Tech-Clarity

Close the Engineering Skills Gap

Prepare New Graduates to Be Real-World Ready

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Executive Overview

As globalization trends make it that much harder to stand out in today's competitive environment, companies must rely even more on innovation to engineer winning products that will stand out, capture market share, and secure future revenue streams. Unfortunately, shortages in engineering talent with the right skills make this a challenge. A majority of companies (69%) project their engineering department will need to grow over the next five to ten years. Complicating this further, many of the engineers in the largest segment of the engineering workforce, those with over 20 years of experience, will approach retirement soon. As they leave the workforce, it will put even more pressure on hiring strategies to recruit new engineers.

80% of companies indicate that hiring the right engineers will be either highly or very critical to the future success of their business.

Tech-Clarity research finds that an overwhelming 80% of companies indicate that hiring the right engineers will be either highly or very critical to the future success of their business. Underscoring why it is so critical, 98% of companies report there will be a negative business impact if they can not find and hire the right engineers. These impacts range from loss of competitiveness, poor innovation, higher costs, to lost revenue. Unfortunately, the top challenge of managing the engineering workforce is finding engineering staff with the right skills. Part of the problem is due to the gap between the skills new engineering graduates have and what industry needs. This situation creates a sense of urgency to improve how engineers are prepared during their schooling so that we can close the skills gap.

To identify these gaps, Tech-Clarity conducted a global survey of 201 companies. Respondents represented companies of different sizes, across a wide variety of industries, and multiple geographic regions.

Most companies (75%) want students to be able to apply the technology to solve problems, not just know the "picks and clicks" of the software.

The results show that manufacturers have a clear preference for how to prepare engineering students for the real-world. They favor students with in-depth project experience involving multiple roles, complete lifecycle stages, and simulate a corporate environment. Schools that incorporate this type of experience into their engineering curriculum will have an advantage as there should be more demand for their graduates in the workforce.

Industry would like to see new graduates better prepared to use several skills. Engineering software is very prevalent on this list. This is largely because most companies (75%) want students to be able to apply the technology to solve problems, not just know the "picks and clicks" of the software.

The research also finds that industry needs to be more involved in academia to close the skills gap. Interestingly, companies report they are not as engaged as they expect others to be. To close the skills gap, engineering companies should at least double their current involvement with academia.

This report identifies the top skills that create the engineering skills gap. The report further explores the types of academic programs and experiences that provide students with the right skills they need to be successful in industry.

State of the Engineering Department

A company's products are central to its business, and those products would not exist without engineering. In fact, during a past Tech-Clarity study, *Product Lifecycle Management Beyond Managing CAD,* survey respondents were asked how they differentiate their products. As the results in Figure 1 show, performance, innovation, and quality are critical to differentiating products. Part of this is because increasing globalization has made it that much harder to be competitive. Consequently, companies must rely on the work done by engineering to truly stand out from their competitors. As a result, future revenue streams are more dependent than ever on the talents of the engineering department.

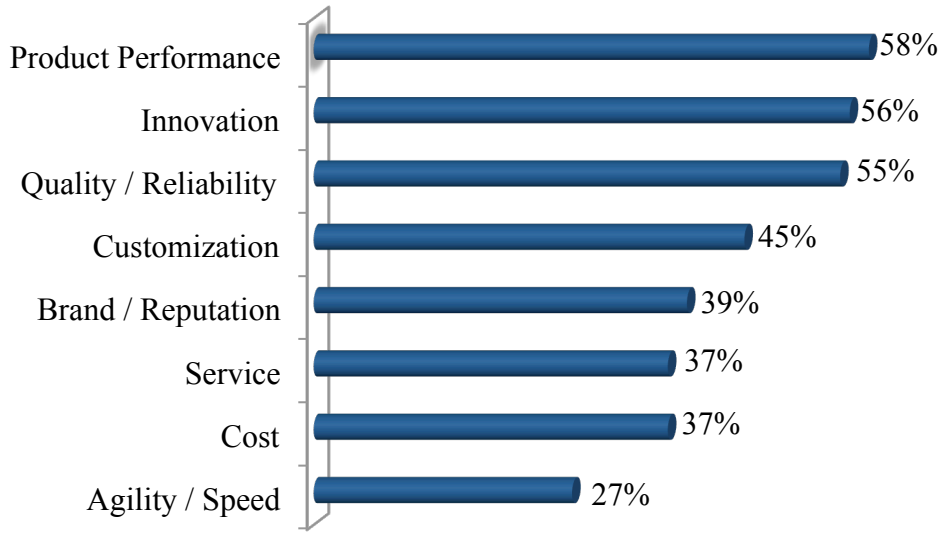

Figure 1: Top Product Differentiation Strategies

Given the important role of the engineering department, it is not surprising that to stay competitive, the majority of companies, 69%, anticipate growing the engineering department over the next five to ten years. To support this growth, hiring strategies and finding the right staff will be especially critical. Hiring will be especially challenging because engineering departments are currently "top heavy" with experience, with greater percentages of experienced engineers compared to newer ones. When looking at the experience levels of the engineering department, the largest group, 27% of the staff, have more than 20 years of experience. Over the next five to ten years, companies expect the size of this group to shrink and the largest group will shift to those with only five to ten years of experience; which should make up about 29% of the engineering department.

95% of manufacturing engineers indicate that hiring will be very to highly critical to future success.

While the majority of companies will feel the pain from the engineering shortage, manufacturing engineers will be hit especially hard. A large percentage of them (39%) have over 20 years of experience, meaning this department will face especially severe shortages as their engineers approach retirement age. Consequently, 95% of manufacturing engineers indicate that hiring will be very to highly critical to future success. From an industry perspective, Aerospace and Defense, as well as Industrial Equipment, will face similar challenges as these industries also having higher percentages of their workforce (38% and 35% respectively) with more than 20 years of experience. Small companies also have a disproportionate percentage of experienced staff compared to medium and large businesses, with 34% of the staff from small companies with more than 20 years experience. Oddly, despite the impending workforce shortage, only 72% of small companies rate hiring the right staff as very or highly critical to future success. In contrast, 85% of medium companies and 95% of large companies rate hiring as very or highly critical. Perhaps this is a reflection of the lack of hiring small companies have needed to do in the past, compared to their larger peers, so they are less exposed to the challenges of finding staff with the right skills.

As experienced engineers approach retirement, not only must companies work hard to replace their experienced talent, but they also must hire to support their expected growth.

Overall, as experienced engineers approach retirement, not only must companies work hard to replace their experienced talent, but they also must hire to support their expected growth. This potential shortage of engineers makes the ability to recruit and hire qualified engineers essential to future company success.

