2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #34514

A Provisional History of the Idea of ”Soft” vs. ”Hard” Skills in Engineering Education

Dr. Kathryn A. Neeley, University of Virginia

Kathryn Neeley is Associate Professor of Science, Technology, and Society in the Engineering and Society Department of the School of Engineering and Applied Science at the University of Virginia. She has served twice as chair of the Liberal Education/Engineering and Society Division of ASEE and received that division's Sterling Olmsted Award for outstanding contributions to liberal education for engineers.

A Provisional History of the Idea of "Soft" vs. "Hard" Skills in Engineering Education

soft *adj.* 1. not hard, firm, or rough. 2. not loud or bright. 3. gentle. 4. (too) sympathetic and kind. 5. weak, foolish. 6. (of drinks) nonalcoholic, 7. (of drugs) not highly addictive.
soft option easy alternative. **soft-pedal** v. refrain from emphasizing

--*Oxford Mini Reference Dictionary and Thesaurus,* p.598

disparage *v.* suggest that something is of little value or importance.
syn. belittle, criticize, decry, denigrate, deprecate, minimize, run down, undervalue.

--*Oxford Mini Reference Dictionary and Thesaurus,* p.172

The definitions above capture three important dimensions of the word "soft." First, it is often defined in the negative, as the absence or opposite of something. Second, it is vague in the sense that it means very different things in different contexts. Third, in most contexts, it is fundamentally disparaging. As a term used in engineering education, "soft skills" is filled with contradictions and ambiguity. For example, the "hard" skills map easily onto recognized academic disciplines (mathematics, basic science, engineering), while the expertise that constitutes "soft" skills is difficult to locate in academic disciplines and departments. Still, whatever these "soft skills" are, they are significant predictors of future success in engineering.

All of the humanities and social sciences have the potential to contribute to the development of "soft skills," but none can lay exclusive claim to them. The multidisciplinary nature of "soft skills" means that they are both everywhere and nowhere in an academic context. Both the "soft" and the "skills" elements of the concept have been called into question. In both categories, alternatives have been proposed, but none has become widely accepted. This paper reports on the first phase of a work-in-progress: a historical and philosophical inquiry into why the terminology of soft versus hard skills emerged, how it has evolved, why it has been so persistent, why it is problematic, and how we might be able to move beyond it in engineering education.

Here, the focus is on the circumstances that led to the emergence and prevalence of the term in two different contexts: (1) the discourse community of speakers of English as represented in the *Oxford English Dictionary* (OED) and (2) the discourse community of engineering education as reflected in papers published by the American Society for Engineering Education (ASEE) in the period 1996-2020. The combination of these two perspectives reveals that (1) the conversation on soft skills is by no means limited to engineering education; (2) interest in the topic has increased dramatically since 1996; and (3) implementation of the EC2000 accreditation criteria provided the impetus for the dramatic increase in interest within ASEE.

Research Approach: Qualitative and Quantitative Analysis of Publications Over Time

The research approach used here starts with the assumption that the circumstances in which a term emerges offer valuable insight into the function it was created to fulfill. More specifically, this study combines qualitative and quantitative methods and draws on the conventions of the history of ideas, which traces the origins and development of the beliefs that guide decisions and actions (see, for example, Skinner, 1969 and Bevir, 2000). In its most basic form, the history of ideas traces change over time and consists of three sequential steps:

1. focus on the emergence of new terms as an indication of broad cultural changes,
2. identify influential authors and publications on those terms, and
3. correlate the emergence of terms and authors with events that could motivated them.

As Philip Wiener put it in the preface to his five-volume *Dictionary of the History of Ideas: Studies of Selected Pivotal Ideas* (1973), "the historian of ideas makes his [sic] particular contribution to knowledge by tracing the cultural roots and ramifications of the specialized concerns of the mind" (p. vii).

