Closing the professional skills gap for engineering graduates: Recent trends in higher education

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Abstract

The research paper discusses how higher education has responded to the existing gap between employers' expectations and qualifications of recent college graduates in professional skills reported by national surveys of employers. During the last decade, the National Association of Colleges and Employers has been reporting that less than 50% of employers evaluate college graduates as proficient in the competencies such as professionalism/work ethic, oral/written communications, teamwork/collaboration, leadership, and other related skills.

The paper presents a two-fold analysis of Engineering/Industrial/Operations Management undergraduate programs offered by Colleges of Engineering in the higher education institutions in the United States. The analysis includes a review of the programs' curricula and published course catalogs to determine the degree to which professional skills are incorporated in these programs. Another facet of the analysis includes review of literature related to the initiatives the engineering colleges pursue to address the gap in student professional skills.

The paper includes discussion of the higher education trends and their match with the rapidly changing workforce arena with prognoses for the future of engineering professions. It also provides best practices and benchmarks of the Engineering/Industrial/Operations Management undergraduate programs which successfully address the workforce requirements and needs. The authors outline recommendations for strategic changes in the programs/curricula for successful fulfillment of the mission of higher education to prepare highly qualified graduates and to address the human resource development challenges.

Keywords: Engineering Education, Professional Skills, Teamwork, Communication, Leadership, Ethics, Engineering Management

Introduction

The engineering workplace outlook has changed drastically worldwide in the last few decades as a result of globalization and technological progress [1-3]. The fast pace of change poses challenging conditions for higher education institutions because it is difficult to keep up with the changes necessary to prepare qualified college graduates [1, 4-5].

Contemporary workforce requirements change the old stereotype of an engineer as a highly knowledgeable and technically qualified but introverted specialist. Professional skills that are transferable to any workplace are displacing technical knowledge at the top of the list of employers' requirements for engineers. Today, engineers are expected to work in multidisciplinary teams, effectively communicate with diverse audiences and stakeholders, and understand the societal impact of engineering decisions [6-7]. However, national reports indicate that less than 50% of employers consider college graduates proficient in competencies such as professionalism/work ethic, oral/written communications, teamwork/collaboration, leadership, and other related skills [8-9]. Another complication in this situation is that a majority of college graduates (over 80%) believe they are proficient in these skills when entering their first workplace [9-10].

The goal of this study is to explore how the higher education system responds to these challenges and what is still needed to be done to reduce these gaps and prepare qualified graduates ready for a successful career. To examine how higher education adapts to emerging employer

needs and implements the necessary changes in engineering education, we completed a two-part study. In the first part of the study, we performed a literature review, analyzing curricular initiatives reported in national journals and conference proceedings. In the second part of the study, we surveyed 60 engineering program curricula across the nation by examining publicly available curriculum materials.

Background

Since the publication of the Grinter report in 1955, engineering curriculums have been directed to focus on basic science and engineering science education [11]. Over the years, with the advancement of science and engineering, the engineering curriculum has added more and more science, math, and engineering coursework to improve the technical knowledge of our graduating engineers and engineering professionals. As the technical content increased, the space for other knowledge and skills has decreased. Many engineering curricula have expanded the engineering requirements and left little to no room for any other instruction other than the minimum coursework necessary for a university Bachelor of Science degree.

In the last 20 years, employers have expressed concerns about the preparation of their newest engineering professionals [12]. While they are usually very satisfied with their new engineer's technical preparation, they are dissatisfied with the ability of those new hires to function effectively in a professional environment [13]. Professional skills have long been listed as some of the most important skills necessary for a successful engineering career, yet there was little change in academia toward improving graduate professional skills [14-15].

Recent changes in the Accreditation Board for Engineering Education criteria have sparked an interest in studies on the integration of professional skills into the education of engineering professionals. The ABET 2020 accreditation criteria called for not just a few courses that may have included professional skills. The new criteria called for an accounting of whether engineering students actually achieved outcomes that included professional skills such as communication, team skills, knowledge of ethics, and awareness of global and societal issues [12]. This has led to a more concerted effort to integrate professional skills within the engineering curriculum.

