Tech-Clarity

Tech-Clarity Insight:

Developing the STEM Workforce of the Future

Partnering to Meet the Demand for Engineering and Manufacturing Talent

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Executive Overview

Not too long ago the term "STEM" didn't mean much to most of us. In recent years, however, numerous studies show that much of the world faces an engineering and manufacturing workforce shortage. This casts a lot of attention on science, technology, engineering, and mathematics (STEM) education. There are a variety of causes for the technical skills gap, including:

- Increased demand due to the manufacturing renaissance, recovering economies, and "re-shoring" manufacturing closer to demand driving greater need for technically qualified employees
- A large number of skilled, experience employees reaching retirement age

A healthy manufacturing industry demands a reliable pipeline of qualified, capable individuals trained in STEM disciplines.

This paper doesn't go into depth on this gap. This issue has been well documented and discussed at national and international levels. Instead it focuses on the implications of the gap on the manufacturing industry and explores practical solutions to address it. A healthy manufacturing industry demands a reliable pipeline of qualified, capable individuals trained in STEM disciplines. As Vass Theodoracatos, Program Manager, GM Vehicle Engineering STEM Outreach of General Motors simply states, "*There is an extreme need for well-trained and innovative talent to enter the workforce, not only for the future needs of General Motors, but for the industry as a whole*." There are many challenges to developing this workforce ranging from garnering interest in STEM at a young age all the way through graduating (and retaining) qualified employees with the right training.

One of the biggest gaps in today's educational approach to filling the STEM demand, and perhaps the biggest opportunity for improvement in developing the future workforce, is including hands-on experience to augment theoretical learning. "*The way people learn is through an applied project where they can apply theory to a very complex problem and add their creativity, ambition, enthusiasm, and the skills of the team*," shares Kristen De La Rosa, Argonne National Laboratory Director of the DOE Advanced Vehicle Technology Competitions. "*That's how they become leaders*."

Industry, academics, governments, and software companies are partnering to help attract, develop, and retain the technical workforce of the future by developing hands-on, real-world learning experiences for students of all ages.

Industry, academics, governments, and software companies are partnering to help attract, develop, and retain the technical workforce of the future by developing hands-on, real-

world learning experiences for students of all ages. These partnerships offer short- and long-term solutions to address the technical workforce gap. One industry insider who has researched this issue extensively is Michael Richey, PhD, Associate Technical Fellow, Engineering Education Research of Boeing. As Dr. Richey shares, "*The current state of education is not working. I partner with universities to close gaps in our current workforce*." This paper shares examples of successful partnerships and identifies the common factors that make them successful, including:

- Practical, engaging experiences
- Real, industrial-strength processes and tools
- Involved mentors
- Committed leadership and funding

Understand The Implications of the Technical Workforce Gap

By now you have heard about the technical workforce gap. The world's economies face a shortage of engineers and manufacturing resources trained in STEM disciplines. Although this paper is not intended to quantify or prove the gap, here are some brief statistics to highlight the severity of the problem:

- The World Economic Forum indicates that there are 10 million manufacturing jobs unfilled – many of which are in areas with high levels of unemployment
- The average age of an auto controls engineer is greater than 50 and one out of 10 employees in the aerospace engineering workforce is already eligible for retirement

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Many people are retiring and leaving the business.
They will not be replaced if we don't get kids into technology.
Mike Howell, Ambassador and Growth Project Manager, Greenpower

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You have probably heard these facts, but what is the real impact? For manufacturers it means there is a smaller pool of qualified candidates to satisfy their workforce needs. This means they can't grow and they don't have the necessary workforce pool to take advantage of market opportunities. Many are lucky if they can just replace retirees with qualified workers. "*Many people are retiring and leaving the business,*" says Mike Howell, Ambassador and Growth Project Manager of Greenpower. "*They will not be replaced if we don't get kids into technology*." It impacts governments as well, the gap prevents them from filling steady, well-paid, long-term jobs that stabilize the economy and drive growth.