The approach to the history of ideas outlined above is greatly facilitated by what has come to be termed "text mining," "an artificial intelligence (AI) technology that uses natural language processing (NLP) to transform the free (unstructured) text in documents and databases into normalized, structured data suitable for analysis" (Linguamatics, What Is Text Mining). Search engines provided by Google and others have made the quantitative analysis of large bodies of texts far less labor-intensive than it was in the days of card catalogues.

Although it is possible to do sophisticated assessments of the impact of publications, the approach taken here rests on a simple premise: an increase or decrease in the number of publications indicates increasing or declining interest in a topic or idea. Such an approach is appropriate because scholarship in the history of ideas seeks correlation rather than causation and advantageous because it allows for efficient discernment of changes over time across disciplines and domains. In sum, the comprehensiveness and scope of the history of ideas approach make up for what it lacks in specificity and causality.

The text mining capability provided by document repositories such as ASEE's PEER database, makes it possible to do quantitative analysis that provides at least a rough outline for the history of particular ideas in engineering education. Given the size and scope of ASEE as an organization, it seems reasonable to infer that papers published in the proceedings of the various conferences that ASEE sponsors are broadly representative of trends in engineering education since 1996.

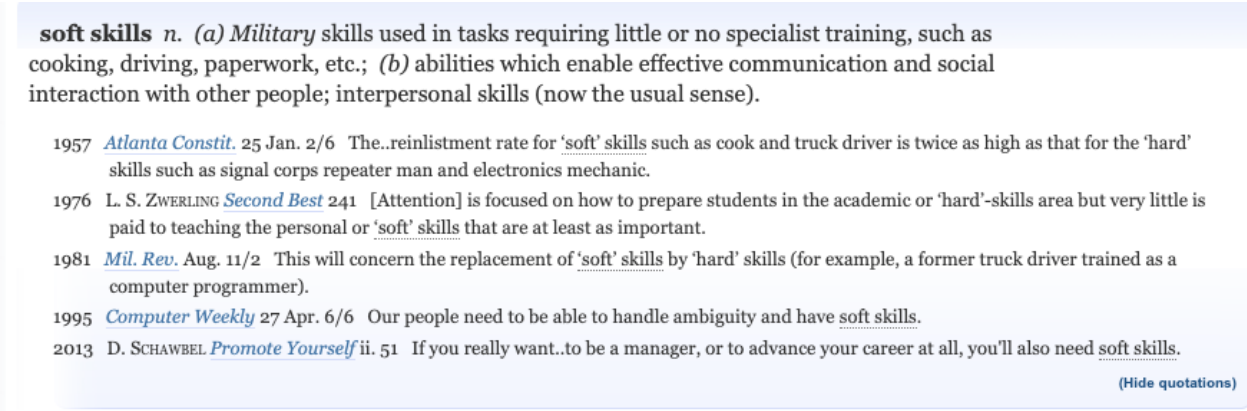
Humphreys and Wang (2018) explain the theoretical foundations of quantitative text analysis (including automated text analysis) as consisting of three basic propositions: (1) "by studying language [we] study thought. . .language is conversely important because it shapes thought" (p. 1278), (2) "language represents attention in two ways. When [people] are thinking of or attending to an issue, they tend to express it in words. Conversely, when [people] are exposed to a word, they are more likely to attend to it" (p. 1279), (3) "Word frequency, measuring how frequently a word occurs, is one way of measuring attention" (p. 1279), and (4)

automated text analysis provides "tools for analyzing language, aggregating insight, and distilling knowledge from this overwhelming amount of data" (p. 1275), including "prediction of variables outside of the text" (p, 1291).[1]

Using the framework Humphreys and Wang provide, the analysis described here takes a "top-down approach" (p. 1284) because it began with a focus on a particular language construct, "soft skills." A search of PEER using the term "soft skills" yielded the details presented below in two different domains: (1) the numbers of papers featuring that terminology over time and (2) the pervasiveness and distribution of the scholarly discourse on soft skills based on the number of divisions treating the topic and the divisions in which the topic seems to play the most important role. Understanding the origins of the term, however, requires going back to a time before automated text analysis and the establishment of the PEER repository.

