2020 SURVEY FOR SKILLS GAPS IN RECENT ENGINEERING GRADUATES

ASEE CORPORATE MEMBER COUNCIL





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ASEE Corporate Member Council Survey for Skills Gaps in Recent Engineering Graduates

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Suggested Citation

American Society for Engineering Education. (2020). ASEE Corporate Member Council Survey for Skills Gaps in Recent Engineering Graduates

CMC E-book Acknowledgements

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How do we empower engineering and engineering technology educators to meet the needs of students before they enter the workplace?

This study investigates the gap between skills acquired from education and in the workplace. Graduates enter this new and impending workplace environment where necessary skills change quickly due to the development of new technologies as they adapt to the fourth industrial revolution.

This requires graduating engineers' agility in their knowledge, skills and abilities to keep up with the rapid changes.



SHERYL SORBY

Professor of Engineering Education

PRESIDENT OF ASEE

Engineering faculty are very good at adding but not so good at subtracting. Further, most of our curricula are not attractive to wide swaths of our diverse population, to the detriment of our profession. In order to prepare our students for the engineering careers of the future, we must examine what we are teaching and how we are teaching it. we must be willing to subtract things that were necessary in the past but that may not be necessary for the future. We must examine our programs to ensure they are inclusive and attractive to all learners.





DORA SMITH

Senior Director, Global Academic Program at Siemens

CMC CHAIR-ELECT

We must prepare the next generation of digital talent with the right mix of knowledge, skills and abilities. This survey provides a unique perspective directly from fresh hires and student interns. Their voices tell us clearly what they were best and least prepared for. They are well prepared with curiosity for lifelong learning. Yet they need so much more in critical thinking and emerging technologies. It will take industry and academia coming together like never before to help each other address these skills and knowledge gaps. Together we can transform engineering education to better prepare future engineers, technologists and business leaders.

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EXECUTIVE SUMMARY

In partnership with ASEE's Corporate Member Council (CMC) a survey was conducted to assess the current skills gap recent graduates experience as they enter the workforce and what skills they had to learn after being hired in their new role. This survey is comprised of a series of questions aimed at gathering enough information to create a clear set of suggestions to empower engineering and engineering technology reform to prepare students for their future careers.

The questions were divided into two main categories:

Professional Skills and Technical Skills.

We define professional skills as skills essential to thrive in a work setting but are not historically included in engineering or engineering technology coursework.

The nine professional skills surveyed were: communication skills, emotional intelligence, teamwork and multidisciplinary work, curiosity and a persistent desire for continuous learning, project management (supervising, planning, scheduling, budgeting), critical thinking, self-drive and motivation, cultural awareness in a broad sense (nationality, ethnicity, linguistic, sexual orientation) and high ethical standards, integrity, and global, social, intellectual and technological responsibility.



For each skill, we asked survey respondents to rate their level of preparedness on a scale of very prepared to gained skill after graduation. The most common response was a need for improved training in **project management and business skills**. The National Science Foundation (NSF), ASEE, Transforming Undergraduate Engineering Education Phase II; Insights from Tomorrow's Engineers (TUEE) survey, conducted in 2015, showed comparable results and recommended including project-based and problem-based learning to the coursework as it can directly benefit the students in multiple ways. By providing students with this type of hands-on activity, institutions can bridge the gap between what is learned in a classroom and what is expected in the workplace.

There were 14 technical skills questioned in the second category: augmented reality, artificial intelligence, ability to identify, formulate, and solve engineering problems, hard sciences and engineering science fundamentals, digital twin, economics and business acumen, systems integration and systems thinking, additive manufacturing, model-based systems engineering, Internet of Things (IoT), data analytics-interpretation and visualization, simulation, security knowledge (data, cyber, etc.), and robotics. Most notably **artificial intelligence, augmented reality and additive manufacturing skills** were all identified by survey respondents as areas that were significantly lacking in their education.

Another portion of the survey focused on co-op and internship experience as it related to five skills that were identified: strong applied skills, an understanding of emerging technologies, industry specific knowledge, mentoring and professional skills. Respondents were asked to categorize where they learned each of the skills as follows: both undergraduate program and internship / co-op, internship/co-op, or in their undergraduate degree program.



ASEE |CMC

PROFESSIONAL SKILLS

The results maintain findings from other studies regarding management and business skills with 59% expressing that they felt unprepared, had very little preparation or learned these skills in the workplace. These skillsets are "low hanging fruit" as they are easy to include in engineering coursework by adding project management in design courses, labs and capstones as well as involvement and leadership in student organizations, student chapters of professional societies, and other community work.

The 2015 TUEE survey showed comparable results and recommended "project-based activities should be promoted throughout the entire curriculum from the beginning."

Results showed that 60% of respondents feel unprepared in ethical standards, integrity and responsibility. Critical thinking was ranked lowest at 63% of respondents feeling underprepared or unprepared.