Impact of the Engineering Shortage

In this environment of an impending shortage of engineering talent, the biggest engineering workforce challenge is the inability to find people with the right skills, followed by the loss of knowledge as experienced staff retire (Figure 2).

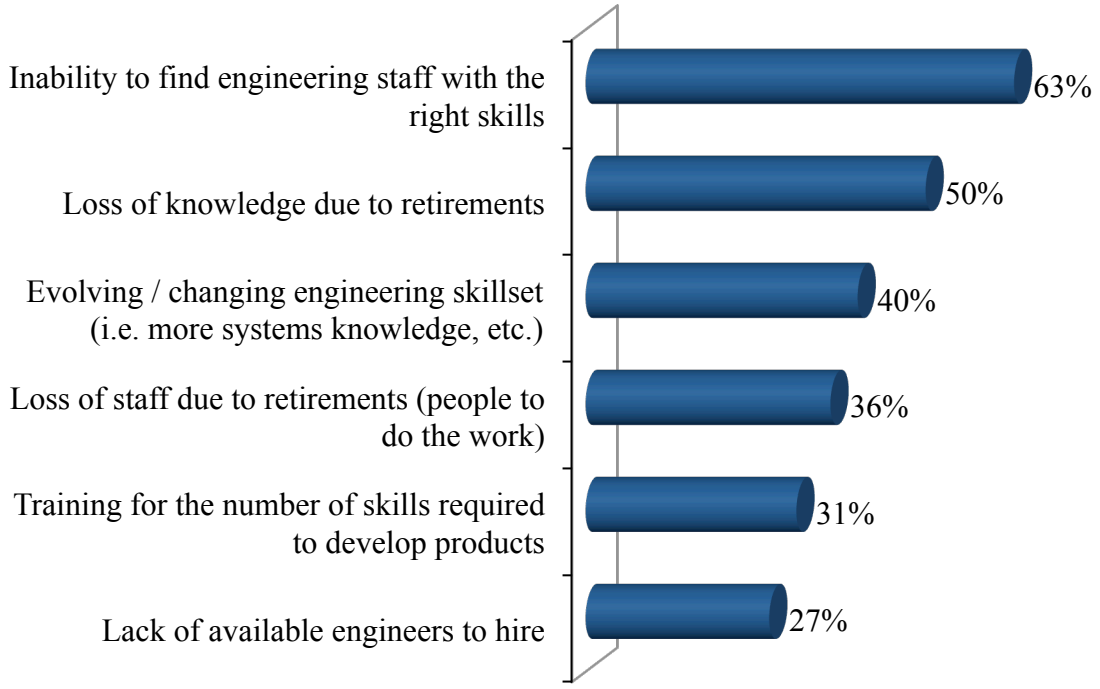

Figure 2: Top Engineering Workforce Challenges

With market trends to make products smarter and growing product complexity, engineers are expected to know more than ever. The loss of knowledge will be painful, so companies will rely on new engineers to replace that lost knowledge as quickly as possible. The more prepared engineers are when they graduate, the better off companies will be.

98% of respondents believe there will be a negative business impact if they can not find and hire the right engineers.

Skills new graduates acquire during their formal education will help reduce the learning curve and on the job training so that new engineers can contribute more quickly.
If companies can not find the right staff, with the right skills, the business will suffer. In fact, 98% of respondents believe there will be a negative business impact if they can not find and hire the right engineers. These business impacts, include loss of competitiveness, poor innovation, higher costs, and lost revenue (Figure 3).

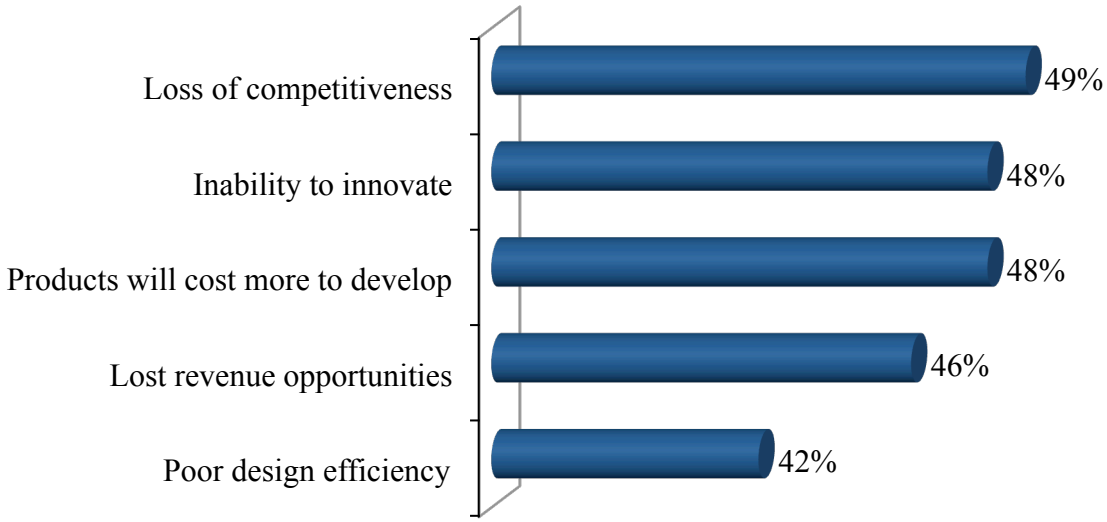

Figure 3: Top Business Impacts if Companies Cannot Hire Needed Engineers

Companies who cannot find the right staff will struggle to compete, so it is essential for their future competitiveness that they tap into sources of engineering talent with the right skills. While hiring the right staff is critical to success, the majority of companies have concerns they will be unable to hire the right engineering staff. This is an international concern, with those in Asia and Latin America especially concerned (Figure 4).

