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From ”Soft Skills” to Humanistic Education for Engineers: In Search of a Deeper Understanding of the Problem to Be Fixed

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If a problem is understood, maybe it can be fixed.

--Betsy Burroughs, founder of IDEO and co-founder of Stanford d.School

Philosophy is about learning to be aware of problems in your own thinking where you might not have suspected them.

--William Stimson, "Engineering and Philosophy," p. 26

Prologue and Introduction

This paper began as a study of faculty in the early twentieth century who shared many interests with current members of the Liberal Education/Engineering and Society Division (LEES) of ASEE. The group includes Fred Newton Scott (1860-1931) at the University of Michigan (Neeley 2025), Sada Annis Harbarger (1884-1942) at Ohio State University (Adams, 1993; Connors, 1999; Duncan, 2023) and Joseph Lee Vaughan (1905-1999) at the University of Virginia.[1] These faculty thrived as professors of humanistic education for engineers, that is, education in the humanities and social sciences (HSS) that helps engineering students grow as individuals and develop the capabilities needed to succeed in engineering practice.[2]

My original project foundered when I realized that writings by and about faculty like Scott, Harbarger, and Vaughan provide insight into their backgrounds, motivations, and pedagogical strategies but do not define or provide a suitable name for the enterprise in which they were engaged. By the time the new ABET accreditation paradigm known as Engineering Criteria 2000 (EC2000) was introduced in the late 1990s, the most common name used to describe the enterprise was "soft skills," terminology used to describe the ABET outcomes that fall partly or entirely outside of engineering as traditionally conceived.[3] Table 1 below lists and describes the educational outcomes that fall in the domain of partly or entirely outside of engineering as traditionally conceived. Even a cursory examination of the table reveals that the terminology of "soft skills" is an inadequate description of these educational outcomes.

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[1] All three of these individuals established programs of what was then referred to as Engineering English but had much more intellectual breadth than one might expect from that descriptor. The Depart of Engineering and Society in the School of Engineering and Applied Science at the University of Virginia is the only one of those programs still extant as a department today.
[2] The same traits and capabilities allow students to function effectively in their personal lives and as citizens in a democracy, as the research cited later in this paper demonstrates.
[3] In fact, the use of the term "soft skills" increased dramatically as they EC2000 paradigm was being implemented (Neeley, 2021a).

Table 1. ABET/EC2000 Outcomes That Fall Partly or Entirely Outside of Engineering as Traditionally Taught. The description of each outcome as provided by ABET appears in bold type. The elaboration that follows interprets the outcome as it can be developed in non-technical courses, including but not limited to communication.

ABET Criterion 3 Outcomes and Assessment
(d) **an ability to function on multi-disciplinary teams**: appreciate perspectives that differ from your own and integrate your individual expertise and perspective with those of other people to accomplish a goal that no member could have accomplished on their own
(e) **an ability to identify, formulate, and solve engineering problems**: identify, think critically about, and reflect on the processes of problem definition, engineering design, and project management; develop multiple frames for a single topic or issue
(f) **an understanding of professional and ethical responsibility**: apply knowledge of professional and ethical responsibility to particular engineering projects and to the engineering profession as a whole; recognize ethical dimensions in circumstances where they are not obvious
(g) **an ability to communicate effectively** with both expert and non-expert audiences; provide context that establishes the meaning of a topic to the intended audience; select appropriate details, translate specialized terminology, and choose communication modes suited to an audience and occasion
(h) **the broad education necessary to understand the impact of engineering solutions in a global and societal context:** ask and seek answers to questions related to implementation and impact; use that understanding in the formulation of engineering problems, solutions, and designs
(i) **a recognition of the need for, and ability to engage in, lifelong learning:** develop the research and analytical skills necessary for confidently tackling unfamiliar problems and applying knowledge in new contexts
(j) **a knowledge of contemporary issues**: recognize and analyze the role that science, technology and engineering play in important contemporary issues and use a knowledge of social and historical context to put contemporary issues in perspective
ABET Criterion 4 Outcomes and Assessment **As part of the major design experience, consider and integrate economic, sustainability, ethical, political, health and safety and sociopolitical issues into the design, implementation, and management of technological systems**: systematically explore the full range of non-technical issues that are part of the problem addressed by a project and might arise in the design, implementation, and management of technological systems that make up the context of that project

After many years of wrestling with the terminology of "soft skills" and trying to understand why no widely accepted model for developing them had yet emerged, I concluded that we needed to do more than critique terminology or repeat the justifications offered by employers who emphasize the need for the traits and abilities associated with soft skills. Working from the premise that the rhetoric of soft skills is a symptom rather than the root cause of the "technical expertise is not enough" problem, this paper draws on the history and philosophy of engineering education and research on engineering practice as resources we can use to generate a deeper understanding of the problem we have been wrestling with—an understanding that can reliably inform curricular and instructional design.

