Building a Better Engineering Technology Graduate

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The application of technology in the industrial workplace has led to unprecedented productivity and quality advances over the last 30 years.   Companies have transformed the way they do business from huge behemoths using a large labor pool as their primary resource, to lean, "right sized" organizations that use automation, systems, and the collection and usage of data to reduce operational costs. This has allowed U.S. industries to remain competitive in a global market despite rising labor costs.

> "From 2018 to 2020, global robot installations are estimated to increase by at least 15% on average per year (CAGR): 15% in the Americas and in Asia/Australia, and 11% in Europe. Total global sales will reach about 520,900 units in 2020. Between 2017 and 2020, it is estimated that more than 1.7 million new industrial robots will be installed in factories around the world.
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> Due to the dynamic development of robot installations since 2010, the robot density in the United States increased significantly from 114 installed robots per 10,000 employees in the manufacturing industry in 2009 to 189 robots in 2016." (1)

This data refers to robotic applications, but the same trends hold true for automation in general, as it applies to this discussion. By leveraging technology, you can reduce the number of people required to run an operation, but there is a shift in the job function and subsequently the skillset required to perform those remaining jobs. This shift is one that requires more interaction with the technology.

One of the challenges that has resulted from this higher level of technology is the shortage of people with the skills to apply and maintain it. This is compounded by a workforce whose training and experience can become, somewhat obsolete over time.

After the downsizing that took place during the last recession, the remaining staff were typically tasked with additional responsibilities. This has now become the norm. The lines of demarcation are also becoming blurred in a lot of job descriptions. Engineers need, in addition to their discipline of study, a reasonable understanding of various other engineering disciplines. Job candidates that have these skills are in short supply and the competition to hire them is very strong. Many jobs go unfilled for months for the lack of qualified people.

The American Society for Quality (ASQ) conducts the Manufacturing Outlook Survey annually to gauge manufacturing professionals' views on the year ahead. More than 650 manufacturing professionals responded to the survey, which was conducted online in October and November. Respondents represented a multitude of industries, including automotive, medical device, aerospace, and oil and gas.

According to this year's results, 41 percent of manufacturers said finding skilled workers will be the number one challenge in 2018, compared with 30 percent who reported the economy as their biggest hurdle. (2)

This difference between the skills required to perform a specified job, and the actual skills that employees possess is defined as "skills gap."
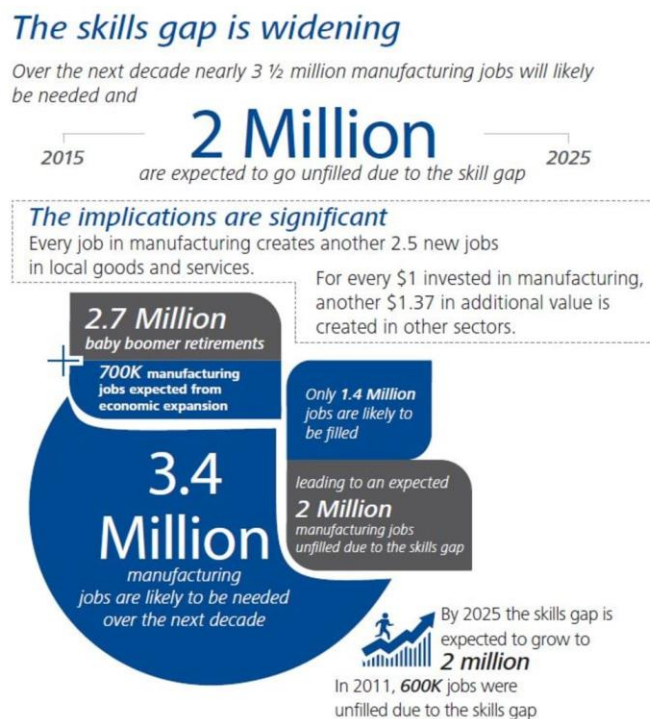
Over the next decade, nearly three and a half million manufacturing jobs likely need to be filled and the skills gap is expected to result in 2 million of those jobs going unfilled.(4) There are two major contributing factors to the widening gap – baby boomer retirements and economic expansion. An estimated 2.7 million jobs are likely to be needed as a result of retirements of the existing workforce, while 700,000 jobs are likely to be created due to natural business growth.(5) In addition to retirements and economic expansion, other factors contribute to the shortage of skilled workforce, including loss of embedded knowledge due to movement of experienced workers, a negative image of the manufacturing industry among younger generations, lack of STEM (science, technology, engineering and mathematics) skills among workers, and a gradual decline of technical education programs in public high schools. (6)

In an interview with Inside INdiana Business, Corporate Communications Director Steven Ostrowski said the figures illustrate the tech skills gap. Nationally, he said about 500,000 postings at the end of last year had gone unfilled.