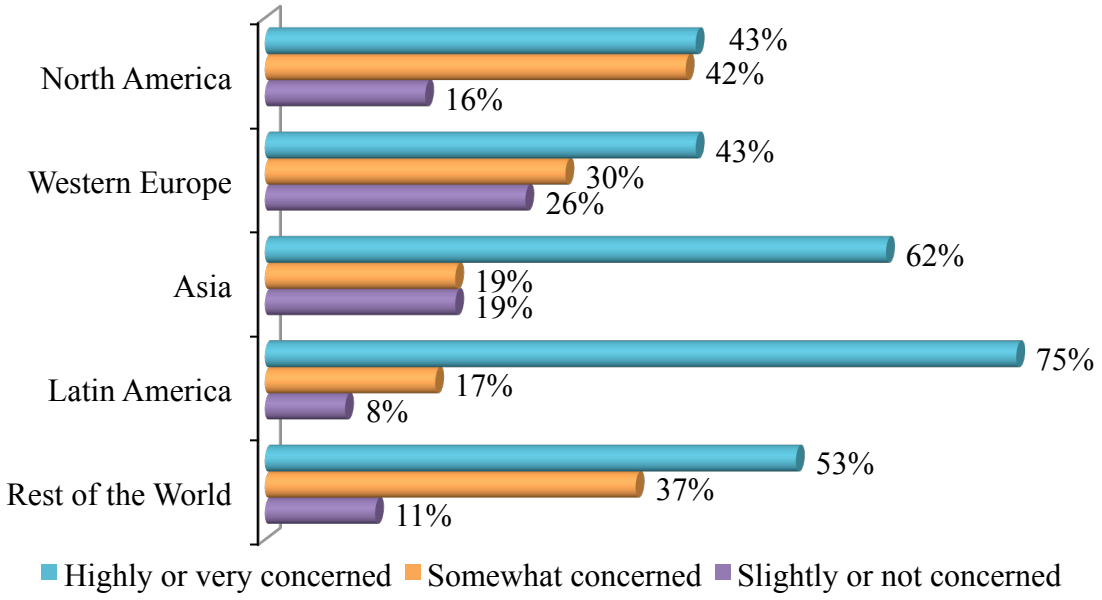

Figure 4: Ability to Hire the Right Engineering Staff by Geography

Identifying the Top Performers

To understand successful approaches for acquiring engineering talent, priorities, and what companies should look for, Tech-Clarity identified Top Performing companies who exceed their competitors. To identify them, survey respondents rated themselves against their competitors, on a scale of one to five, with five meaning significantly surpassing competitors. We defined the top 20% as Top Performing companies. Table 1 shows the metrics used to determine success and the respective average scores for each group.

Ability to:	Top Performers	Average Performers
Develop products efficiently	4.4	3.3
Develop high-quality products	4.8	3.6
Develop innovative products	4.7	3.3
Meet product cost targets	4.2	3.0

Table 1: Definition of Top Performers

As expected, Average Performers rate themselves about a three, meaning they are doing about average compared to competitors. On the other hand, Top Performers significantly exceed their competitors, putting them at a significant advantage.

New hires at Top Performing companies stay 7.2 years, 39% longer than they remain at Average Performing companies.

Supporting the better job Top Performers do at hiring and retaining the right talent, new hires at Top Performing companies stay 7.2 years, 39% longer than they remain at Average Performing companies. Figure 5 reinforces the importance and emphasis Top Performers put on hiring the right engineering staff. Top Performers are 96% more likely than Average Performers to consider hiring the right engineering staff as highly critical to the success of their business.

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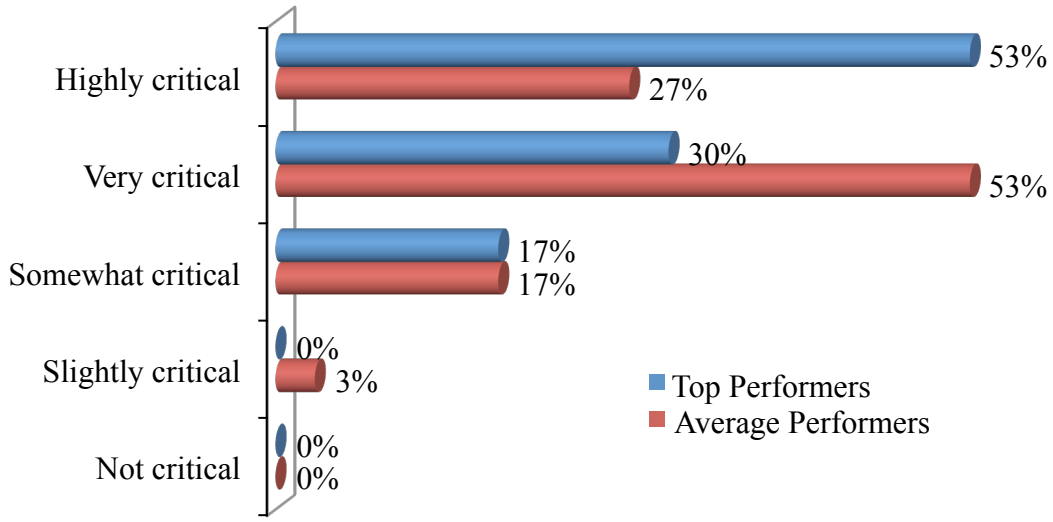

Figure 5: Criticality of Hiring the Right Engineering Staff

Look for the Right Engineering Skills

With the future success of companies impacted by the talents of new engineering graduates, it is essential that engineering schools prepare students with the right skills. Incidentally, the "right skills" are also evolving.

Engineers who have been exposed to other engineering disciplines and have experience working on multi-discipline teams will be more prepared to participate in today's product development teams.

Trends toward smarter, more innovative products, have driven many companies to hire a mix of mechanical, electrical, software, and systems engineers to work on their products. Interestingly, while mechanical engineers make up the greatest percentage of development teams for both performance groups, Top Performers balance engineering disciplines across their teams more evenly with 55% of the engineering staff coming from other engineering disciplines such as electrical, software, and systems engineers. On top of that, 70% of Top Performers expect the balance of engineering disciplines to continue to change over the next five to ten years. This trend underscores that innovation will require the collective expertise of a variety of different skills and collaboration will be critical. Engineers who have been exposed to other engineering disciplines and have experience working on multi-discipline teams will be more prepared to participate in today's product development teams.

On top of the growing need to involve different engineering disciplines, companies have found the type of skills they need in new hires has evolved as well. While schools excel at teaching theory and concepts, companies also want engineering students that have the practical skills needed to be successful at their jobs. Figure 6 shows the top skills that manufacturers feel students have not been prepared for well while at school.