The paper begins by describing the current discourse on soft skills and why it often takes a superficial approach. It transitions to examining the underlying causes for the superficiality in faculty expertise and then explores several sources that can add depth to the discourse: (1) empirically grounded research on soft skills, including history; (2) research that provides detailed descriptions of engineering practice; and (3) philosophy of engineering and engineering education. One goal is to illuminate the depth of expertise humanists and social scientists bring to engineering education and the intellectual, organizational, and pedagogical challenges we face. Perhaps most importantly, the point is to make the intellectual motivation for our work and the deep satisfaction we get from it visible. Finding the depth that underlies the superficial discussion of soft skills has the potential to diminish the opprobrium associated with "service" courses and make way for understanding humanistic education for engineers as a domain of creative work.

The Discourse on Soft Skills: Who Is Writing and Why?

One would be hard pressed to find a more unproductive discourse in engineering education than the one variously labeled "soft skills," "professional skills," "general education," or "liberal education" for engineers. Even the authors of the first major report on soft skills—who were concerned with identifying and developing leaders in the armed forces of the United States—recognized "soft skills" as a fundamentally problematic label for very important educational outcomes (United States Continental Army Command (CONARC) Staff, 1973). The inadequacy of the terminology notwithstanding, the discourse on soft skills has developed and continues to generate a voluminous body of publications. Humanists and social scientists engaged in engineering education tend to recoil instinctively from the terminology but often find ourselves frustrated by an inability to get beyond identifying its negative implications to articulate the intellectual rationale for humanistic education for engineers.

The most striking feature of the discourse on soft skills is the presence of lists of specific skills, many of which do not qualify as skills at all (empathy and perseverance, for example). The appendix to this paper contains three representative examples of such lists. Some lists seem to be developed arbitrarily. Sometimes the lists are generated from a corpus of texts such as engineering education journals or advertisements for engineering jobs. Often, the data collection process that yields these lists goes unexplained, so the "evidence" they generate is mostly anecdotal. More problematically, the items in the lists are at widely varying levels of abstraction, and there seem to be no logical categories into which the items fall. These difficulties are exacerbated by the typical length of a list, 25-30 items or more.

The characteristics of the discourse outlined above can in part be attributed to the contexts in which the lists are generated and the people who generate them. Despite the fact that the need for capabilities beyond the technical has been documented and recognized since the Mann Report (1918), authors often justify their writing by asserting that the relevant stakeholders have just recently discovered this need. For example, Deming (2017) writes about economists being 'increasingly focused on the importance of so-called "soft skills" for labor market success,' and Hirudayaraj, Baker, Baker, and Eastman (2021) frame their argument by asserting that "Concerns related to a lack of soft skills among engineers and engineering graduates have come to the forefront over the last decade" (p. 2). It is not surprising, then, that the description of strategies for developing soft skills are vague and seldom go beyond things such as working on teams or participating in extracurricular activities, both of which pose challenges for assessment. Many of the authors (Graham and Porterfield, 2018; Heckman and Katz, 2012; Klaus, 2009) appear to be in the business of developing soft skills through executive training or online courses, a situation that probably contributes to but does not completely explain the prevalence of clever titles, especially those that focus on the antithetical relationship of "hard" and "soft." Examples include *The Hard Truth About Soft Skills: Workplace Lessons Smart People Wish They'd Learned Sooner* (Klaus, 2009) and "Soft Skills = Hard Results" (MacLachlan, 2019).