Ostrowski says employers have to take steps to stock the pipeline. "They're going to have to broaden their perspective and not use the same old formulas that they used in the past to try and find people," he said. "That may mean going to different places, expanding their geographic reach. They may have to evaluate what wages and benefits they're offering. They may have to look to partner with other organizations, specifically, schools, community colleges, places like that where there might be young people interested in getting into this field." Companies Ostrowski adds, are no longer waiting for the perfect candidate, instead, they are hiring near-matches and spending time "skilling them up." (8)

The need to "skill them up" as Mr. Ostrowski refers to is an added expense, it requires resources, it takes time, it is not a core business of the companies, and it doesn't provide any value added to

the customer as a result. It is the cost of doing business. Another factor is that the most recent data from the Bureau of Labor Statistics shows that the average worker stays at a job for 4.6 years.(9)   Then, you are faced with "skilling up" the next person.

The effects of the talent shortage are expected to be felt in functions throughout manufacturing companies. When asked which business areas will be affected most due to the talent shortage, more than three-fourths of manufacturing executives believe the greatest impact of the skills shortage will be in maintaining or increasing production levels (in line with customer demand) and implementing new technologies while achieving productivity targets. As manufacturers struggle to support their strategic, business, and production plans with insufficient human capital, they tend to stretch their existing resources. In fact, current data suggests the average annual working hours in manufacturing is 17 percent more than in all private industries. In addition, the use of frequent or forced overtime in order to maintain base production levels is not only economically unviable in the long term, but also suppresses productivity.(12) In an era where many companies have spent significant time and resources to streamline operations, improve the ability to meet customer demand, and implement the latest technologies, this result highlights the effort that should be considered by most manufacturers to combat the expected severity and impact of future skills gaps.

A recent study estimates an average U.S. manufacturer is potentially losing 11 percent of its annual earnings (EBITDA) or $3,000 per existing employee due to the talent shortage.(13) Yet another study paints a bleaker picture: a loss of an average $14,000 per open position that goes unfilled.(14) Given that more than 50 percent of U.S. companies are planning to increase their domestic production levels by at least 5 percent in the next five years,(15) the lost earnings figure presents an alarming precedent.

This problem shows that there is a disconnect between the needs of industry and the curriculum being taught. This is not a new problem, but the nature of technology itself in that it is constantly changing and evolving, which will make this gap wider over time. This is especially true in the electrical and I.T. fields.

At the university level, the courses tend to be more mathematically intensive. These courses provide the fundamental knowledge that the students need up front to build a solid understanding of their field. These courses are often completely separated from each other and there is no link to tie them together or to real world situations. These courses are based in theory and equations with minimal hands on experience with devices similar to what will be seen in industry.

One attempt to address this is with technical colleges as opposed to universities. The intent is to focus on job related skills and reduce the depth of the instruction in the theory behind the technology. While this works well for some entry level positions, this lack of a foundation of knowledge the person has to build upon can make it difficult for that person to advance.

In both settings, labs are designed to support the lecture material, which is important, but the steps are frequently laid out in detail, requiring little thought as to how to set up the lab itself. The focus is more directed towards the observations made during the lab as it relates to the material presented. Many industrial labs have the equipment setup, wired, configured, and ready to go. This is fine for beginning level students, but the more the experiments relate to experiences that they will encounter at the job, the better prepared the student will be. For example, requiring students to hook up devices to I/O cards on a PLC and having the student lookup data sheets or find information in the device manuals to figure out how to do so, promotes a much more complete understanding than inserting something in an educational simulation software.

The ability to find solutions in the standard documentation of industrial devices and/or to source items based upon the design specifications from vendor catalogs are valuable skills.