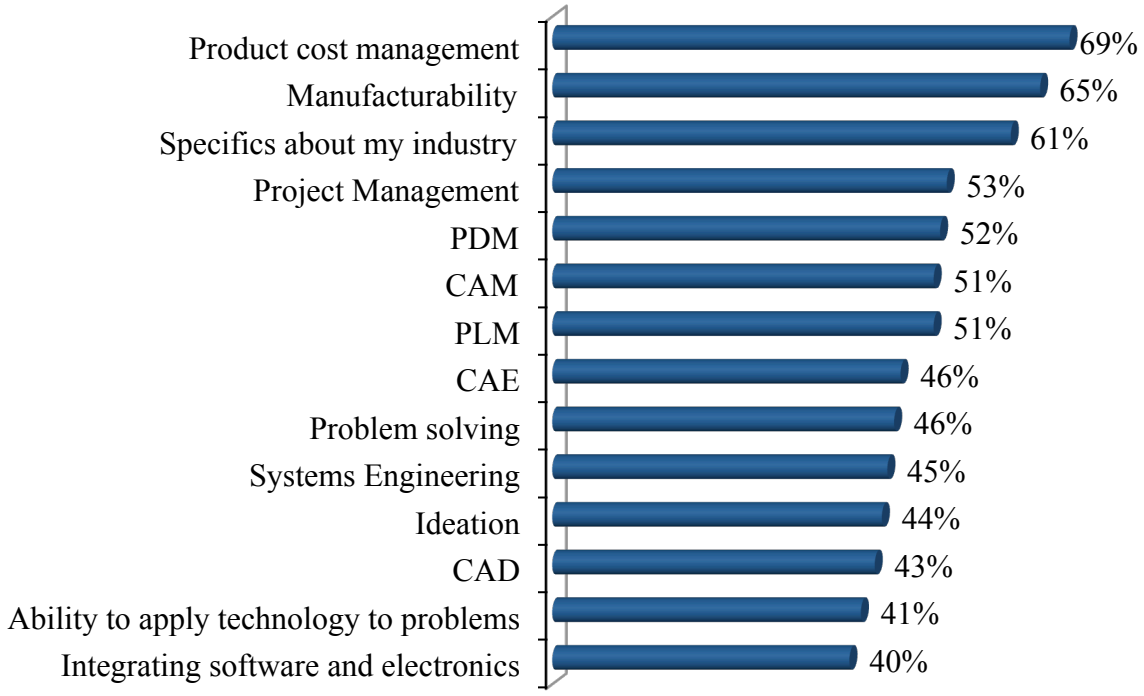

Figure 6: Top Skills Schools Do NOT Prepare Students Well

While 40% or more respondents overall feel that schools do not prepare students well for the skills listed in Figure 6, Top Performers report schools do not prepare students well at even greater rates for the majority of these skills. In addition to these skills, high percentages of Top Performers also feel that schools do not prepare students well in the following skills:

- Collaboration (including global) (47%)
- Additive manufacturing / 3D printing (44%)
- Embedded software (44%)
- Digital twin (44%)
- Mechatronics (44%)

The interest in these skills reflects the forward thinking of Top Performers who are likely looking beyond the skills they need for today, but the skills that will help them become

more competitive in the future. These are skills that can help companies explore new geometries or services with 3D printed parts or develop more innovative smarter products. Also of note, nearly half of hiring managers (47%) find that students do not have enough familiarity with embedded software.

While understanding the "picks and clicks" of the software is important, most companies (75%) also want students to be able to apply the technology to solve problems

Interestingly, for all skills, management is even more likely than staff to feel that schools do not prepare students well. This disconnect is especially apparent with CAD where 62% of staff believe that schools prepare students well. On the other hand, the majority of management (52%) feel that students are not well prepared. This discrepancy may be due to differing expectations for what it means to be proficient with the software. In addition to CAD, there are multiple types of engineering software is on this list, indicating a potential need for changing the way schools teach engineering software. While understanding the "picks and clicks" of the software is important, most companies (75%) also want students to be able to apply the technology to solve problems (Figure 7).

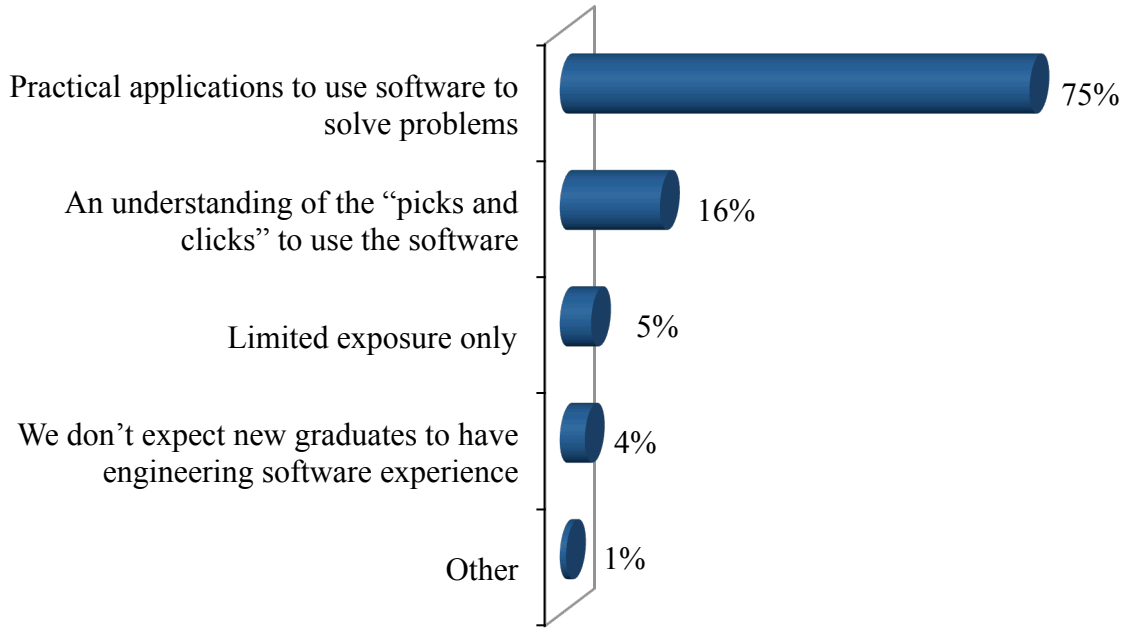

Figure 7: Desired Experience with Engineering Software Tools

However, there is much room for improvement as 81% feel students either not prepared or they still need significant training. Only 2% think students do not need additional engineering software training when they graduate (Figure 8).