Underlying Causes in the Expertise and Experience of Engineering Faculty

Interest in soft skills is by no means limited to engineering and is particularly prominent in the literature on management. The content of the lists and reasons for calling attention to soft skills are not discernibly different in the management literature than they in engineering, but there tends to be a significant difference between faculty in engineering and those in management: faculty in business schools tend to have more direct experience of and ongoing interactions with people in corporations and other workplaces outside of academia. Most MBA programs do not admit people who come straight from undergraduate degrees, and many management school faculty have significant experience outside of academic contexts. Business faculty are thus more likely to interact with the world of practice through executive education or consulting, which helps them keep up with emerging trends and refreshes their memories of the distinctive characteristics of practice.[4]

In contrast, the majority of undergraduate engineering students have little work experience and most engineering faculty have been educated in and progressed in their careers entirely in academic contexts where specialization and individual achievement are highly valued, and siloing of knowledge in departments, subdisciplines, and labs is common. Disciplinary structures isolate departments from each other within engineering schools and colleges, and the rewards system prioritizes research productivity over pedagogical innovation and relevance to the world beyond academia. Added to these factors is the important but often unrecognized reality that departments within engineering schools typically do not depend on each other for their survival and success. The structure of accreditation is an obvious example of this: accreditation is granted (or denied) to degree programs rather than the college or school as a whole. Additionally, the members of accreditation teams are experts in a single engineering discipline and thus not in a position to be expert peer reviewers of instruction and outcomes in most of the areas listed in Table 1. These circumstances mean there is little incentive to attend to pedagogical goals that transcend disciplinary boundaries.

[4] Trevelyan (2019) makes a similar comparison with engineering vs. medicine.

The result of the factors outlined above is, on the one hand, a large and active body of discourse that seems unanimous in its judgment that engineering graduates do not have the capabilities required for workplace readiness, most of which fall into the category of soft skills. On the other hand, we have engineering educators and administrators who make curriculum decisions based on a thin conception of the outcomes they are charged with achieving and lack the experience and intellectual background to think systematically about engineering education and its goals. It is not surprising, then—well-intentioned mission statements about developing leaders and addressing society's most pressing problems notwithstanding—that the majority of engineering degree programs allow students to fulfill their general education requirements with courses in the humanities and social sciences that make no direct connection between humanistic and social scientific subjects and engineering.[5] Although elective courses making meaningful connections between the humanities and social sciences (HSS) and science and technology exist in most—if not all—institutions devoted to engineering education, those courses are not required and thus have minimal impact on the graduates *en masse.* It makes sense that faculty with no experience of the world of engineering practice and little familiarity with the HSS would define the gaps between engineering education and engineering practice in superficial terms.

Diving Deeper I: What We Can Learn from History and Empirically Grounded Studies

The first empirically grounded study of what we now call "soft skills" was undertaken by Charles Riborg Mann and the Joint Committee on Engineering Education (JCEE) under the auspices of the Society for the Promotion of Engineering Education (SPEE) and eventually published in 1918. A preliminary report on the results of Mann's empirical data was presented at the 1916 meeting of the SPEE. According to formal reports from that meeting, the JCEE distributed in the Spring of 1915 a survey designed to elicit the engineering profession's ideals in the form of factors essential to success (Joint Committee on Engineering Education, 1916). The recipients of the survey were given these instructions (p. 57):

> Please prefix numbers to the groups of qualities listed below to show the order of importance that you give them in judging the reasons for engineering success or in sizing up young men for employment or promotion.
>
> . . . .Character, integrity, responsibility, resourcefulness, initiative.
> . . . .Judgment, common sense, scientific attitude, perspective.
> . . . .Efficiency, thoroughness, accuracy, industry.
> . . . .Understanding of men, executive ability.
> . . . .Knowledge of the fundamentals of engineering science.
> . . . .Technique of practice and of business.

The JCEE received over 6,700 responses, 352 accompanied by letters of explanation. The results showed that 75% of success was based on the first four groups, and only 25% on the last two groups. Mann recognized the limitations in these data but nonetheless argues

[5] The composition and technical communication courses required in most programs typically are not humanistic in the sense the term is used here.

> it is evident that instruction in mathematics, or machine design which aims only at a mastery of fundamental principles and technique, cannot be nearly as efficient as *instruction which, while paying due regard to technique and the mastery of principles, yet develops integrity, initiative, resourcefulness, and common sense* [emphasis added] (p. 59).

It would be easy to interpret these results as undermining the value of fundamentals and technique; however, it makes more sense to interpret the first four categories as being essential for making the technical expertise engineers possess valuable to the organizations where they are employed. Such a reframing differs significantly from the deficit model that dominates the discourse on soft skills.

The results of the survey struck members of SPEE in attendance at the 1916 meeting as both surprising and significant, so they organized a special evening meeting to discuss the results further. Among the many interesting observations made at that evening session were the following. “You cannot possibly develop character in a man unless you come into personal contact with him” (p. 73), “there are things in life that are at least as important as knowledge” (p. 95), and “How are we going to develop the human side of the man while we are training him to a mastery of matter? . . .the problem is to *develop technical ability and human qualities simultaneously* [emphasis added]” (p. 97). In many ways, these statements resemble the optimistic assessment of engineering educators who advocated integrated curricula in the wake of the EC2000 criteria.