A good engineering candidate needs to have a strong understanding of theory and enough hands on experience in things that are relevant to industry to be able to apply that theory.

To understand how to best teach these skills, one must first determine what is relevant and to do that, it requires the involvement of the industries that you are targeting. By getting their input with regards to what skills they value when they are evaluating new graduates for hire, it helps keep courses relevant and it also provides value to both the companies and the graduates.

Obviously, it is impossible to be all things to all companies. That's why it is important to get a good cross section of industries and companies to provide input. Talk to manufacturers, equipment vendors, machine builders, engineering houses, utility companies, food and beverage, pharmaceutical, and industries specific to your area. If there are large facilities that hire a lot of technical personnel, find out what types of equipment they use. Talk to them about trends in their industries. Using this data, it is easy to see common areas and help shape the curriculum.

This might bring to mind the question, "Are we teaching or are we training?" The answer is by combining elements of both, we are preparing. Preparing them to be able to be a contributing member of an organization equipped with tools that are perceived as having value.

The relationship doesn't end there. For industry to be able to have this source of skilled people, they have to be willing to be involved as well. Industrial equipment is expensive and as technology evolves, it becomes obsolete quickly. Even with educational discounts from equipment suppliers, it is still very challenging to acquire these devices. By building relationships with common goals in mind, companies often donate generously so that the labs can be equipped with systems that are the same as the students will encounter if they are hired by that company.

Now that the goals of the curriculum has been aligned with the needs of industry, all the courses need to be looked at to determine, though each discipline, how to put them together as a path towards these final outcomes. Each course should use concepts from previous courses to reinforce them and develop concepts that lead to the next course. It's also important to see the inter-relationships between the different subjects to understand that they are not isolated topics, but branches of the same tree. This may require a little bit of overlap of material when dealing with electives, but it insures that each person going thru the program has the tools that have been defined as necessary and that they will be highly desirable as a result.

One of the biggest challenges for students to overcome is lack of experience. There are so many things to become familiar with that are not possible to see in a classroom setting. It is important to get them exposure to the environment that they will eventually work in, how things are done, and how it all fits together organizationally. At this point, the theory portion has been addressed with some hands on obtained from labs. Setting up field trips throughout the year help with this and are eye-opening experiences for the students. The final piece that the student needs to complete their preparation is to gain real world experience either through an internship or actual job in their field of study. Again, the relationship with your industrial network is crucial. There must be clear objective for what the students' expectations are and what the company has planned for them to do. This needs to be something real and not just an engineering department "go-for".

Another opportunity to partner with industry is by inviting experts in various topics to be a guest speaker. Application engineers from O.E.M. and local distributors are excellent choices. They are familiar with the products and methods, they have seen installations done well and done poorly and can explain why. It helps students build network relationships that can prove helpful in the future. These people do a great job communicating with people who have little or no familiarity with the subject and can keep it informational without turning it into a sales pitch for their products and services.

Also, you can tap into existing expertize at the companies that you partner with to find industry experts to use as adjuncts. They have insight as to how the technology being presented can be employed, and can sight examples to illustrate specific methods and details to tie the information to the real world.

This relationship between academia and industry is a two way street. Educators have an obligation to industry to stay current and keep up with how things are being done now and what trends in the industry infer how they will be in the not so distant future. There are many sources for this information. Obviously, practically everything is available online, this is a great resource, but requires a lot of self-study to pick out the pearls of knowledge amongst all the volumes of material to look at. Local distributors have trained sales professionals that can summarize a lot of that data to deliver the main points. They are also a great resource for what's going on in the industrial world, since they are exposed to so many different companies and industries. And, one of the best ways to completely immerse yourself and go into as much detail as you could ever want, is to attend local and national trade shows. There is no other source that can give you this kind of access to information and factory representatives, across so many different brands of equipment and services. It is an opportunity to see, touch, and examine the physical devices themselves. Also, by looking at what different, but similar companies are doing and how their product offerings are changing, it provides insight into what trends are happening in the industry. Trade shows are also an excellent networking opportunity. Meeting the right people at various companies often opens the door to donations of sample products and free training.