The Current Situation

The National Center for Education Statistics (NCES) reported that there were 2,703 4-year institutions that awarded degrees at the bachelor's or higher level during the 2018-19 academic year. Approximately 13% of these campuses account for 61% of all enrolled bachelor's degree students [16, 43].

Although the total number of degrees conferred in engineering in 2018 was only about 6% (122,000) of the total number of bachelor's degrees nationwide, there has been an increasing trend in the number of bachelor's degrees granted in the field of engineering and engineering technologies. The number of engineering bachelor's degrees conferred increased by 23% between 2008 and 2013, and then increased by another 37% between 2013 and 2018 [16]. The American Society for Engineering Education (ASEE) reported another 20% increase in the 2020-2021 academic year. The top four degrees granted in 2021 were Mechanical Engineering (23.8%), Computer Science (16.2%), Civil Engineering (9.3%) and Electrical Engineering (9.2%) [17, 39].

The National Center for Education Statistics (NCES) reported that in the 2007-2008 academic year, 41.9% engineering and engineering technology bachelor's degree recipients earned credits for Writing beyond English Composition with median of a 3 credits; and 24.5% earned a

median of 2.7 Ethics credits [18]. No other courses directly related to professional skills were included in the report. No data is available from the NCES for recent academic years.

To better understand the current situation, we analyzed publicly available data to explore how higher education institutions have reacted to the increasing need for professional skills for college graduates. For the first part of this study, the sources used include journal publications and conference proceedings papers that discuss teaching of professional skills to engineering students. Other sources used for the second part of this study are program requirements, undergraduate course catalogs, and course descriptions published on universities' and colleges' official websites.

The initial analysis was carried out in 2019 on 60 engineering programs (29 Engineering Management programs and 31 Mechanical Engineering Programs) based on the ASEE 'Engineering by Numbers' report for 2018 [17] and ABET sample report for 2018. The analysis was then repeated in 2022 on 89 engineering programs (49 Engineering Management & 40 Mechanical Engineering programs) based on the updated ASEE 'Engineering by Numbers' report for 2021 [39] and ABET sample report for 2021. This approach enables analysis of the dynamics of implementation of professional transferable skills in the respective engineering programs.

Delimitations of the Study

A literature review of professional skill teaching practices for the first part of this study was delimited to papers discussing national practices in the United States of America. Although we acknowledge the large body of papers that discuss international (European, Asian, and other) practices, they were not included in this study.

The second part of the study was delimited to United States higher education institutions which offer ABET accredited 4-year bachelor in science programs in Industrial Management (IM), Engineering Management (EM), Engineering Technology Management (ETM), and Operations Management (OM) within a College of Engineering. For simplicity of analysis and discussion we denote these programs as Engineering Management (EM) programs. Similar programs offered in colleges of Arts and Sciences (Bachelor of Arts) or Business Schools were not included in the study. Also, a sample of national Mechanical Engineering (ME) Bachelor of Science programs was included in the analysis to compare and contrast with the Engineering Management related programs.

Other engineering programs were not included in this stage of the study due to limited resources and timeline to collect and analyze the extensive amount of data. Prioritizing the management-related programs in engineering was purposeful as these programs seem to be a natural fit for offering professional skills education/training in the program curricula for engineering students.

Analysis of Published Literature

The first part of this study is an analysis of literature undertaken to explore contemporary education strategies used in engineering related curricula to improve outcomes in professional skills. Included is a review of the relative success of these methods as reported in the literature.

The integration of professional skill education has taken a number of forms. Some engineering programs rely on additional courses outside core engineering science courses to meet the student outcomes. Some engineering programs count on co-curricular activities to engage students in professional skill development. Some engineering programs tack additional

requirements in professional skills onto engineering sciences courses. Others rely on industry sponsored and or service-learning activities to enhance student skills. The vast majority of these development activities have not significantly altered the overall content and delivery of the technical core of the engineering professional degree [14].