Nearly 100 years later, Heckman and Katz (2012) published the results of research done at the University of Chicago as part of that institution’s New Science of Virtues project. The authors were concerned with public education at all levels rather than engineering education, but their definitions, analysis, and results are helpful for deepening our understanding of the goals we are trying to achieve by focusing on individual development in engineering education. A central theme of that report is “the explanatory power of personality.” They define personality as “The traits and other acquired skills [that] evolve over time through investment and habituation” (p. 22) and present convincing evidence that

> Standardized achievement tests do not adequately capture many skills that matter in life. GED recipients perform about as well as high school graduates on achievement tests but perform much worse in many aspects of life because they lack important personality traits. . . .Interventions that promote beneficial changes in personality have an important place in a portfolio of public policies to foster human development (p. 38).

These arguments for investments in individual human development in education apply equally well to humanistic education for engineers and add depth to the rationale for such education.

Heckman and Katz continue “measures of personality traits predict meaningful life outcomes. Conscientiousness—the tendency to be organized, responsible, and hardworking—is the most widely predictive of the commonly used personality measures. It predicts educational attainment, health, and labor market outcomes as strongly as measures of cognitive ability” (p. 5). Quoting

Roberts (2009), they define personality traits as "the relatively enduring patterns of thoughts, feelings, and behaviors that reflect the tendency to respond in certain ways under certain circumstances" (p. 10, 140 in original). Perhaps most significantly for our purposes here, they conclude "Personality traits predict and cause outcomes" (p. 37).

A study published by Neeley, Foley, Zhu, and Li in 2023 adds depth to our understanding of humanistic education for engineers by revealing the similarity between soft skills and the divisions of ASEE who focus on intersections between STEM and various contexts of engineering practice. Over half (28 of 54) of the divisions of ASEE focus on the intersections between STEM disciplines and different contexts of engineering education and practice. All 28 divisions emphasize humanistic content and goals. Table 2 below lists those divisions and organizes them into three categories: (1) humanistic content and goals (intersections with other areas of expertise), (2) distinct groups of students, faculty, practitioners, and other stakeholders, and (3) different arenas of activity/organizational contexts.

Table 2. "Engineering and. . ." Divisions of ASEE

Emphasis	Divisions
Humanistic Content and Goals (Intersections with Other Areas of Expertise)	1. Engineering and Public Policy 2. *Engineering Communicators Constituent Committee*[6] 3. Engineering Economy 4. Engineering Ethics 5. Engineering Leadership Development 6. Engineering Management 7. Entrepreneurship and Engineering Innovation 8. Equity, Culture, and Social Justice in Education 9. Liberal Education/Engineering and Society 10. Technological and Engineering Literacy/Philosophy of Engineering
Groups of Students, Faculty, Practitioners, or Other Stakeholders	11. College-Industry Partnerships 12. Engineering Libraries 13. Faculty Development 14. Military and Veterans 15. Minorities 16. New Engineering Educators 17. Pre College Engineering Education 18. Student 19. Women in Engineering
Arenas of Activity/Organizational Contexts	20. Community Engagement 21. Continuing Professional Development 22. Co-operative and Experiential Education 23. Design in Engineering Education 24. Educational Research and Methods 25. First-Year Programs 26. Graduate Studies 27. International 28. Two-Year College

[6] This constituent committee existed when the 2020 study was conducted but no longer exists.

These divisions share goals such as connecting the technical and non-technical dimensions of engineering and transforming engineering education so that it more effectively prepares graduates for workplace success. In other words, they seek to meet many of the same needs as soft skills education. In their detailed analysis, Neeley, Foley, Zhu, and Li focused specifically on the "Engineering and. . ." divisions concerned with engineering leadership and entrepreneurship.[7]

Content analysis of papers from the engineering entrepreneurship and engineering leadership divisions revealed that both focus on developing individual capabilities that bear remarkable resemblance to the lists of soft skills. These capabilities fall into four somewhat overlapping categories: (1) individual traits; (2) thinking tools, that is, strategies for seeking out and organizing knowledge; (3) teams and groups; and (4) identity and culture.