Q: Please rate your level of preparedness of the following professional skills upon completion of your undergraduate degree.

| | COMMUNICATION SKILLS | EMOTIONAL INTELLIGENCE | TEAMWORK MULTIDISCIPLINARY WORK | CURIOSITY AND PERSISTENT DESIRE FOR CONTINUOUS LEARNING | PROJECT MANAGEMENT (SUPERVISING, PLANNING, SCHEDULING, BUDGETING ETC.) |
|-------------------------------------|-------------------------|---------------------------|---------------------------------------|---|--|
| Very Prepared | 49% | 26% | 31% | 59% | 17% |
| Somewhat Prepared | 40% | 35% | 30% | 34% | 24% |
| Very Little Preparation | 7% | 22% | 17% | 2% | 18% |
| Not Prepared at all | 1% | 10% | 16% | 2% | 29% |
| Gained Skill After Graduation | 2% | 6% | 5% | 3% | 12% |

"I did have extensive previous work experience prior to my undergraduate studies. This helped bridge any gaps for soft skill learning that the degree may not have helped with."



PROFESSIONAL SKILLS



PROFESSIONAL SKILLS

| | | SELF-DRIVE AND MOTIVATION | CULTURAL AWARENESS IN THE BROAD SENSE (NATIONALITY, ETHNICITY, LINGUISTIC, GENDER, SEXUAL ORIENTATION) | HIGH ETHICAL STANDARDS, INTEGRITY, AND GLOBAL, SOCIAL, INTELLECTUAL, AND TECHNOLOGICAL RESPONSIBILITY |
|-------------------------------------|-----|------------------------------|--|---|
| Very Prepared | 20% | 31% | 29% | 22% |
| Somewhat Prepared | 16% | 31% | 42% | 18% |
| Very Little Preparation | 12% | 25% | 19% | 23% |
| Not Prepared at all | 48% | 10% | 6% | 35% |
| Gained Skill After Graduation | 3% | 3% | 4% | 3% |

Critical Thinking





Self-drive and motivation

"It would have been helpful to have a practical application of industrial electrical equipment"



High ethical standards, integrity, and global, social, intellectual, and technological responsibility Cultural awareness in the broad sense (nationality, ethnicity, linguistic, gender, sexual orientation)





Professional Skills Findings:

Experience with project management and basic business skills is lacking from the curriculum. This was noted most commonly by the survey participants. Adding these skillsets into existing coursework by including real world case studies and project-based learning in courses is a very simple solution to address this gap.



"Learning to be prepared for the real world problems might have been nice to help with the culture shock coming out of university. The under-stimulating environment stunts creativity."



The responses regarding artificial intelligence, augmented reality and additive manufacturing skills were all identified as areas that should be improved with responses from 72% to almost 90% expressing that they were inadequately prepared. These results are not surprising and research in these fields is currently being conducted. There is a need to blend results and lessons learned into existing coursework to provide students with the most up-to-date information. "Technology used in the classroom should be kept current in order to keep pace with skills and approaches in demand beyond the classroom." (TUEE Phase II, 2015) Another area identified as lacking was security knowledge - data, cyber, etc. Only 5% of respondents said they felt very prepared in this area and only 18% stated they felt somewhat prepared in this area knowled be improved. Only 9% of respondents said they felt very prepared in this area when they graduated and 32% of respondents felt they were somewhat prepared.

Q: Please rate your level of preparedness of the following professional skills upon completion of your undergraduate degree.

| | | ARTIFICIAL INTELLIGENCE | ABILITY TO IDENTIFY, FORMULATE, AND SOLVE ENGINEERING PROBLEMS | HARD SCIENCES AND ENGINEERING SCIENCE FUNDAMENTALS | DIGITAL TWIN |
|-------------------------------------|-----|----------------------------|--|--|-----------------|
| Very Prepared | 3% | 5% | 55% | 44% | 3% |
| Somewhat Prepared | 8% | 13% | 38% | 44% | 9% |
| Very Little Preparation | 20% | 29% | 4% | 7% | 14% |
| Not Prepared at all | 65% | 47% | 2% | 1% | 68% |
| Gained Skill After Graduation | 5% | 5% | 3% | 4% | 5% |



"Students should have the opportunity to apply data in real world problems, solving problem with multiple disciplines of engineering"





| | ECONOMICS AND BUSINESS ACUMEN | SYSTEMS INTEGRATION AND SYSTEMS THINKING | | MODEL-BASED SYSTEMS ENGINEERING |
|----------------------------------|----------------------------------|---|-----|------------------------------------|
| Very Prepared | 9% | 20% | 7% | 16% |
| Somewhat Prepared | 32% | 45% | 22% | 32% |
| Very Little Preparation | 35% | 23% | 22% | 22% |
| Not Prepared at all | 14% | 6% | 44% | 24% |
| Gained Skill After Graduation | 9% | 6% | 5% | 6% |

"I wished I had more preparation for working on enterprise level software programs."