Adding Coursework to Curricula

Several programs report using additional course work beyond the core curriculum to integrate professional skill learning opportunities offer communication courses and leadership courses. Some authors describe forms of leadership institutes or elective course tracks [19]. The leadership institutes described are usually not included in the base curriculum and require the student to take additional credits to earn certificates. Elective course tracks described are often specific course selections from the university general requirements that are specifically designed to improve the desired professional skills [20, 40]. There are also instances where university general requirements are courses that are tailored to the specific needs of engineering graduates [21, 41]. Integrating professional skills in this manner separates them from the technical content of the major.

Co-curricular Activities

Co-curricular activities are another way in which engineering professional programs expect student outcome improvement in professional skills. Carter, Ro, Alcott, and Lattuca (2016) report the co-curricular engagement does improve student professional skill development to differing degrees [22]. Co-curricular activities are considered any activities that do not lead to earned degrees or certificates. Engineering programs encourage their students to become involved in professional and honor societies, clubs, community outreach, networking events, study aboard, internships or cooperative education opportunities, extracurricular engineering design competitions, and other related activities outside the curriculum. While none of these things provide instruction in professional skills, they do provide the opportunity to practice and improve professional skills [23,42].

Integration in Current Curricula

Another way that engineering programs integrate professional skills in their curriculum is to add professional skills to existing courses. Students are often given group work and are required to write technical reports. Presentation to industry representatives or in public venues also encourages a student to focus on professional skills. One note of interest is that faculty tend to focus more on the technical content than on the professional skills in these instances [24]. It is important to note that engineering program faculty are often not professionally prepared to give instruction in professional skills. Some programs have addressed this by assigning professional skill experts to co-teach courses and give professional skill feedback separately [25]. Research evidence shows that this can be an effective way of integrating professional skills in technical courses [24-26].

Integration can be accomplished in other ways, as well. Professional skills are sometimes addressed through additional course requirements using alternate methods of delivery of technical content that include the use of professional skills [5]. Assigning students projects that require teamwork and collaborative problem solving is one method [27]. This strategy is successful in improving core discipline learning outcomes, but, if lacking appropriate instructional support, it can create a larger gap in a student's professional skills [28]. Service-learning activities where students

apply the coursework to solve a problem outside the classroom is another method [29]. Undergraduate research projects are also used.

Measurement of Success

The measurement of success of instruction has been called into question. While much of the literature on professional skill development in engineering students shows progress and success, there is little evidence that instruction has been successfully transferred to the professional workplace [21]. There is limited real data on improvement in professional skills reported by employers of graduates. Success is measured using secondary methods such as attainment of engineering positions, reported salaries, and involvement in community activities [14].

One of the often-used methods used to gauge whether students are achieving outcomes is to ask the student whether their skills have improved. The students often report an improvement in skills and assessment indicates that success at the department level, but perception of skills proficiency at the university does not match the perception of skill mastery of the employer. Donnell, Aller, Alley, and Kerowicz (2011) performed a study illustrating the gap [21]. After surveying a large number of both department heads and employers regarding communication skills, they discovered that while 52% of department heads considered skills to be strong, only 9% of employers considered these same skills as strong for graduates of engineering professional programs. This happens because it is common practice to assess learning outcomes for core discipline content in the team projects with little or no assessment of their professional skills [30].

Faculty Perspectives on Professional Skill Development

No less important, the influence of faculty in perspectives of professional skills can be a barrier to learning [24, 26, 31-33]. Some faculty have recognized the importance of professional skill instruction. The Higher Education Research Institute (HERI) Faculty Survey Report indicates that faculty have gradually shifted their teaching methods toward cooperative learning and group projects in the period between 1989-2014, but the percent of faculty implementing these methods is still relatively low, 45.5% and 60.5%, respectively, in 2014 [34]. Also, the HERI 2016-2017 survey indicates that only 26.8% of faculty believe they play a role in student's emotional development, 37% of faculty help students develop their personal values, and only 40% help to develop student's moral character, which are necessary prerequisites for professional skills development [35]. Thus, engineering faculty training is necessary to improve students' learning of professional skills.