Traits (Possessed by Individuals)
Ethical sensitivity
Tolerance for ambiguity/uncertainty; agility/adaptability to change
Self-awareness and knowledge (capability/learning style assessment, affective domain, confidence and self-efficacy)
Networking, relationship building
Creativity
Thinking Tools (Strategies for Seeking Out and Organizing Knowledge)
Systems thinking/big picture view; synthesis and problem definition
Understanding of human behavior (individually and in groups)
Structured reflection
Making analogies
Communication (broadly defined—writing, reading, speaking, listening; managing process; adapting approach to circumstances; persuading and influencing others)
Teams and Groups
Coordination, cooperation, collaboration
Multidisciplinary teams, knowledge integration
Negotiation and conflict management
Relationship between individual capabilities and group functioning
Identity and Culture (Mental Models and What It Means to Be an Engineer)
Getting beyond dualistic thinking (technical/nontechnical; either/both; simplistic/complex; deterministic/contingency)
Significant differences depending on stage of career/role in organization
"Typical/average engineer" as leader or entrepreneur (norm vs. exceptional)

Similar themes emerge from research on engineering practice (Sheppard, Colby, Macatangay, and Sullivan, 2006 and Trevelyan, 2007, 2010, 2013, and 2019). Sheppard *et al.* compared definitions of engineering practice in the research literature with data gleaned from interviews with

[7] Engineering management and engineering and public policy also share these goals. These divisions are much smaller than leadership and entrepreneurship and have a much smaller corpus of texts published in the proceedings of ASEE annual conferences.

engineering educators and students to create a model of engineering work consisting of (1) engineering as problem solving, considering the systematic processes that engineers use to define and resolve problems; (2) engineering as knowledge, considering the specialized knowledge that enables. . .the process; and (3) engineering as the integration of knowledge and process (p. 429). They define the purposes of engineering education and make a clear and direct case for the crucial role of knowledge of practice: “Professional education ideally must *reflect practice* if it intends to *produce practitioners*” [emphasis added] (p. 430). They also highlight the gap between typical classrooms and the world of practice: “One of the biggest challenges [is] to teach and learn the integration of knowledge, practical skills, and ethical judgment in a setting often far removed from practice” (p. 430). Given these definitions of engineering practice, one might say that one goal of humanistic education for engineers is to bridge the gap between engineering education and engineering practice.

Trevelyan’s research on engineering practice consists largely of detailed studies of workplace behaviors of engineers, both direct observations and interviews with practicing engineers. The most interesting results of his work as it pertains to soft skills and humanistic education for engineers are features of practice that are either sidelined altogether or treated at a superficial level in engineering education. Trevelyan argues that lists of engineering competencies (as reflected in inventories of soft skills) are not “a proxy for knowledge of engineering practice [and we cannot assume] that graduates who develop these competencies and attributes will somehow meet the needs of employers” (2019, p. 2). Among the surprising results Trevelyan reports are these: (1) “academic performance has little correlation with job performance” (2019, p. 825); (2) “engineers spend much of their time on informal teaching activities” (2019, p. 829); (3) “coordinating people, and gaining their willing cooperation, is the most prominent aspect of engineering practice for many (but not all) engineers” (2007, p. 196); and “we can better understand engineering practice by reframing engineering as a human social performance. We can only fully understand engineering if we understand how people think, feel, act, and interact as they perform” engineering work (2010, p. 33).

Diving Deeper II: Philosophy of Engineering Education—What Are Our Aims and How Do We Achieve Them?

Within ASEE, the Technological and Engineering Literacy/Philosophy of Engineering Division (TELPhE) has been, as far as I can tell, the only division that has recognized the need for both a philosophy of engineering and a philosophy of education if we are to have what John Heywood calls “a defensible philosophy of engineering education” (2021, p. vi). The preface to *Philosophy and Engineering Education: New Perspectives, An Introduction* (Heywood, Grimson, Bassett, and Krupczac, 2021) offers insights and perspectives that frame the need for a philosophy of engineering education. The first is that we all “enter teaching with an operational philosophy, that is, with a set of beliefs about how students learn. These beliefs drive our motivation, and we seldom question them” (p. xv). In other words, we all have a philosophy of education (even if we are unaware of it), and one of the major tasks for educators is to make those beliefs explicit, think critically about them, and learn how to act on them effectively in our teaching. As one of the quotes that frames this paper suggests, one of the purposes of philosophy is to make us aware of problems in our thinking of which we have not previously been aware. In the case of engineering education, one major source of difficulty is that the purpose of engineering education as articulated in documents such as *The Engineer of 2020* have not been connected in a meaningful way with curriculum design.