Why is it hard to provide a reliable pipeline of qualified technical employees? Part of the problem is that not enough people are interested in STEM at a young age. In many

countries it's not considered "cool" or children feel they aren't good enough at math and science to contribute, so they avoid advanced science and math courses. As Kristen De La Rosa of Argonne National Lab reveals, "*Our research shows that students decide what they think they are capable of by middle school. Most of the driving force between what they think they can become is based on what they think they can or can't do, and if they don't think they can be successful in STEM they won't fight their way through the hard courses*."

Clearly there is a need for a better way to attract and train a job-ready technical workforce.

Beyond the fact that low numbers of students enter STEM college curriculums is that even fewer graduate. Many technical programs are designed to "weed out" a percentage of students as opposed to encouraging them into related studies. Of those that do graduate, many are hired away by other high-growth industries like software companies. To add to the issue, those that do enter industry don't have the right skills to step in and be productive right away and must be retrained. Clearly there is a need for a better way to attract and train a job-ready technical workforce.

It's important to note that not everyone agrees that there is a STEM workforce shortage. Some believe that the STEM talent shortage is overhyped. Our review of recent studies and discussions with leaders in industry for this report, however, give manufacturers good reason for concern. Manufacturers can't wait to act. Talented, well-trained technical people are a "long lead time" item to produce!

Recognize Industry's Needs and Perspective

What does the manufacturing industry need in order to fill the workforce gap? The simple answer is a pipeline of qualified employees. To replenish and grow their technical staff, manufacturers need individuals with the right training so they are productive "day one" without extensive, additional training. Manufacturers need technical workers with some level of theoretical understanding, but they are also looking for specific technical capabilities. Manufacturers want to hire people with:

- Knowledge of STEM
- An understanding of engineering and product development disciplines
- Competency with manufacturing processes and tools
- Practical experience

They also covet soft skills in addition to technical skills, including leadership and the ability to work collaboratively in a team. As Argonne National Lab's De La Rosa observes, "*It used to be knowledge that separated people, but now it's their leadership*

skills, their ability to process information in complex systems, and working with each other across both technical and non-technical disciplines." Industry also wants people with a broader viewpoint. Experience with systems-driven product development, simulation tools, and product lifecycle management (PLM) processes in addition to technical engineering knowledge is highly valuable. In fact, the workforce shortage extends beyond just engineers. There is an immediate need for skilled technicians, production workers, and maintenance support.

As an automotive manufacturing company … we need candidates that are already trained in our systems and development process so they can hit the ground running.

Vass Theodoracatos, Program Manager GM Vehicle Engineering STEM Outreach

Manufacturers can't develop these competencies on their own. They require students to gain a strong STEM foundation and be trained in technical disciplines. "*As an automotive manufacturing company, our focus is on cutting edge solutions and innovations; therefore, we need candidates that are already trained in our systems and development process so they can hit the ground running*," says GM's Vass Theodoracatos. Unfortunately this is not what today's education system is producing, at least in the necessary quantity, so manufacturers have to spend time and money retraining new hires.

Evaluate Current Academic Programs

Studies show that STEM workforce challenges start early in K-12 education. This is a systemic problem that will take time to change. "*Technology, globalization, the rapid pace of technology in services, and micro-economies have all contributed to an imbalance between the traditional, agrarian 'three Rs' compared to the tech-savvy skills we need today*," shares Boeing's Michael Richey. "*The education system simply has not had time to respond*." Primary education is an important area to address, but this paper focuses on higher education because manufacturers can have more immediate, direct influence at that level.

Unfortunately there is a disconnect between what industry needs and the educational goals of most higher education institutions.

Unfortunately there is a disconnect between what industry needs and the educational goals of most higher education institutions. Many leading universities are driven to produce new knowledge through research, and professors are often more motivated toward research than providing practical experience for students. Universities want to educate critical thinkers. "*Teachers are the best tool we have today to educate the next generation of our national leaders and innovators*," says Vass Theodoracatos of GM.