Although earlier work on professional skills development is reported in the literature [36], there remains "a gap in [our] research basis for broader developmental trajectory of professional skills" [5, p.5]. The first part of this study shows that there is evidence in the literature that engineering professional programs are attempting to address professional skills in curricula, however, there is much work needed. The first part of this study suggests that engineering profession faculty, researchers, and administration must have more awareness of the gap and work to develop more coherent strategies and methods to improve student outcomes from the employer's perspective.

Analysis of Engineering Management and Mechanical Engineering programs curricula

Sample

In the second part of this study, we analyzed 89 engineering programs. These programs are all offered through Colleges of Engineering in the United States. All offer 4-year ABET accredited bachelor's degree programs. Among them, 49 programs were in Engineering Management

(Engineering Management (EM), Industrial Management (IM), Engineering Technology Management (ETM), and Operations Management (OM)) and 40 programs were in Mechanical Engineering (ME). The EM sample was retrieved from the ABET website list of Engineering Management related accredited programs. The ME sample includes institutions that conferred 1,000 or more degrees in the years 2009-2021 based on the ASEE 'Engineering by Numbers' report [17, 39].

Analysis Framework

We considered seven components of the ABET student outcomes [37] that support the program educational objectives and reflect professional skills sets: professionalism, ethics, oral communication, written communication, teamwork/collaboration, and leadership. Other professional skills which do not fall in any of the categories were included in the 'Other' category.

We used courses listed in the 2010 Course Map Report by the National Center for Education Statistics (2012) as a basis for the course catalog search [38]. The College Course Map (CCM) is a taxonomy system for coding postsecondary education courses developed by the NCES and used in NCES research studies. The following Code Categories were selected for inclusion in the analysis for the listed professional skills categories: 37 Personal Awareness and Self-Improvement, 35 Interpersonal and Social Skills, and 09 Communication. The list of courses used in the analysis and the course descriptions are provided in Appendix 1.

All information regarding program requirements was retrieved from the higher education institutions' official websites, their published program requirements, and undergraduate course catalogs.

Some program requirements included a reference to blocks of Humanities or Social Sciences disciplines with a broad spectrum of various courses to choose from: both related and not related to professional skills. If elective courses related to professional skills were not specified in the recommended electives list for a program, they were not included in the analysis.

Courses that included three or up to all seven categories of professional skills in a course description were classified in the Professionalism category. Courses that included two professional skills categories were classified into one of the categories based on the description specifics and per our discretion. These courses were not duplicated in the second category of professional skills.

For some courses that did not contain the key words in the name of a course, but had a high probability of including professional skills, we screened the course descriptions for key words. The majority of the screened courses were related to management or design.

Capstone courses were not included in the analysis because these courses are usually considered a culmination of a program of study where students demonstrate their technical and professional skills rather than learn them. Therefore, the capstone courses are mostly used to assess and report student learning outcomes in the program of study.

Findings

The results and major findings of the program analysis are summarized in the tables below.

Table 1 includes examples of courses that were classified into the selected Professional Skills categories. Professionalism-related courses were mostly freshman-level introductory

courses to the profession. The ethics category included engineering/management/professional ethics and social responsibility. Oral Communication covered professional/effective/interpersonal/business oral communication. Written Communication included mostly technical/technical report writing, writing for the profession, writing for managers, and writing techniques. The teamwork category was limited to engineering teams' theory and practice and team-based design. The leadership category comprised mostly engineering leadership, organizational leadership, and leadership principles. Under the category 'Other' there were primarily courses related to diversity, global studies/awareness, and foreign languages. Table 1 presents examples of courses that contained professional skills in the course descriptions.

Additional courses were included that indirectly related to professional skills categories. The course descriptions did not specifically state professional skills; however, a reasonable person would conclude that the course contained professional skills development. For example, a course description may say, "the course deals with understanding management concepts and functions of encouraging employee's enthusiasm and creativity; finding shared vision, norms, and values, sharing information and power." It can reasonably be assumed that communication and leadership are subjects in this course.