Philosophy and Engineering Education is particularly useful for thinking about the prerequisites for getting beyond the notion of soft skills and defining humanistic education for engineers. In "Philosophy and Engineering Education: Should Teachers Have a Philosophy of Education," (2021) John Heywood links "belief systems that drive the curriculum debate" (p. 4) to questions about how the EC2000 criteria should be interpreted and implemented: 'Change is only possible when a "deep" understanding of these philosophies is held by all the participants. . . .many of the debates about engineering education are conducted at a "surface" level which prevents understanding of different points of view, and causes any "in-depth" discussion of the aims of education to be neglected.' (p. 10) One of Heywood's contributions is to multiply and articulate the differing points of view.

Heywood identifies four types of ideology, each of which reflects an aim of engineering education and has a distinctive focus.

1. **Transmission of knowledge:** The *scholar academic ideology* is teacher centered and focuses on the systematic transmission of knowledge from academic disciplines, both facts and concepts, but also the cultivation of a particular way of thinking that is distinctive to engineers and engineering (as in "thinking like an engineer"). The scholar academic ideology is the underlying primary cause of the emphasis on coverage of topics and the multiplication of electives at the senior level in engineering education.

2. **Creating wealth:** The *social efficiency ideology* rests on the belief that "the curriculum serves utilitarian purposes, namely the creation of wealth" (p. 6). In this view, educational institutions should be run like businesses and have measurable outcomes regarding what graduates will be able to do. Little attention is given to individual students except as graduates who contribute to economic growth. The social efficiency ideology is clearly reflected in the outcomes-based approach currently used by ABET.

3. **Individual development:** The *learner centered ideology* sees knowledge as created by individuals as they interact with their environment and is strongly associated with inquiry-based learning and reflection processes. Perhaps most importantly, this ideology focuses on individuals and their "natural developmental growth rather than demands external" to the individual (Dewey quoted by Heywood, pp. 6-7).

4. **Critical thinking to reconstruct existing institutions:** The *social reconstruction ideology* assumes that existing institutions are incapable of solving social problems, so the goal of education is to get students to make their beliefs explicit, test them, and construct an improved view that can in turn be used to reconstruct existing institutions. In many ways, this ideology is the antithesis of the social efficiency ideology. Instruction based on the social reconstruction ideology focuses on discussion, group processes, and engineering design. To the extent that engineering educators focus in their courses on "making the world a better place," they are acting on this ideology.

Heywood presents these four perspectives as complementary rather than competitive. The first and second are most prominent in the discourse on engineering education. The third and fourth ideologies tend to be dominant in the humanities and social sciences. As Heywood presents the situation, educators need not agree on a single ideology, but they do need to understand the validity of all of them and be deliberate in articulating and exploring the appropriate balance among the four.

In *Becoming a Human Engineer: A Philosophical Inquiry into Engineering Education as Means and Ends* (2023), Alan Cheville also explores multiple aims of engineering education but, instead of focusing on multiple ideologies, uses the work of one philosopher, John Macmurray, a twentieth-century Scottish philosopher, to define a goal that applies to all forms of education: "While there are specific ways of knowing, acting, and being that come from being educated as an engineer, *underlying all forms of education is the central element of growing as a person*" [emphasis added] (p. 21). Like Heywood, Cheville recognizes that education has multiple goals, but he also sees individual development as the most fundamental and observes "To put it bluntly, engineering degree programs mostly choose to *educate engineers at the expense of educating persons*" [emphasis added] (p. 120).

Two threads in Macmurray's thought are particularly relevant for deepening our understanding of the problem we are trying to solve with humanistic education for engineers. First, given that human development is the underlying purpose of education, creating an environment for growth is the highest priority. Growth requires four conditions: (1) social, material, and personal freedom to make choices and express ourselves within reasonable constraints ("develop into what we really are"), (2) the ability and opportunity to test our beliefs against reality, reflect on our experience, and use what we learn to shape future action; (3) a clear sense of what we value and what gives meaning to our actions; and (4) a moral stance in which we develop through others and our own freedom depends on supporting others (pp. 119-120). As Cheville summarizes the argument, "Ideals cannot be achieved by an agent in isolation, rather they can only be developed through others and in community" (p. 119), which means that relating to others and experiencing belonging in a community are important features of a good educational environment.

Second, a complete education develops three modes of perceiving and reflecting on experience ("aperceptions" in Macmurray's terminology): pragmatic, contemplative, and personal. The three modes do not yield easily to definition, so Cheville uses multiple descriptions for all of them.