Qualitative Results: The Story of Origin That Emerges in the First Published Attempts to Define "Soft" vs. "Hard" Skills

According to the *Oxford English Dictionary* (OED), the leading historical dictionary in the English-speaking world, the first published mention of "soft skills" occurred in 1957 in an article published in the *Atlanta Constitution*. The first systematic scholarly publication on "soft skills"originated from a conference convened by the U.S. Continental Army Command (CONARC) in 1972. The screenshot below shows the entry on "soft skills" in context. The astute reader will notice that the report from the 1972 conference is not recorded, a surprising omission on the part of the OED. Still, the publications included in the entry on "soft skills" provided an entry point for identifying other publications, including the CONARC report.



soft skills *n.* *(a) Military* skills used in tasks requiring little or no specialist training, such as cooking, driving, paperwork, etc.; *(b)* abilities which enable effective communication and social interaction with other people; interpersonal skills (now the usual sense).

1957 *Atlanta Constit.* 25 Jan. 2/6 The..reinlistment rate for 'soft' skills such as cook and truck driver is twice as high as that for the 'hard' skills such as signal corps repeater man and electronics mechanic.

1976 L. S. Zwerling *Second Best* 241 [Attention] is focused on how to prepare students in the academic or 'hard'-skills area but very little is paid to teaching the personal or 'soft' skills that are at least as important.

1981 *Mil. Rev.* Aug. 11/2 This will concern the replacement of 'soft' skills by 'hard' skills (for example, a former truck driver trained as a computer programmer).

1995 *Computer Weekly* 27 Apr. 6/6 Our people need to be able to handle ambiguity and have soft skills.

2013 D. Schawbel *Promote Yourself* ii. 51 If you really want..to be a manager, or to advance your career at all, you'll also need soft skills.

(Hide quotations)

Experts in the social and behavioral sciences were convened at the CONARC conference to develop a model of systematic training that would help military personnel cultivate the capability "to command, counsel, supervise, and lead." It is worth noting here that the connection of "soft skills" and leadership has been an enduring theme in engineering and beyond. Even at that early stage in deliberate use of the terminology, the participants in the 1972 conference recognized "that the use of the terms 'Soft Skill' and 'Hard Skill' [should] be discontinued" (p. I-2). Nearly 50 years later, the use of the distinction is still common.

[1] It is an open question whether the search functions in PEER actually constitute text mining. In any case, the theoretical foundations that Humphreys and Wang provide apply to data generated through PEER.

The reports on the CONARC conference use the soft-hard distinction to differentiate between specialized and non-specialized skills, or perhaps more accurately, domain specific vs. generally applicable or transferable expertise. When Turley (1981) used the hard-soft distinction in an assessment of U.S. mobilization of manpower [sic] during a national emergency, he used "technical" and "nontechnical" as synonyms and provided these examples: a "signal corps repeater man" or an "electronics mechanic" exemplify "hard skills," while cooking, driving, and handling various forms of paperwork exemplify "soft skills" that do not become obsolete in the way "hard" or technical skills do (Turley, 1981, p.11).

From the beginning, the soft skills proved devilishly hard to define. One of the experts at the 1972 conference observed somewhat wryly that the CONARC definition of soft skills as "job-related skills involving actions affecting primarily people and paper (II-4). . .*leaves much to the imagination*" [emphasis added] (p. II-5). Eventually, the same expert concluded that soft skills could only be clearly defined in the negative: "Those job functions about which we know a good deal are hard skills and those about which we know very little are soft skills" (p. II-7).