Tables 2-4 illustrate the analysis results and findings on how many programs include professional skills courses in the program requirements.

Table 1. Selected example of courses directly related to the Professional Skills categories reported in program catalogs.

Professional Skills Categories	**Examples of Courses**
Professionalism	Introduction to Profession, Business Practices of Design
Ethics	Engineering Management & Ethics, Engineering Ethics and Social Responsibility, Professional Ethics
Oral Communication (beyond Speech 101)	Oral Communication for Engineers, Technical & Professional Communications, Communication in the Major, Effective Speaking, Interpersonal Communication, Communication in Business and the Professions
Written Communication (beyond ENGL 101 Composition)	Technical Writing, I & II, Critical Analysis and Writing, Writing Techniques, Writing for the Professions, Written Communication for Managers, Writing Across the Curriculum
Teamwork/Collaboration	Engineering Teams: Theory and Practice, Team-based Design & Innovation
Leadership	Introduction to Engineering Leadership, Engineering Leadership, Organizational Leadership & Team Development, Fundamentals of Self-Leadership, Principles of Leadership
Other	Diversity, Foreign Language, Critical Thinking, International Perspective, Engineering for Social Change, Global Studies

Table 2. Professional Skills offered in the ABET accredited Engineering Management programs.

Professional Skills Categories	**Programs which require/ offer courses directly related to the skills**			
	# of programs		**%**	
	2018	**2021**	**2018**	**2021**
Professionalism	3	13	10%	27%
Ethics	13	18	45%	37%
Oral Communication (beyond Speech 101)	14	30	48%	61%
Written Communication (beyond ENGL 101 Composition)	20	41	69%	84%
Teamwork/Collaboration	3	10	10%	20%
Leadership	6	11	21%	22%
Other	8	24	28%	49%
Program information that reflects Professional Skills (per program description or a program website content)	2	10	7%	20%
# of programs which offer courses for all skill categories	0	0	0%	0%
# of programs which offer no courses related to the Professional Skills categories	1	2	3%	4%
# of programs which offer courses for at least three Professional Skills categories	13	25	45%	51%
Total # of programs	29	49	100%	100%

Table 3. Professional Skills offered in the largest Mechanical Engineering programs

Professional Skills Categories	**Programs which require/ offer courses directly related to the skills**			
	# of programs		**%**	
	2018	**2021**	**2018**	**2021**
Professionalism	6	10	19%	25%
Ethics	6	6	19%	15%
Oral Communication (beyond Speech 101)	7	13	23%	33%
Written Communication (Beyond ENGL 101 Composition)	24	32	77%	80%
Teamwork/Collaboration	0	0	0%	0%
Leadership	2	3	6%	8%
Other	9	17	29%	43%
Program information that reflects Professional Skills (per program description or a program website content)	7	11	23%	28%
# of programs which offer courses for all skill categories	0	0	0%	0%
# of programs which offer no courses related to the Professional Skills categories	3	4	10%	10%
# of programs which offer courses for at least three Professional Skills categories	6	9	19%	23%
Total # of programs	31	40	100%	100%

Table 4. Comparison of Professional Skills offerings in ME vs EM programs

Professional Skills Categories	**Percent of Programs which require/offer courses directly related to the skills**			
	2018		**2021**	
	EM (29)	**ME (31)**	**EM (49)**	**ME (40)**
Professionalism	10%	19%	27%	25%
Ethics	45%	19%	37%	15%
Oral Communication (beyond Speech 101)	48%	23%	61%	33%
Written Communication (beyond ENGL 101 Composition)	69%	77%	84%	80%
Teamwork/Collaboration	10%	0%	20%	0%
Leadership	21%	6%	22%	8%
Other	28%	29%	49%	43%
A program information that reflects Professional Skills (per program description or a program website content)	7%	23%	20%	28%
# of programs which offer courses for all skill categories	0%	0%	0%	0%
# of programs which offer no courses related to the Professional Skills categories	3%	10%	4%	10%
# of programs which offer courses for at least three Professional Skills categories	45%	19%	51%	23%
Total # of programs	100%	100%	100%	100%

The analysis shows that the Written Communication category is the most widely addressed category in both Engineering Management (EM) and Mechanical Engineering (ME) programs, although a higher percentage of ME programs offer Written Communication courses beyond the introductory composition level (77% vs 69%). However, Oral Communication is a weaker category for the ME programs. Only 23% of Mechanical Engineering programs address oral communication while 48% of Engineering Management programs include these skills in their curricula.