- **Pragmatic** (generalization): drawing broad conclusions from the results of action and generalizing the results in a way that supports subsequent action (p. 42) with the intention of improving performance. The pragmatic mode focuses the individual's attention on determining whether an action was effective or ineffective without considering whether the action was emotionally satisfying (significant) (pp. 47-48).
- **Emotional/contemplative** (particularization): "the capacity to value one's experiences and find meaning and satisfaction in them" (p. 45). It focuses on whether the individual found the action and its results personally meaningful and involves the exercise of "constructive imagination. . .to try to get to the essence of the object through *a process of emotional rather than intellectual reflection*" [emphasis added] (p. 87).
- **Personal/moral** (personalization) focuses on whether an action is moral and leads us to reflect on "how our actions affect others" . . . .Like the other modes, the personal mode of

apperception is only defined through action in the cycle of withdrawal and return where it is developed through caring for others' welfare and freedom and by paying attention to these aspects of our actions" (p. 45).

Standard models of engineering education value the pragmatic at the expense of the other two modes. Humanistic education for engineers develops the other two modes of perception and relates them to the first. The ideal is to have the three modes function synergistically and for the individual to develop all three.

To account for the scale of the systems engineers create and intervene in, Cheville adds a fourth mode, "systemic," that is particularly relevant to—but often not developed in—engineering.

- **Systemic** (systems theory broadly conceived): "the ability to perceive the larger system in which [engineering] work is embedded" (p. 64) [and] see our own fate as being "tied to that of others and the larger world" (p. 65). "The systemic mode provides a counterbalance to human manipulation by recognizing that all engineering work occurs within larger systems which cannot always be controlled, optimized, or even quantified" (p. 69).

Cheville makes an explicit connection between systemic thinking and professional skills: "Since all action is relational, a student must develop knowledge of other agents with whom the student is engaged in action which captures the broad discussion of professional skills in engineering education" (p. 61).

Conclusion, Implications, and Future Work

The research and perspectives presented above only scratch the surface of what empirical research and the philosophy of engineering education have to offer. Future work will more thoroughly synthesize the resources provided by the philosophy of technology, history, and empirical studies of engineering practice and develop a more robust definition of humanistic education of engineers. Those limitations notwithstanding, this paper does demonstrate the paths by which greater depth of understanding can be achieved and the means by which we can move from superficial notions about soft skills to a deeper understanding of humanistic education for engineers.

One definition of humanistic education for engineers based on the perspectives presented in this paper is that it entails focusing on fundamental aspects of human experience and what generations of scholars have learned and conveyed to us through the humanities and social sciences. It also captures the foundational ideas that engineers and engineering students

- are first and foremost individual human beings who have personal and public as well as professional lives,
- must collaborate with others to solve problems and achieve goals,
- and seek meaning in what they do.

Even without fleshing out, the arguments presented here have important implications for the pedagogical approaches of those of us engaged in humanistic education for engineers and seeking to redirect the discourse on soft skills. First and foremost, humanistic education for engineers does not require "dumbing things down." It is about showing how what appear to be esoteric concepts from the humanities and social sciences can be used to better understand phenomena occurring outside the disciplinary domain where they originated. We must avoid the mistake of underestimating the intelligence of engineering students in domains outside their chosen fields. In other words, they don't need things "watered down." They *do* need translation, context, and connection. We cannot assume background knowledge and should be aware of operating with concepts that are loaded with meaning for us, but amorphous or vague for people outside of our disciplines. For us as translators, it means making tacit knowledge explicit and articulating and thinking critically about assumptions. It also implies much more creative and satisfying work than that implied in the discourse of soft skills.

APPENDIX. Sample Lists of Soft Skills

Sample 1. Hirudayaraj, M., Baker, R., Baker, F. &Eastman, Mike. "Soft Skills for Entry-level Engineers: What Employers Want." *Education Sciences, 11,* 641.

1. Leadership
2. Deliver effective presentations
3. Global and cultural awareness
4. Plan and think strategically
5. Write effectively
6. Deal with uncertainty in relating to people and situations
7. Social and individual responsibility
8. Creativity: come up with 'out-of-the-box' ideas and solutions
9. Communicate effectively with diverse groups of people
10. Time-management
11. Handle multiple priorities
12. Critical thinking (identify, construct, and evaluate arguments; detect inconsistencies and errors in reasoning; solve problems systematically; reflect on underlying values and beliefs)
13. Understand, articulate, and solve complex problems
14. Make sensible decisions based on available information
15. Work under pressure
16. Focused: the ability to stay focused on a task
17. Willingness to take initiative
18. Staying/ being organized
19. Self-efficacy: belief in one's capabilities to achieve a goal or outcome
20. Flexibility and adaptability
21. Curiosity
22. Self-motivation
23. Responsibility
24. Reliability
25. The ability to work in teams
26. Positive attitude

Sample 2. Drew, C. "27 Soft Skills Examples." *Helpful Professor.com.* The published list skips 23 and 24.