Systems Integration and Systems Thinking





KEY

| VERY PREPARED |
|-------------------------|
| SOMEWHAT PREPARED |
| VERY LITTLE PREPARATION |
| NOT PREPARED AT ALL |
| GAINED SKILL |
| AFTER GRADUATION |

"For mechanical and electrical engineers: a design course for manufacturing and design for assembly. These concepts are essential to understand in design, development, and R&D roles but were not even glossed over in the curriculum."



| | INTERNET OF THINGS (IOT) | DATA ANALYTICS-INTERPRETATION AND VISUALIZATION | SIMULATION | SECURITY KNOWLEDGE (DATA, CYBER, ETC.) | ROBOTICS |
|----------------------------------|-----------------------------|--|------------|---|----------|
| Very Prepared | 3% | 22% | 13% | 5% | 6% |
| Somewhat Prepared | 22% | 35% | 34% | 18% | 18% |
| Very Little Preparation | 19% | 23% | 21% | 26% | 27% |
| Not Prepared at all | 43% | 13% | 24% | 44% | 43% |
| Gained Skill After Graduation | 8% | 8% | 7% | 7% | 6% |

Internet of Things (IoT)



Data analytics-Interpretation and visualization



"My transition to industry was met with a steep learning curve to be truly effective with FEA tools, statistical analysis software, and computational platforms."





Security knowledge (data, cyber, etc.)





Technical Skills Findings:

Artificial intelligence, augmented reality and additive manufacturing skills were all identified by survey respondents as areas that should be improved. Academic research in these fields is being conducted, however, it should be blended into coursework to provide students exposure to emerging technologies.







CO-OP INTERNSHIP EXPERIENCE

Q: If you participated in an internship or co-op while an undergraduate, please indicate where you gained the most experience with the following skills/knowledge.

| | STRONG APPLIED SKILLS | AN UNDERSTANDING OF EMERGING TECHNOLOGIES | INDUSTRY SPECIFIC KNOWLEDGE | MENTORING | PROFESSIONAL SKILLS |
|--|--------------------------|--|--------------------------------|-----------|------------------------|
| Both Undergraduate Program and Internship/Co-op | 21% | 23% | 31% | 41% | 30% |
| Internship/Co-op | 25% | 36% | 43% | 35% | 39 % |
| Undergraduate Degree Program | 54% | 41% | 26% | 24% | 30% |

Strong Applied Skills



An Understanding of Emerging Technologies









CO-OP INTERNSHIP EXPERIENCE



"We need to learn how to solve realworld engineering problems. My program put immense emphasis on memorization and math instead of use of modern tools such as simulation to solve problems."



RECOMMENDATIONS

The survey of approximately 350 recent graduates throughout the country revealed several clear indicators. Students need increased exposure to both professional skills and new and emerging technical skills. There are multiple ways to provide this, both in the current curriculum and in extracurricular activities available through their university.

It is also apparent that, while students may be taught some of these skills in their classes, they are unable to make the necessary connections between knowing skills and knowing how to apply them. One student stated that "The knowledge we are gaining in college and actual knowledge required for industry is totally different." As was proposed in the 2015 TUEE Phase II study, the survey indicates that the application of these skills should be included through more realistic project-based learning in the curriculum and by adding real-world engineering applications into existing courses. Writing and presentation should be incorporated into various courses and the real-world impacts should be illustrated in courses through case studies.

Another option for increasing exposure to technical skills is by tapping into the research in which universities are engaged. Universities can find targeted ways to blend the knowledge gained through these projects into existing curriculum. While many universities are undertaking significant research in the three technical skills (artificial intelligence, augmented reality and additive manufacturing) in which students are weakest, they are not using this wealth of knowledge to bridge the gap and bring the discoveries into the classroom.



"The knowledge students gain in college and the actual knowledge required on the job is totally different"



RECOMMENDATIONS

Students can also gain many professional skills through involvement and leadership in extracurricular activities. Students should be strongly encouraged to participate in clubs, national professional organization chapters, and other pre-professional engineering groups on campus.

Lastly, industry is positioned to directly support academia in closing these skills gaps through increased internships, co-ops, curriculum supporting content in emerging technologies, credentialing (certification/badging), mentoring, guest lectures, advisory board roles, etc. They are also able to commit to ongoing workforce development in these areas in collaboration with academia.

GOOD NEWS

There is good news! Our research affirms that students and companies alike are resilient and willing to adapt to the needs of our changing world. We can move forward to embrace this opportunity and we have the means and time to adapt. By including the input of all stakeholders -- industry leaders, universities, students & recent grads in the workforce -- we can work together to empower engineering education to meet the needs of students.



"A professional writing course workshop (on how to write an email and writing reports to nonacademic audiences) combined with training on networking and workplace interactions would be useful."