It has become quite a balancing act to determine what needs to be covered and at what depth since these migrations to newer technologies aren't cliff events. As new technologies are implemented, they have to be supported along with the existing installed base that hasn't been upgraded. Again, that's why having a network of people that can communicate the reality of what they are using or are planning to use soon is tremendously important. It is counter-productive to spend a great deal of time on products and technologies that have been phased out. But, the only way to know that is to keep a finger on the pulse of what is happening in industry.

In summation, it is possible to have a synergetic relationship between industry and academia. The skillset of the graduate has to be considered to be one of the main goals to strive for, and that skillset must correlate with the basic needs of industry. This requires ongoing relationships between all facets of industry, educational institutions and educators as these skills are constantly in flux.

This challenge can be looked at in a way similar to producing a product in manufacturing. The customers' needs must be determined, a plan must be put in place to meet those needs, the product needs to be put to use and feedback must be evaluated to determine what adjustments must be made in the future.

By expanding on these ideas, it is possible for industry and academia to jointly and aggressively take on the skills gap by coming together to build a better engineering technology graduate.

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Biographical Information

William Shapiro has worked in manufacturing for over 30 years. He has held several positions including Design Engineer, Field Service, Maintenance Technician / Supervisor, Engineering Manager, Manufacturing Technical Development Engineer, and Project Manager, some of which while pursuing a degree at night. He has worked for small privately held companies and large corporations whose facilities performed operations ranging from machining and heat treating, the design and build of custom automation machinery, and a 7 days per week, 3 shifts per day automotive foundry. He has overseen the installation of several million dollars' worth of equipment. He was involved in the one of the most automated sand core robotic assembly systems in North America, which was featured as a cover story for Modern Castings magazine. He was a presenter at the 2001 Robotics Industries Association (RIA) Conference in Orlando, where he discussed robotic sand core assembly. During his career, he has worked very closely with members of management, engineering, and with shop floor personnel, becoming a trainer and mentor to many of the U.A.W. Skilled Tradespeople. With the closure of the Navistar Indianapolis foundry, William is applying his manufacturing experience and perspective, and love of educating people to the role of Adjunct Instructor, teaching industrial controls and automation courses at Indiana University Purdue University at Indianapolis (I.U.P.U.I). William is an alumnus of the I.U.P.U.I. Electrical Engineering Technology Department where he received his bachelor's degree and was awarded Outstanding Graduate for both Associate and Bachelor Degrees, and of Southern Ohio College where he received an Associate's Degree, Cum Laude, in the field of robotics and automated machinery.

Author Comments

The alignment of the needs of industry and the goals of academia is a topic that is particularly resonant with me. The experiences, both academically and professionally, that I have had, I feel, give me a unique perspective of this issue and is one that I have dedicated the last 3 years of my professional life to address.

For most of my 30+ years in industry, I have been witness to many of the facts that the data in this report states. Starting with education, itself, I went back to school, primarily due to the opportunity of tuition re-imbursement with my employer and the desire to have a bachelor degree to backup that I "really knew what I was already doing." I had an associate degree from a technical college and was working in my field for a few years. I was manager of the controls department for a mid-sized custom automation OEM. Because of this, I knew a lot about the electrical engineering technology field before I started pursuing my bachelor degree from a university. I continued to work full time and go to school part time. While the math was much more in depth and I came away understanding theoretical phenomena much better than with the tech degree, I noticed that very little of what I was learning directly applied to my real job.

Throughout my career, this observation was demonstrated over and over again when there were job vacancies to fill. The very small pool of people who were qualified, were snapped up by other companies, sometime before there was a chance to interview them. It would take months to find someone to fill an open position and during that time, everyone else has to do their job and the vacant persons' job, too. As the report stated, this results in extreme work conditions. Personally, mandatory seven day work weeks were the norm where I worked.

As I have had positions throughout my career that have required some travel, I have had the opportunity to work with several people from all over the United States and many other countries as well. The topic of a skills gap has been a universal theme, where ever I have been.

It is for these reasons that I transitioned to teaching. This has proved to be a very natural evolution from years of doing it to teaching others to do it. I employ many of the ideas brought forth in the report. I also take advantage of a very large network of people in industry who are very generous with things such as field

trips and being guest speakers as well as providing hardware donations. They realize that it is in their best interest and the best interest for the industry as a whole.

I am also grateful to be working with a very progressive administration that is allowing me to participate in helping them shape the curriculum to better serve the industrial community, which in turn better serves the student.