1. Communication Skills: talking, listening actively; supports collaboration, cooperation, and results
2. Teamwork: work effectively to achieve common goals; connecting with colleagues from different backgrounds
3. Empathy: put self in someone else's shoes and connecting emotionally
4. Problem Solving: assess issues objectively and systematically, approach problems from various angles, be open minded
5. Adaptability: change behavior and approach appropriately when circumstances change
6. Leadership: Inspire and guide others toward a common goal
7. Time Management: planning out achievable daily tasks that advance bigger projects
8. Emotional Intelligence: recognize, understand, and express emotions

9. Negotiation Skills: listen, empathize, understand the other person's perspective; communicate persuasively with the goal of achieving favorable outcomes for all
10. Conflict Resolution: listen actively, understand perspectives, identify common ground, address disagreements respectfully, and develop creative solutions
11. Creativity: develop innovative ideas and unique solutions to known problems, implement unconventional thinking patterns
12. Critical Thinking: analyze and evaluate information objectively and make judgments based on evidence
13. Interpersonal Skills: interact effectively with others, foster trust, camaraderie
14. Self-Motivation: do tasks of one's own free will and initiative without relying on rewards, incentives, punishments, or deadlines
15. Work Ethic: values that guide attitude and behavior towards work (reliability, professionalism, accountability, diligence
16. Patience: remain calm and composed in situations that take time to resolve
17. Organization: ability to optimize oneself for efficiency and productivity
18. Cultural awareness: recognize, understand, and respect different customs, beliefs, languages
19. Decision-Making Skills: make sound choices after evaluating all the available facts
20. Attention to Detail: being meticulous about even small things
21. Initiative: take charge of one's work without prompting or supervision from higher authorities
22. Lifelong Learning: constantly acquire new knowledge and enhancing existing capabilities
23. Flexibility: willingness to adapt to new technologies, procedures, or new information
24. Positive Attitude: enthusiasm
25. Mentoring: supporting teammates, having patience working with them, encourage peers

Sample 3. Graham, R. & Porterfield, T. (2018) "Preparing Today's Engineering Graduate: An Empirical Study of Professional Skills Required by Engineers: The Surprisingly Broad Range of Skills Required for Engineers." Paper presented at the Annual Conference of the American Society for Engineering Education.

1. Analytical: reviewing evidence, problem analysis, reasoning
2. Career planning
3. Change management: adapting to organizational and technological change
4. Character: ambition, confidence, empathy; understand and respect other professionals
5. Communication: communicate with customers, across cultures and disciplines; graphical and oral communication; report writing, speak clearly and express ideas clearly
6. Conflict management
7. Creativity: creative thinking, innovation, generate new ideas
8. Critical thinking
9. Cultural awareness: work in a cross-cultural team, cultural adaptation and awareness
10. Deal with ambiguity and uncertainty
11. Decision making
12. Ethical and professional responsibility: ethics and equity, professional ethics, morals
13. Flexibility: adjust quickly
14. Give and receive feedback and criticism: from students in other disciplines or cultures, constructive criticism; evaluate performance of others; accept and give constructive feedback
15. Goal-oriented
16. Information management: identify and apply relevant information
17. Interpersonal skills: ability to interact with others
18. Leadership: lead a team; motivate and supervise others; build team cohesion; develop and manage teams; coordinate groups

19. Lifelong learning: acquire new skills and knowledge continually
20. Listening
21. Manage information
22. Negotiation: negotiate to reach a decision
23. Plan work: coordinate and plan tasks; organize things effectively
24. Problem solving: adapt knowledge to solve a problem; creative problem solving
25. Professional and ethical responsibility: aware of political issues; act with awareness of global, economic, and environmental issues; act with integrity; personal responsibility; understand roles and responsibilities; understand the impact of innovations on society; uphold norms
26. Project management: project planning and monitoring
27. Relationship management: build and maintain working relationships; interpersonal relations; trust building; work with individuals from other fields or disciplines
28. Resource management

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