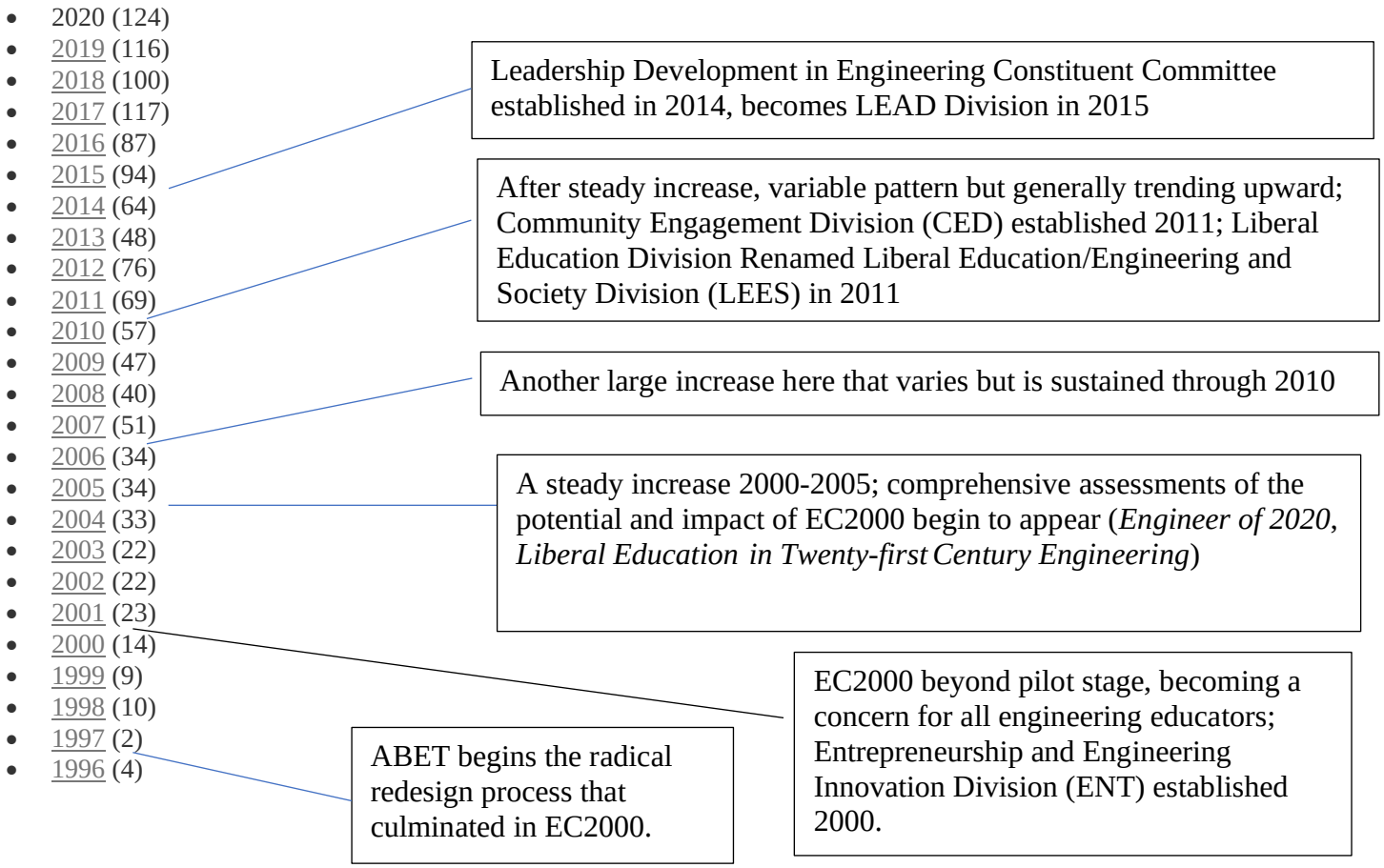
This conclusion bears remarkable resemblance to a remark made to the author of this paper at an ABET annual meeting in the late 1990s: "Soft is what an engineer calls anything he [sic] doesn't understand." On one hand, these difficulties make it even more puzzling that the idea and terminology of "soft skills" have persisted. On the other hand, the ambiguity is probably an indicator of the enduring appeal of "soft skills," especially in the context of engineering education: it provides a way to name something important without being overly specific about what is being named.