More EM programs include Ethics courses (45% vs. 19%) and Leadership courses (21% vs. 6%) in comparison with ME programs, yet Professionalism courses and courses indirectly related to professional skills are more likely to be offered by the ME programs (19% vs. 10% and 16% vs. 10% respectively). The 'Other' category is approximately equally represented in both EM and ME programs (28% and 29%).

Interestingly, the Teamwork/Collaboration category is one of the lowest for the EM programs (10%), and no specific courses related to this category are offered in the ME programs. This finding supports the observations that although engineering programs require group work/projects, it is often assumed that students will learn teamwork skills naturally from the group assignments.

A higher percentage of ME programs include professional skills in the program description, although the percentage is still low (23% of ME programs vs. 7% of EM programs). None of the programs from the sample requires/offers professional skills courses for all seven categories. Almost half of EM programs (45%) cover three or more categories in comparison with 19% of ME programs. There are programs in the sample which have no evidence of offering professional skills related courses in their curricula. These include 3% of EM and 10% of ME programs.

Another remarkable finding is that although, on average, one course is offered per each category for EM programs, ME programs offer either more options for courses in each category for professional skills or require more than one course per category.

The analysis shows that there is still a low percentage of engineering programs that offer formal courses on professional skills, or which include these skills in other technical-oriented courses. Similarly, a low variety of options/courses is available to target specific categories of professional skills. Because all analyzed programs are ABET accredited, they are required to assess and report student learning outcomes for all categories of professional skills. This raises questions about the efficacy of assessment tools for professional skills. It also raises questions of how to assess program progress on skills that are largely learned by students to varying degrees outside the curriculum.

Further analysis was carried out based on the year 2021 numbers. The total number of accredited engineering management programs according to ABET increased by 69%, from 29 in 2018 to 49 in 2021 while the number of institutions that conferred more than 1,000 mechanical engineering degrees increased by 29%, from 31 to 40 based on ASEE 'Engineering by Numbers' report (39).

The analysis shows that there was an increase in numbers for all skills categories except for the ethics category. There was a negligible increase of 1% of programs that did not offer courses in any of the seven skills categories for both Engineering Management and Mechanical Engineering programs. Written communications remained the highest addressed category in 2021 in numbers and percentages while teamwork & collaboration was the least addressed category in both EM and ME programs. There were no courses for teamwork and collaboration for ME in both years. There was an increase in the number of programs that offer at least three courses for all skill categories for both EM and ME while there was no program that offered courses in all skill categories. This shows that even though institutions have taken into account the need for professional skills, there are still questions on how to ensure that students are well equipped in all the skill categories to prepare themselves for industry positions.

Limitations of the Study

There are a few limitations of the study acknowledged by the authors. This stage of study did not include all Engineering programs such as Computer and Electrical Engineering, Civil Engineering, and other 'pure' engineering programs besides Mechanical Engineering.

A course catalog name and description were analyzed for key words indicating professional skills. However, instruction in each particular course could be different per instructors' discretion, teaching style, and attitude toward professional skills teaching. Course catalog descriptions may not reflect these instructional approaches.

EM/IM/ETM/OM degrees represent about 7% of all Engineering bachelor's degrees granted in the 2018 academic year. The small percentage and management specifics of these programs may not reflect the accurate picture of the teaching trends in all engineering programs.

The analysis of published literature related to teaching of professional skills to engineers is not comprehensive and may have unintentionally omitted some related studies.

