on this topic. The ECPD's 1951 appeal to the ASEE, via Hollister, to carry out a major evaluation of engineering education was designed to lend legitimacy to a change Hollister already wished to see, but for which he felt that an ASEE study was necessary to amass the necessary consensus. Hollister got what he wanted, but through a process that invited backlash. One of the major reasons for the 1968 Goals Report was the widespread discontent that engineering educators had embraced scientific knowledge and methods to the exclusion of any substantial training in engineering. See Atsushi Akera, "Engineering Science Ideology and U.S. Engineering Education, 1946-1955," unpublished manuscript.
[38] This point is made by Reynolds and Seely, (n. 2 above), 145; Ad hoc ASEE Committee for Review of Engineering and Engineering Technology Studies (The REETS Committee), "Engineering & Engineering Technology Education" *Engineering Education* (May 1977): 765-776.
[39] See Reynolds and Seely (n. 2 above).
[40] "Report of the Committee on Engineering Education after the War," JEE 34 (1943-44): 589-614, 595-600.
[41] See Akera, "Engineering Science Ideology" (n. 37 above).

[42] Joseph Bordogna, Eli Fromm, and Edward W. Ernst, "Engineering Education: Innovation through Integration," *Journal of Engineering Education* 83 (1993): 3-8.
[43] Ibid., 7.
[44] See for instance, James Stice, "PSI & Bloom's Mastery Model: A Review & Comparison," *Engineering Education* (November 1979), 175-180. The reference is to Benjamin. S. Bloom (ed.), *Taxonomy of Educational Objectives* (New York, 1956).
[45] Again, see Lynch (n. 28 above), for a general discussion and definition of these terms.
[46] Joseph Bordogna, "Entering the '90s: A National Vision for Engineering Education," *Engineering Education* 80 (1989): 646-649.