Quantitative Results: A Burgeoning Conversation Prompted by the EC2000 Criteria

The frequency data from PEER reveal a burgeoning conversation that grew from 4 papers in 1996 to 23 in 2001, 51 in 2007, 94 in 2015, 117 in 2017, and 124 in 2020. Although the pattern is a little irregular, the overall picture is one of rapid growth. Figure 1 below correlates significant changes in the total number of papers on "soft skills" with developments within ASEE and engineering education more broadly.

These trends and correlated events suggest that "soft skills" provided a readily available name for competencies in the EC2000 criteria that were outside of the STEM disciplines. In other words, engineering educators needed a name for the heterogeneous set of abilities that were not developed systematically in their own areas of specialization. Beyond that, it seems reasonable to infer that the categories of "hard" vs. "soft" appealed because they reflected a binary, hierarchical framework in which the "hard" (STEM) disciplines were superior, even when the outcomes grounded in the HSS outnumbered those developed through STEM.

Figure 1: Results by Year for PEER Search of "Soft Skills" 1996-2020.



The table below identifies the outcomes (d-j of Criterion 3 and Criterion 4) that require or are significantly enhanced by expertise that falls outside of engineering as traditionally taught and understood. Only four of the Criterion 3 outcomes (a-c and k) can be developed through STEM disciplines alone. At least implicitly, the new criteria put the STEM disciplines in minority status. The hard/soft distinction, then, shifted the focus to epistemological hierarchy and supported the dominant core-periphery mental model (Downey 2005).

The ABET criteria have been modified recently and now consist of a shorter list of outcomes, some of which collapse one or more of the items in the table. The original list is included here because of the detail it provides, the competencies are essentially the same, and these were in use for most of the period covered in this study.

Table 1: EC2000 Outcomes That at Least Partly Fall Outside of Engineering as Traditionally Taught and Understood

ABET Criterion 3 Outcomes and Assessment *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.*
(d) **an ability to function on multi-disciplinary teams**: appreciate perspectives that differ from your own and integrate your individual expertise and views with those of other people of both technical and non-technical backgrounds
(e) **an ability to identify, formulate, and solve engineering problems**: identify, formulate, articulate, and solve engineering problems; think critically about and reflect on the processes of problem definition, engineering design, and project management
(f) **an understanding of professional and ethical responsibility**: understand professional and ethical responsibilities as they apply to both particular engineering projects and to the engineering profession as a whole
(g) **an ability to communicate effectively** with both expert and non-expert audiences
(h) **the broad education necessary to understand the impact of engineering solutions in a global and societal context:** understand the impact of engineering solutions in a global and social context and 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:** the development of the research and analytical skills necessary to engage in lifelong learning and understand why it is necessary
(j) **a knowledge of contemporary issues**: recognize and analyze the role that 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 the project and might arise in the design, implementation, and management of technological systems that make up the context of the project

We can gain additional insight into the ways members of ASEE responded to the new criteria by looking at (1) the proliferation of new divisions within ASEE and (2) the divisions in which the scholarly conversation about soft skills is most prominent. Table 2 below (based on

the frequency data) shows where the conversation on "soft skills" has been most prevalent in the various divisions of ASEE.