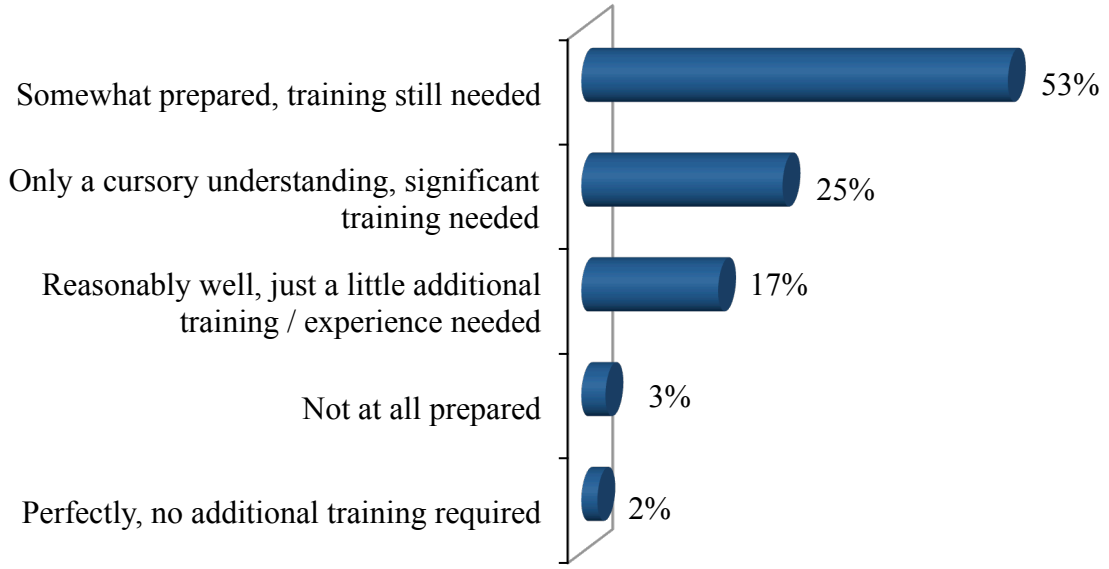

Figure 8: How Well Do Schools Prepare Students to Use Engineering Software

While there were many skills listed as important, Figure 9 shows that top five skills respondents rated as most important for schools to prepare students. Ironically, these critical skills are also skills that companies find students have not been prepared for while at school. A lot of this comes down to experience with practical applications.

Respondents frequently cited concerns that new engineers often struggle with understanding that just because they can design something, doesn't mean it can be built.

Respondents frequently cited concerns that new engineers often struggle with understanding that just because they can design something, doesn't mean it can be built. Obviously, if a design is not manufacturable, it costs the company money in terms of delays and scrap. Respondents stressed the importance that new engineers need more exposure to production environments so they can acquire more knowledge around manufacturing rules of thumb. This experience has become increasingly important as engineering and manufacturing are typically not in the same facility or even the same country. Consequently, companies continuously struggle to break down walls between engineering and manufacturing.

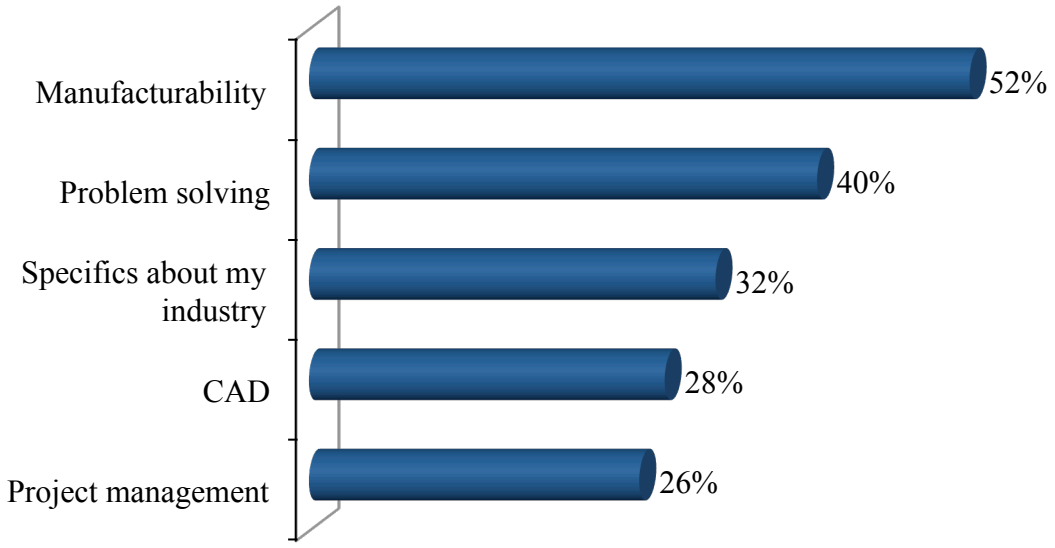

Figure 9: Top Skills Most Important for Schools to Prepare Students

Problem solving is also critical to success. While understanding theoretical concepts is essential, engineers need hands-on experience to apply that theory to solve problems. Experience with creative thinking and coming up with solutions is a valued skill companies want engineers to have.

Companies also value industry-specific knowledge. Each industry has its nuances, but it can often be hard to acquire that industry knowledge in the classroom. Students with some industry background will be able to come up to speed that much more quickly once employed.

Companies want to see new graduates who can use the software to design and solve problems, not just know the menu picks and clicks.

A CAD course is typically part of the engineering curriculum, but as Figure 7 shows, companies want to see new graduates who can use the software to design and solve problems, not just know the menu picks and clicks to model a block with a hole in it. Finally, companies also value project management skills. Companies would like to hire students who understand the concepts and best practices around project management. However, they also want them to have had opportunities to practice those skills to develop them further.

Internationally, manufacturability and problem solving top the list no matter where you are. Latin America is a little less concerned about industry specifics with only 17% rating

this as an essential skill, but 33% consider systems engineering a top skill. In addition, 33% in Western Europe rank product cost management as critical as well as PDM (29%) and collaboration (29%). In Asia, 27% rated PLM (Product Lifecycle Management) as valuable.

Consider Programs that Offer Real World Experience

When looking at the engineering programs that best prepare students for the "real world" of a digital enterprise, companies prefer in-depth projects that involve multiple roles, complete lifecycle stages, and simulate a corporate environment. Table 2 shows the top five academic programs Top Performers think best prepare students for real-world industry work.

Programs that Top Performers believe best prepare students for real-world work	Percentage of Top Performers
Team-based projects simulating a typical "corporate" structure involving mechanical, electrical, finance, marketing/communications, project management	59%
Projects that include design, analysis, test, and build phases	53%
Competitions solving "real-world" problems	50%
Team-based projects with technical focus (other engineers only)	47%
Multi-discipline projects such as building a race car	47%

Table 2: Programs That Best Prepare Students for Real-World Work

These programs all give students practical experience to apply the academic theories they have learned and practice using them. Students then get exposure to a variety of skills that complement their coursework, but use them in the same way they would in an industrial or corporate environment.