Conclusions and Discussion

This study has attempted to gain a better understanding of the professional skills gap that exists between employer's expectations and the qualifications of their new engineering hires. To do this, a 2-part study examined both evidence in the literature regarding education methods and evidence of course work required of engineering professional graduates in their pursuit of a bachelor's degree. Based on the findings of this research, while engineering professional programs are making progress toward better professional skills, it appears that there is still much work to do to ensure that graduates are well qualified for professional practice.

Evidence suggests that written communication skills are the most widely addressed professional skills in engineering professional curriculum. Many programs require students to take more than one course with instruction in these skills. Oral communication is not required as widely as written communication. Even though communication skills are emphasized in the largest percentage of programs, it is still unclear if this emphasis is adequately developing the skills of students in the programs.

Not surprisingly, professional ethics and leadership is not as widely taught in engineering curricula as it is in EM curricula. Yet, these two categories are addressed by less than 50% of all the programs in the study. Instruction in teamwork/collaboration is woefully lacking. It appears that teamwork/collaboration skills are expected to be cultivated by students on their own or through practice. Only a few schools offer actual instruction in teamwork/collaboration. Literature suggests that students are often asked to work with teams to develop skills, but, there is little evidence of how they obtain these skills.

What is important to note is that these professional skills and technical skills are equally represented in the ABET criteria for each ABET accredited program. While a certain amount of individual interpretation is allowed for individual programs, the criteria for all ABET accredited institutions requires progress on the outcomes of all required elements including professional skills.

Evidence also suggests that additional professional skills training is needed for faculty and instructors who teach in engineering and EM programs. Technical content experts have less

knowledge of professional skills instruction as their own training and background is usually in the technical engineering sciences.

Assessment of professional skills is also called into question. Much of the literature on professional skill development shows that these skills are assessed largely through secondary means. The few studies which examined employer's satisfaction with professional skill development show that there is a gap between what the programs believe are adequate outcomes and what the employers believe are adequate outcomes. The means of assessment are not well matched to employer needs.

There is evidence that higher education institutions are attempting to address some of these gaps. Literature shows programs are continuing to implement new and novel instruction methods as well as propose new ideas on curriculum to address gaps.

Recommendations

As a result of this study, we recommend better instruction for engineering professionals in professional skills.

Engineering professional education should include required course work within the curriculum that teaches students professional skills. Professional skills instruction must occur before students are required to practice these skills. Evidence shows these skills should be integrated with technical content to show its importance to the profession and these skills should be practiced and developed throughout the curriculum.

There are some methods reported in the literature that illustrate effective integration of professional skills in technical courses. However, more study is necessary to evaluate instruction techniques for professional skills in technical courses. Much of the evidence on effectiveness is secondary evidence.

Active learning techniques is one instructional method that shows promise as an excellent means for professional skill instruction. More effort is necessary to fully develop this method and integrate it in the engineering curriculum.

In addition, for effective instruction, engineering faculty should receive additional training in professional skills, or efforts should be made to collaborate with professional skills faculty to offer the appropriate training in professional skills tied to technical content. Collaborative instruction with communications studies and liberal arts faculty has also been shown to be effective. More work is necessary to develop effective collaborative instruction techniques.

Of vital importance is the use of formal instruction, effective assessment, and feedback for professional skills in engineering professional curricula. Instruction and assessment must more accurately represent the achievement of skills that are necessary for professional practice.

And finally, success will require an overall unified effort lead by the college of engineering administration to effectively integrate professional skills instruction across the engineering curricula. Without the commitment of the administration to integrated instruction in professional skills, efforts will remain little more than additional instruction tacked onto a primarily technical curriculum. Truly integrating professional skills in the curricula requires the entire faculty's collaboration.

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Appendix 1

Table A1. Excerpt from the College Course Map [18].