Table 2. Divisions with the Most Papers on "Soft Skills"

Divisions with the Most Papers on "Soft Skills" 1996-2020		
	Division	Number of Papers on "Soft Skills"
50+	Design in Engineering Education	58
	Educational Research and Methods	53
	Engineering Technology	58
	International	54
	Liberal Education/Engineering and Society	57
40+	Entrepreneurship and Engineering Innovation[2]	42
	First Year	48
30+	Civil	35
	Electrical and Computer	37
	Graduate Studies[3]	37
	Mechanical Engineering	37
	Multidisciplinary[4]	39
20+	Community Engagement Division[5]	24
	Cooperative and Experiential Education	26
	Engineering Leadership Development[6]	29
	Manufacturing	26
15+	Biomedical	16
	Chemical	20
	College Industry Partnerships	15
	Engineering Management	16
	Computers in Education[7]	19

Not surprisingly, the divisions in which the conversation has been most concentrated are those not limited to a single engineering discipline, which suggests that they function as common

[2] Established 2000
[3] Established 2009
[4] Established 2003
[5] Established 2011
[6] Established 2014
[7] Established 2002 (no date on original bylaws; journal first published 2002; division may have formed earlier)

ground for engineering education. Six of these divisions were established in 2000 or later. Their emergence can be explained in part by the increasing interest in developing professional skills. Among the divisions that focus on a particular engineering discipline, those with the most active conversations are listed below along with their disciplinary professional society.

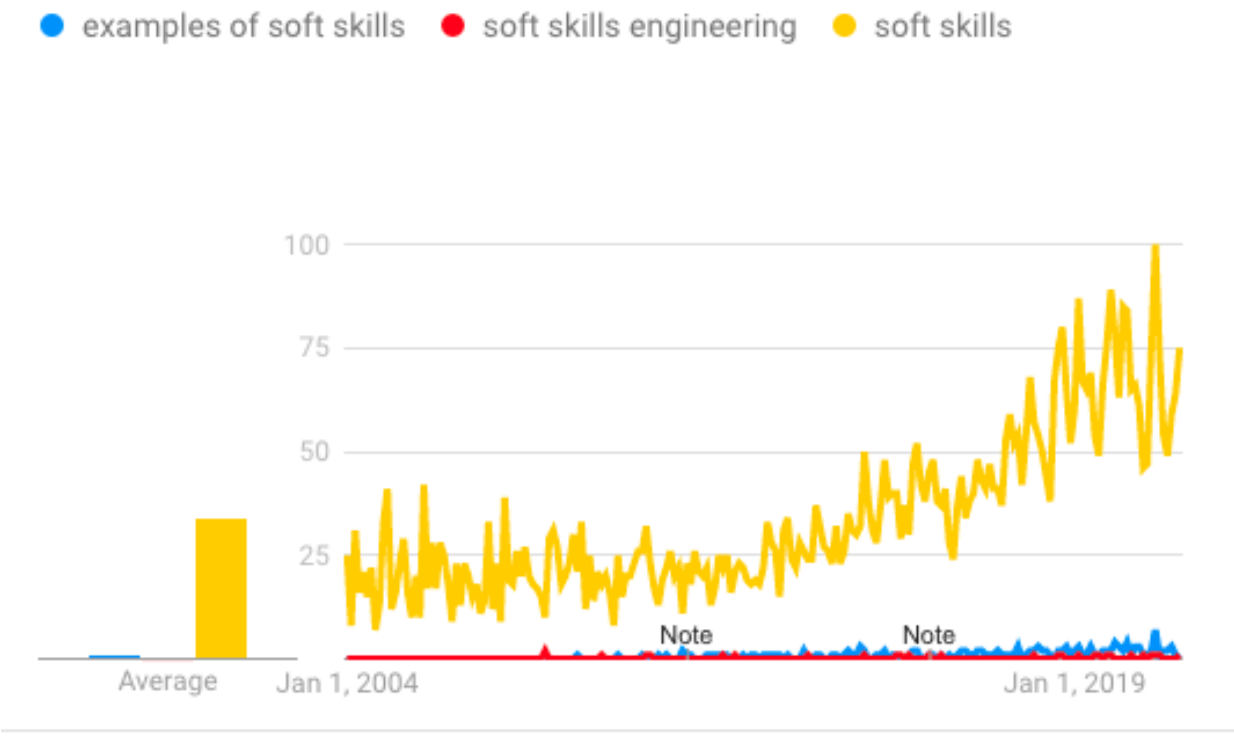
1. Electrical and Computer Engineering (IEEE)
2. Civil Engineering (ASCE)
3. Chemical Engineering (AIChE)
4. Mechanical Engineering (ASME)

A preliminary examination of the websites of these four professional societies suggests that they have significant efforts underway with respect to professional skills. For example, IEEE has an Ebook series on "soft skills." AIChE also uses the term "soft skills." ASCE and ASME, on the other hand, eschew the terminology of "soft skills" and use "professional skills."