Top Performers value not only engineering collaboration experience, but also collaboration that extends to other roles such as finance and marketing.

A big part of this experience is collaboration. As products get more complex and involve multiple engineering disciplines, collaboration becomes increasingly critical. Plus companies have become more segregated, and development teams often include third party suppliers and partners. Consequently, Top Performers value not only engineering collaboration experience, but also collaboration that extends to other roles such as finance and marketing. This experience provides excellent exposure to the way companies conduct projects in a corporate environment. Figure 10 shows the top collaboration experiences that would make a company more likely to hire a student.

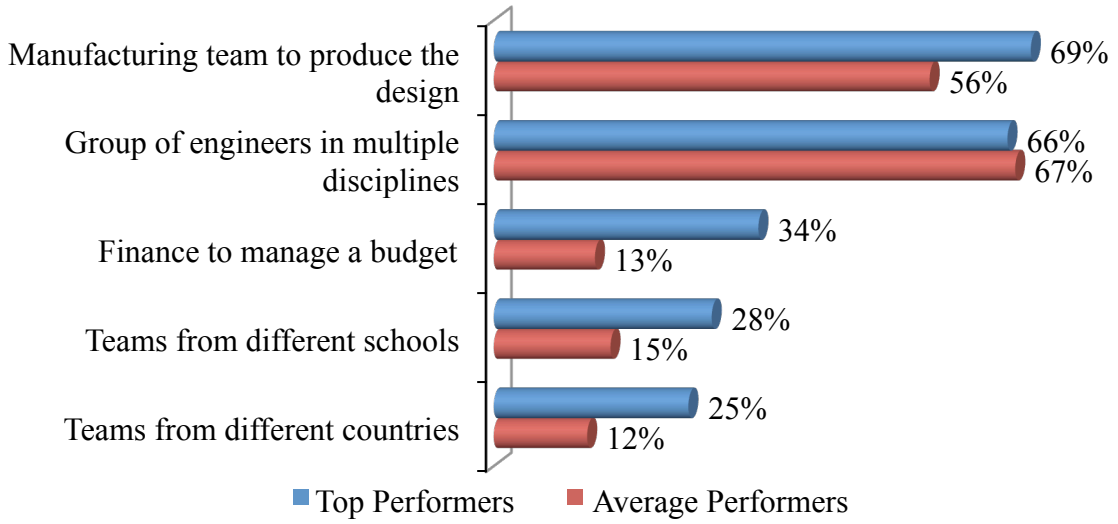

Figure 10: Collaboration Experience Making Companies More Likely to Hire a Student

Top Performers are 23% more likely to rate manufacturing collaboration as the top experience that would make them more likely to hire a candidate.

Top Performers value engineering collaboration with a manufacturing team the most. Manufacturing collaboration helpfully addresses one of the top skills companies care about, manufacturability. Top Performers are 23% more likely to rate manufacturing collaboration as the top experience that would make them more likely to hire a candidate. Top Performers also value engineering collaboration across multiple disciplines, reflecting requirements for many of today's development projects. In addition to manufacturing and multi-discipline engineering collaboration, Top Performers also like to see other types of collaboration experience in their new hires. Managing to a budget as well as working with unfamiliar groups from other schools or even teams from different cultures is also favorable experience that makes a new graduate a more desirable candidate.

Develop a Good Hiring Strategy

Given how important practical experience is for developing desired skills, it makes sense that obtaining it through real-world projects tops the list of desired experiences companies look for in new hires (74%). Next, companies look for enthusiasm for technology (60%). Candidates with higher levels of interest will be more likely to have the desire to learn new technology quickly. Companies also value the character of the student and look for someone who will fit in with the company culture. The interview

provides an excellent opportunity to assess this. Interestingly, in Asia, the interview is not valued as much as it is in other areas of the world, with only 35% saying it is an important part of the hiring process. Finally, companies also value work history obtained through internships, co-ops, and summer employment. Again, this provides students with some of the practical experience companies want their new hires to have. Recommendations from professors or prior employers are also important in Latin America (33%) and North America (29%).

Practical experience obtained through real-world projects tops the list of desired experiences companies look for in new hires.

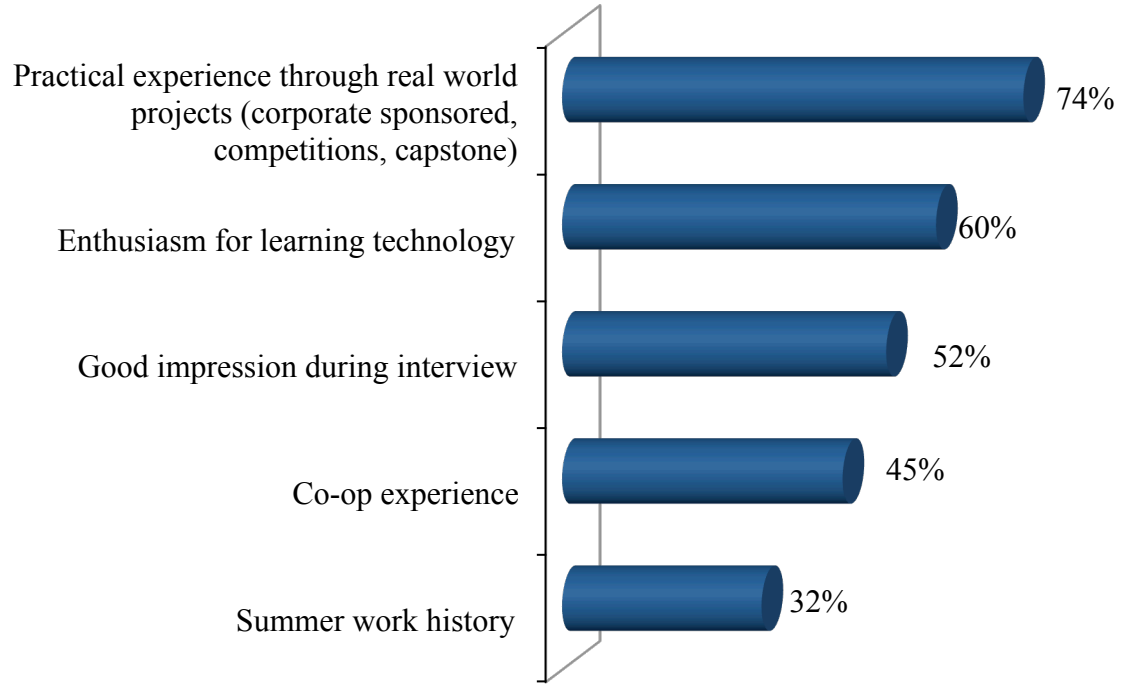

Figure 11: Desired Experience / Qualities in New Hires

What's especially fascinating is the qualities that did not make the top five list. Only 22% indicated that they consider completed coursework and just 15% said a high GPA was important.