"*They have the unique ability to positively or negatively affect the interest and passion in these essential fields of education. However, many teachers lack the opportunity for ongoing educational and developmental opportunities to bring the fundamentals they teach into the context of today's technological development*."

Most universities are designed to educate on theory and disseminate knowledge. They are not designed to provide hands-on experience with today's modern manufacturing tools.

Most universities are designed to educate on theory and disseminate knowledge. They are not designed to provide hands-on experience with today's modern manufacturing tools. For example, most programs don't provide experience with the full suite of software tools used by engineers today. While some programs provide experience with software, primarily with Computer Aided Design (CAD), fewer have expanded to provide more than a conceptual understanding of simulation and analytical tools like finite element analysis (FEA) or computational fluid dynamics (CFD). Even fewer have embraced tools that enable collaboration and information sharing such as product data management (PDM), let alone broader tools that integrate engineering with the business of manufacturing like PLM. These skills, which have become an essential part of an engineer's success as much as the knowledge of engineering principles, are absent from most educational curriculums.

Evolve Academic Programs

What can be done to fix the gap between industry's needs and education's output? Major universities recognize that they are not delivering the skills industry is looking for, but they face significant obstacles to changing their curriculums. As Nathan Hartman, Associate Professor of Computer Graphics Technology and Director of the Product Lifecycle Management Center at Purdue advises, "*You have to have an appreciation for the curriculum constraints at whatever level you deal with. Balancing the interests of the discipline and its domain knowledge, with accreditation requirements, industry and government expectations, and societal perceptions can be a tricky proposition.*" It's also important to realize that academic programs do not change rapidly due to institutional and funding structures.

Major universities recognize that they are not delivering the skills industry is looking for, but they face significant obstacles to changing their curriculums.

Changing academic institutions takes time, but it can happen. Both India and China recognize their shortages and are putting in place measures to produce more qualified engineers. The China Ministry of Education instituted a far-reaching program to

transform engineering education leading to new engineering-related certifications for both teachers and students. In a similar way, India recognized the need to create more job-ready engineers and now offers certificates in PLM.

We need people to grow the business.
Academia produces people that think, business needs people that do.
Michael Richey, Ass. Technical Fellow, Engineering Education Research, Boeing

In the US, manufacturers can engage with different types of academic institutions including universities, community colleges, and vocational schools. Universities offer more theoretical, traditional education in their core curriculum and are only one option. As Boeing's Michael Richey explains "*We need people to grow the business. Academia produces people that think, business needs people that do. Collectively we can build experiential programs for our students preparing them for the knowledge-based economy*. " Perhaps higher education is where the most change is needed for the long-term, but partnering with community colleges that are more flexible in their curriculum is a practical way to meet short-term industry needs and build a pipeline.

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Community, vocational, and technical colleges can teach more practical skills. These smaller schools are more agile and can meet more targeted, local skills needs. "*Vocational and technical schools offer certifications in technical skills and can produce highly valued members of the STEM workforce*," advises Purdue's Hartman. "*We have a continuum of technical education at Purdue – a college of engineering and a college of technology – which cover the spectrum of industry's technology and manufacturing readiness levels.*"

Not everybody needs to go into degree-granting, four year college after high school and incur that level of debt to get good jobs in manufacturing.

Not everybody needs to go into degree-granting, four year college after high school and incur that level of debt to get good jobs in manufacturing. Industry, government, and the academy need to recognize that. There are a variety of opportunities, especially in the manufacturing sector, which are not being served by the current educational approach. As Nathan Hartman of Purdue explains, "*That doesn't meet what industry wants and needs. Industry needs people with a spectrum of skills, not everyone needs to the highest orders of math and science to be successful and to provide value*."