Putting the Discourse on "Soft Skills" in Engineering in a Larger Context Using Google Trends

Google Trends search frequency analysis provides a rough but nonetheless useful way to trace interest in a topic over time by taking the frequency with which a term is searched as an indication of overall interest in it. The graph below displays trends for three different search terms: "examples of soft skills," "soft skills engineering," and "soft skills" as a broad category.

Figure 2. Google Trends Frequency Results March 2021



This graph suggests three potentially significant findings. First, interest in soft skills is by no means limited to engineering. Second, both general interest (as reflected in Google Trends) and interest within ASEE (as reflected in PEER) grow dramatically in from 2004-2020. Third, the interest in "examples of soft and hard skills" reflects the tendency for systematic study of soft skills to focus on inventories (lists) rather than defining what soft skills are as a category or concept or focusing in a systematic way on how those skills are developed.

Conclusions and Future Research

The evidence and analysis presented in this paper suggest that the terminology of "soft skills" emerged in the context of leadership development in the military and as part of an effort to systematically develop an evidence-based approach to cultivating those skills. Although it has proved remarkably persistent, the terminology of "soft" vs. "hard" skills was not the result of a deliberative process (at least there is no evidence of such a process). It seems to have been chosen *ad hoc* as a readily available option whose limitations were recognized at the outset.

Interest in "soft skills" within ASEE increased dramatically as the EC2000 criteria were implemented. It seems likely that it persists because of (1) its vague, capacious nature; (2) the way it maintains a hierarchy of knowledge in which engineering in particular, and the STEM disciplines more generally are at the top while also recognizing what employers want in the engineering graduates they employ; and (3) the non-technical skills are recognized as essential to career success in engineering.

As the title of this paper indicates, the historical narrative presented here is provisional. Nonetheless, it provides a high-level view and the beginnings of an understanding of the factors that contributed to increased use of the terminology "soft skills." The documentary evidence cited here is deserving of deeper analysis. It should be possible to identify the authors and publications that have been important in the discourse on "soft skills." Additionally, this paper has skirted both the debate over what should replace the hard-soft distinction and the relationship between the scholarly and popular press discourses on "soft skills." There seem to be an increasing number of businesses that purport to develop "soft skills," and the efforts of the various professional societies with respect to professional skills deserve mapping in greater detail.

The longer-term goal of this project as I currently envision it is to get beyond inventories of soft skills (of which there are many) and what appears to be perpetual discovery of the fact that they matter so much in engineering. To develop the "soft skills" systematically, we have many conceptual knots to untangle, including the skills-proficiencies-individual trait relationship; the core-periphery distinction that is central to engineering education; how the professional skills differ from the capabilities considered to be the "core" that engineering education in the various disciplines seeks to develop; and how we can structure and assess the efficacy of educational experiences that cultivate those capabilities. At a minimum, though, I hope this provisional account demonstrates the validity of pursuing a historical and philosophical inquiry into the vocabulary of "soft skills."

References

1. Claxton, G., Costa, A. & Kallick, B. (2010). Hard thinking about soft skills. *Educational Leadership,* 73, 60-64.

2. Donaldson, W. (2017). In praise of the "ologies": A discussion of and framework for using soft skills to sense and influence emergent behaviors in sociotechnical systems. *Systems Engineering, 20*(5), 467-478.