Get Involved in the Engineering Curriculum

To help schools close the skills gap, companies have several suggestions to evolve the curriculum (Figure 12).

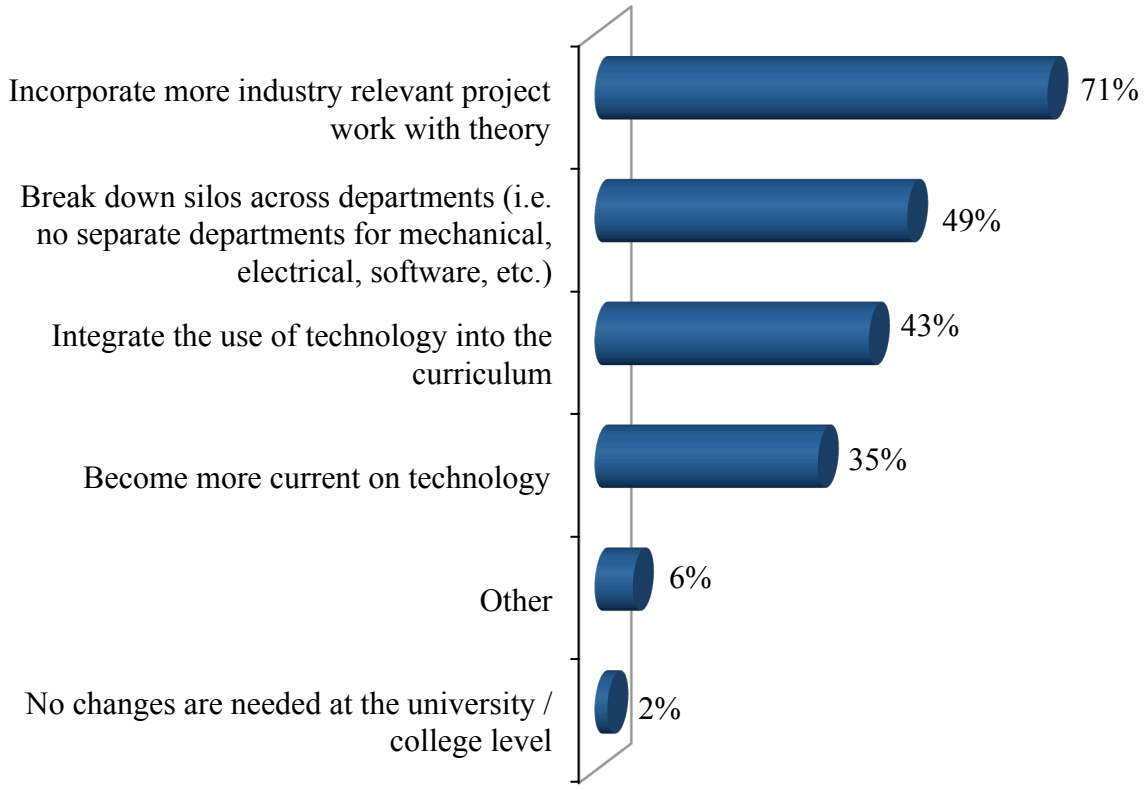

Figure 12: How Schools Should Evolve

The majority of manufacturers would like to see more industry relevant projects integrated with coursework. Projects like this would give students more of the practical experience they look for in new hires. Almost half of companies feel that the structure of the different engineering departments contributes to the inherent knowledge silos across engineering disciplines. Companies would like to see the different engineering departments at schools for mechanical, electrical, and software become more integrated, to better support the education required to develop modern products.

The majority of manufacturers would like to see more industry relevant projects integrated with coursework.

Companies would also like to see more industry involvement in the engineering curriculum as a way to create additional opportunities for industry relevant projects. Overall, manufacturers would like to see industry involved in 18% of the curriculum while 44% of Top Performers think industry should be involved in more than 20%. In fact, 89% of respondents believe that industry involvement would reduce the skills gap,

52% of them presuming it would completely eliminate or significantly reduce the gap. This way new graduates would have the needed skills upon graduation.

89% of respondents believe that industry involvement would reduce the skills gap.

Interestingly, Top Performers are much more likely to be involved in an engineering curriculum with 43% involved in 16% or more of the curriculum. In contrast, just 11% of Average Performers are involved in at least 16% (Figure 13)

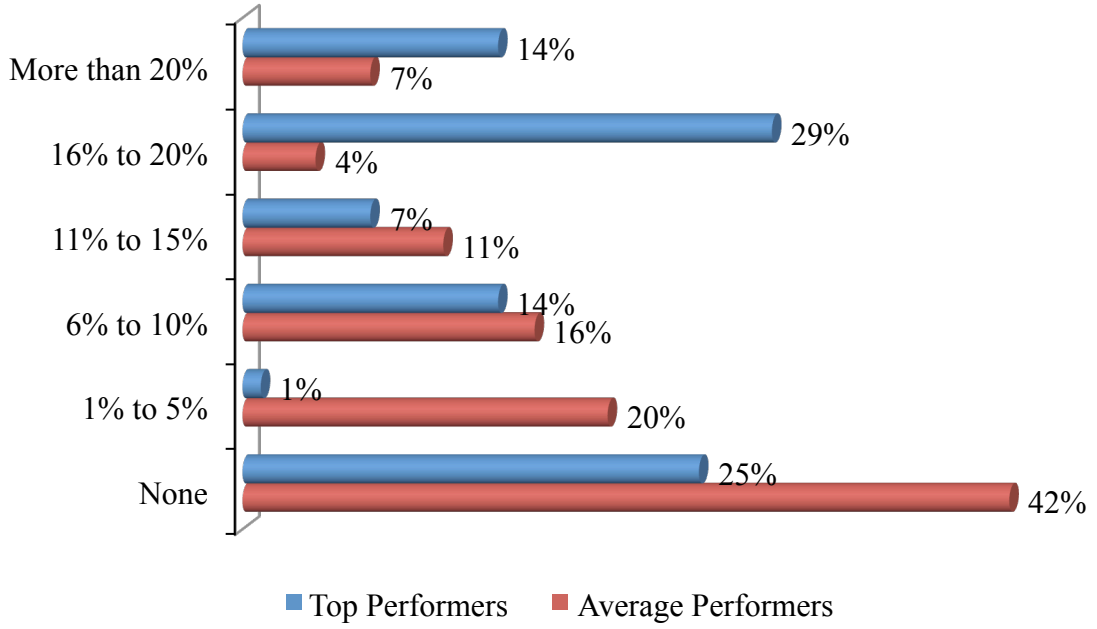

Figure 13: How Involved Should Industry Be in Engineering Curriculum

While industry involvement in the engineering curriculum is an investment of time, it is also an investment in the future with a strong return. With more participation in the curriculum, Top Performers have opportunities to work closely with students, direct the program to develop the skills they want to see, and select the candidates who will be the best fit for their organization. Also, students can contribute to their innovation efforts, in a low risk-way that can help with future generations of products.