37 Personal Awareness and Self-Improvement	
37.0101 Self-Awareness and Personal Assessment.	A course that focuses on the knowledge and skills useful in becoming aware of one's feelings, using methods of assessing one's personal attributes, and being aware of how one is perceived by others.
37.0102 Stress Management and Coping Skills.	A course that focuses on the knowledge and skills useful in avoiding stressful situations and managing them when they occur, including dealing with complex and long-term stressful relationships.
37.0103 Personal Decision-Making Skills.	A course that focuses on how to develop individuals' abilities to assess decisions affecting their lives and to make life choices consistent with needs and beliefs.
37.0104 Self-Esteem and Values Clarification.	A course that focuses on the development of personal philosophies and ideas of positive self-concept and self-worth, and applying these knowledge and skills in everyday circumstances. Also self-appraisal, self-image, daily living, personal attitudes and/or personal life-styles.
37.0199 Personal Awareness and Self-Improvement, Other.	Any course in personnel awareness and self-improvement not listed above.
37.9996 Personal Appearance, Charm, Poise, Manners and/or Social Skills.	Any personal awareness and self-improvement course that deals with topics of personal appearance, charm, poise, manners, and/or social skills.
37.9997 Personal Goals and Objectives and/or Life Planning.	Any personal awareness and self-improvement course that deals with topics of personal goals and objectives and/or life planning.
37.9998 Human Potential, Personal Growth, Self-Development and/or Personal Development.	Any personal awareness and self-improvement course that deals with topics of human potential, personal growth, self-development, and/or personal development.
35 Interpersonal and Social Skills	
35.0101 Interpersonal and Social Skills, General.	A general course that focuses on how to effectively interact with others in private, social and business settings.
35.0102 Interpersonal Relationships Skills.	A course that focuses on how to increase one's ability to establish and maintain mutually satisfactory ties with other human beings. Also, relations.
35.0103 Business and Social Skills.	A course that focuses on how to increase one's ability to function effectively in social and business settings where interpersonal communication is required.
35.0199 Interpersonal Social Skills, Other.	Any course in interpersonal social skills not listed above.

35.9994 Applied Psychology, Personal and Social Adjustment, Human Relations and/or Practical Psychology.	Any interpersonal and social skills course that deals with topics of applied psychology, personal and social adjustment, human relations, and/or practical psychology.
35.9995 Personnel Psychology, Supervisory Psychology, Principles of Supervision, Supervisory Methods and/or Supervisory Skills.	Any interpersonal and social skills course that deals with topics of personnel psychology, supervisory psychology, principals of supervision, supervisory methods, and/or supervisory skills.
35.9996 Teamwork, Team Building and/or Team Dynamics.	Any interpersonal and social skills course that deals with topics of teamwork, team building, and/or team dynamics.
35.9997 Assertiveness, Leadership, Assertiveness Training, Effective Leadership, Leadership Development and/or Leadership Applications.	Any interpersonal and social skills course that deals with topics of assertiveness, leadership, assertiveness training, effective leadership, leadership development, and/or leadership applications.
09 Communication	
09.0100 Communication, General.	A course that focuses on the comprehensive study of communication, and that spans the study of speech communication and rhetoric, mass communication/media studies, old and new media technologies, and social and political applications. Includes instruction in interpersonal, group, organizational, and intercultural communication; theories of communication; critical thinking, argumentation, and persuasion; written communication; electronic media; rhetorical tradition and criticism; media and culture; effects of mass media; media criticism; and methods of inquiry. Examples include communication.
09.0101 Speech Communication and Rhetoric.	A course that focuses on the scientific, humanistic, and critical study of human communication in a variety of formats, media, and contexts. Includes instruction in the theory and practice of interpersonal, group, organizational, professional, and intercultural communication; speaking and listening; verbal and nonverbal interaction; rhetorical theory and criticism; performance studies; argumentation and persuasion; technologically mediated communication; popular culture; and various contextual applications. Also effective speech and/or intercultural/multicultural/cross-cultural communication.
09.0196 Public Speaking, Debate and/or Forensics.	Any communication and media studies course that deals with the topics of public speaking, debate and/or forensics.
09.0198 Communication in Society, Ethnic Communication Modes and/or Interracial Communication.	Any communication and media studies course that deals with the topic of communication in society, ethnic communication modes and/or interracial communication.