3. Downey, G. (2005). Are engineers losing control of technology?: From 'problem solving' to 'problem definition and solution' in engineering education, *Chemical Engineering Research and Design , 83*(6), 583–595.

4. Fry, J.P. (1972, December). Procedures for Implementing Soft-Skill Training in CONARC schools, Paper presented at the CONARC Soft Skills Conference, Texas, 12-13 December.

5. Gadol, J. K. (1973). Universal man. In P. F, Wiener (Ed.), *Dictionary of the history of ideas: Studies of pivotal ideas.* Vol. 4, 437-443.

6. Garicano, L. & Wu, Y. (2012). Knowledge, communication, and organizational capabilities, *Organization Science, 23*(5), 1382-1397.

7. Graham, R., & Porterfield, T. (2018, June), Preparing today's engineering graduate: An empirical study of professional skills required by employers. *Proceedings of the 2018 ASEE Annual Conference & Exposition,* Salt Lake City, Utah. 10.18260/1-2—30887

8. Gray, L. (2013). The depth metaphor and international human resource development: From theory to practice. *Human Resource Development International*, *16*(4), 426-440.

9. Guest, D. (1991, September 17). Managers in focus as the skills gap closes: The hunt is on for the Renaissance Man of computing. *The Independent* (London).

10. Heckman, J.J. &Kautz, T. (2012). Hard evidence on soft skills. *Labour Economics,19.* 451-464.

11. Humphreys, A. & Wang, R.J. (2018, April). Automated text analysis for consumer research. *Journal of Consumer Research, 44*(6), 1274-1306.

12. Hurrell, S.A. (2016). Rethinking the soft skills deficit blame game: Employers, skills withdrawal and the report of soft skills gaps. *Human Relations, 69*(3), 605-628.

13. Kimmel, M. J. & Balzer, R. H. (1984). *Military Leadership Job and Skill Requirements: An Annotated Bibliography*. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

14. Neeley, K.A. (2016). Leadership, Entrepreneurship, Management, Policy: Intersections or Separate Domains? *Proceedings of the 2016 ASEE Annual Conference & Exposition,* New Orleans, Louisiana.

15. Oxford University Press, & Chicago Public Library (2000). Soft skills. *Oxford English Dictionary*. Oxford, UK: Oxford University Press. Oxford University Press, & Chicago Public Library (2000).

16. Parlamis, J. & Monnot, M.J. (2018). Getting to the CORE: Putting an End to the Term "Soft Skills." *Journal of Management Inquiry, 28*(2), 225-227.

17. Rao, M.S. (2018). Soft skills: Toward a sanctimonious discipline. *On the Horizon, 26*(3), 215-224.

18. Russell, J. (2018, July 18). What are soft skills and why are they important? Dave's Charm School (blog) Available: https://davescharmschool.com/2018/07/18/importance-of-soft-skills/.

19. Somerville, M.H., Goldberg, D. E., Kerns, S. E. & Korte, R. (2010, October). A war of words: Using sticky language to effect change in engineering education. *2010 Frontiers in Education Conference (FIE)*. IEEE: T3B-1-T38-2.

20. Turley, J. (1981, August). Mobilization manpower: A credible force or an empty promise? *Military Review*, 2012.

21. U.S. Continental Army Command. (1973, April 5). *CONARC soft skills training conference*. Proceedings of a conference conducted at the Air Defense School, 12-13 December 1972.

22. Wang, X., Bendle, N.T., Mai, F. & Cotte, J. (2015). The *Journal of Consumer Research* at 40: A Historical Analysis. *Journal of Consumer Research*, *42*(1), 5-18.

23. Whitmore, P.C. (1972, December). What are soft skills? Paper presented at the CONARC Soft Skills Conference, Texas, 12-13 December.

24. Whitmore, P.C. & Fry, J.P. (1974). Soft Skills: Definition, behavioral model analysis, training procedures. (Professional Paper No. 3-74). Alexandria, VA: Human Resources Research Organization.