While industry involvement in the engineering curriculum is an investment of time, it is also an investment in the future with a strong return.

From an industry perspective, some industries are more involved in the engineering

curriculum than others. Industrial Equipment indicates that industry should be involved in at least 20% of the engineering curriculum. Given the evolving needs of the industry with increased requirements for smarter, connected products and Industry 4.0 trends, a desire for greater involvement makes sense. Interestingly though, Industrial Equipment ranks among the lowest for industry participation, with only a 5% involvement in the engineering curriculum. Manufacturing engineers are in a similar situation. With significant concerns around the ability to hire staff with the right skills, there should be a lot of motivation to become more involved in academia to ensure they have a pool of qualified engineers from which to hire. Plus, 72% of manufacturing engineers feel that more industry involvement would eliminate or significantly reduce the skills gap. Despite this, manufacturing engineers indicate they are only involved in 5% of the academic curriculum. In contrast, the manufacturing department reports twice the involvement, participating in 10% of the academic curriculum.

Conclusion

The engineering department will play a critical role in the future success of companies. Innovation, quality, and performance all come from the work engineers do and create needed product differentiation to stand out from competitors. Consequently, most companies anticipate their engineering departments will need to grow over the next five to ten years. At the same time, large segments of the engineering workforce are approaching retirement and will need to be replaced. Replacing them along with the anticipated growth means hiring strategies will be critical. Unfortunately, the hardest part of managing the engineering workforce is finding candidates with the right skills.

Companies would like students to understand how to apply technology to solve problems, not just know the software picks and clicks.

Part of the reason it is hard is because graduating candidates lack the skills industry needs. Overcoming this skills gap will require changes to the curriculum taught at schools. Manufacturers would like to see schools update their curriculum to include more in-depth projects that involve multiple roles, follow a product lifecycle, and simulate a corporate environment. Companies would also like to see students more prepared to use engineering software. They would like students to understand how to apply technology to solve problems, not just know the software picks and clicks.

The vast majority of manufacturers (89%) believe that industry involvement will reduce the skills gap.

The updates to the curriculum also fall on the shoulders of industry. The vast majority of manufacturers (89%) believe that industry involvement will reduce the skills gap. Industry involvement would offer students exposure to real-world projects which would

develop those practical skills employers would like to see. Unfortunately, current industry involvement is limited to just 7% of the curriculum while most agree it should be at least 18%, with 44% Top Performers indicating it should be more than 20% of the curriculum.

Recommendations

Based on industry experience and research for this report, Tech-Clarity offers the following recommendations:

- Invest in your engineering staff to support growth and ensure you can recover from the loss of experienced staff to retirement
- Ensure you have the right mix of engineering talent to support the development of products that involve multiple engineering disciplines
- Hire from engineering programs that go beyond just learning theory and software menu picks, but provide opportunities to apply technology to solve problems
- Work with engineering schools to help them develop the curriculum that will develop the skills you would like to see in new hires
- Look at programs that offer students the opportunities to work on team-based projects, similar to the type of work they will do when employed
- Get involved in engineering programs to ensure enough industry exposure during schooling and develop an exceptional pool of talent to hire from

About the Author

Michelle Boucher is the Vice President of Research for Engineering Software for research firm Tech-Clarity. Michelle has spent over 20 years in various roles in engineering, marketing, management, and as an analyst. She has broad experience with topics such as product design, simulation, systems engineering, mechatronics, embedded systems, PCB design, improving product performance, process improvement, and mass customization. She graduated magna cum laude with an MBA from Babson College and earned a BS in Mechanical Engineering, with distinction, from Worcester Polytechnic Institute.

Michelle began her career holding various roles as a mechanical engineer at Pratt & Whitney and KONA (now Synventive Molding Solutions). She then spent over ten years at PTC, a leading MCAD and PLM solution provider. While at PTC, she developed a deep understanding of end-user needs through roles in technical support, management, and product marketing. She worked in technical marketing at Moldflow Corporation (acquired by Autodesk), the market leader in injection molding simulation. Here she was instrumental in developing product positioning and go-to-market messages. Michelle then

joined Aberdeen Group and covered product innovation, product development, and engineering processes, eventually running the Product Innovation and Engineering practice.

Michelle is an experienced researcher and author. She has benchmarked over 7000 product development professionals and published over 90 reports on product development best practices. She focuses on helping companies manage the complexity of today's products, markets, design environments, and value chains to achieve higher profitability.

About the Research

Tech-Clarity gathered and analyzed 201 responses to a web-based survey on engineering staffing, hiring, and required skills. Survey responses were collected by direct e-mail, social media, and online postings by Tech-Clarity. Tech-Clarity also interviewed leaders from leading manufacturers.

The respondents were comprised of almost one-half (46%) who were individual contributors. An additional 39% were manager or director level, and the remaining 15% included VP or executive levels.

The respondents represented a mix of company sizes, including 48% from smaller companies (less than $100 million), 26% between $100 million and $1 billion, and 26% greater than $1 billion. All company sizes were reported in US dollar equivalent.

The responding companies were a good representation of the manufacturing industries, including Machinery and Industrial (37%), Automotive (22%), Aerospace and Defense (22%), Energy, Process, & Utilities (18%), Life Sciences (16%), Consumer Products (14%), Hi-Tech and Electronics (11%) and others. Note that these numbers add up to greater than 100% because some companies indicated that they are active in more than one industry.

The respondents reported doing business globally, with most companies doing business in the North America (89%), 40% doing business in Western Europe, almost one-third doing business in the Asia-Pacific regions (29%), Latin America (13%), Eastern Europe (10%), Australia (9%) and Middle East (8%).

Responses from those determined not to be directly involved in developing or manufacturing products (including software vendors and consultants) were excluded from the analysis.

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