Countries like Germany also have technical schools in addition to research-oriented institutions. "*Classic universities have a main focus on theoretical background. That may be the right way in many cases. But this is not enough for the new topics such as PLM and Industry 4.0. Here we need tight contact to and experience from industry. For this, the German concepts of Universities of Applied Sciences and Fraunhofer-Institutes are very strong. There we have young teams directly cooperating with industry. These people are learning practice from industry and not only theory from books*," shares Dr. Jörg W. Fischer, Professor of Karlsruhe University of Applied Sciences. These schools offer more real-world programs. "*We have created a 'Learning Factory' that lets us train from virtual to real*," Dr. Fischer explains. "*Students can see designs and related production systems virtually in CAD and PLM tools and then see how it looks on real equipment*." The school also combines electronics, mechanics, and software to teach systems-level product development to their students. We should also note that Germany has very strong, mature apprenticeship programs to help develop their manufacturing workforce.

Change is happening at the university level, but it will take time.

There are progressive approaches at the university level as well. The following excerpt from the TUEE May 2013 Workshop Report shares one such initiative. "*With support from the National Science Foundation (NSF), the American Society for Engineering Education (ASEE) has launched a series of meetings to develop a new strategy for undergraduate engineering education that meets the needs of industry in the 21st century.*" Change is happening at the university level, but it will take time. Unfortunately, "*Many schools, along with their industry partners, are trying to retool engineering and technology curricula to try to retain more STEM student and be more inclusive*," offers Nathan Hartman of Purdue. "*But people will be gone in a year if we continue with big lecture rooms and higher order math and science without connection to real life. We have to change our approach*."

Governments' Role

Governments have a large stake in the success of their manufacturing industries. Unemployment isn't always due to a lack of jobs, but a mismatch between the skills needed, the location of the jobs, and the available workforce. Technical workforce shortages limit growth and GDP and contribute to unemployment. Many countries recognize this at a high level. The US Department of Labor, for example, funded $2 billon for TAACC (Trade Adjustment Assistance Community College Capacity) grants to close technical skills gaps. The majority of the colleges receiving the grants added manufacturing curriculum. But there is much more work to be done.

The Chinese Ministry of Education aimed to enable schools to develop courses and educate students to prepare them for real jobs and not just theory.

There has been investment in STEM education at both the K-12 and higher education levels but it has not always been focused. But it can pay off. For example, China made a strong stand with their program for education transformation. The Chinese Ministry of Education aimed to enable schools to develop courses and educate students to prepare them for real jobs and not just theory. The government granted a very large number of engineering software licenses and offered training and certifications for teachers and students. The program reached 72 schools in two years. Clearly, government can play a successful role in transforming education to reduce the technical skills gap.

Recognize the Growing Role of Software Providers

Engineering software companies also play an important role in enabling the future technical workforce. The Chinese transformation program's investment in software reflects how important software has become to the success of engineering and manufacturing businesses. As Boeing's Michael Richey declares, "*PLM is starting to become the digital nervous system where people collaborate and share knowledge bi-directionally*."

Software companies can help educational institutions by providing real engineering software including CAD, FEA, and PLM.

Software companies can help educational institutions by providing real engineering software including CAD, FEA, and PLM to provide students experience with industrial-strength tools. "*The goal is to give students experience with industry-class architecture and industry-relevant problems*," explains Purdue's Nathan Hartman. "*They have to understand that there is an interplay between tools and process and that technology changes the way people work*." Engineering software companies have stepped up to the challenge by donating hundreds of millions of dollars worth of software through grants in kind.

Software companies share knowhow on how to apply tools to business and allow students to gain the practical tools experience they need to succeed.

Software companies have more to offer than just tools. They can also help educate teachers and students alike on modern, systems-driven product development processes and theory. Some offer the same commercial, web-based training they offer professionals at a drastically reduced cost. These software companies share knowhow on how to apply

tools to business and allow students to gain the practical tools experience they need to succeed.

Software companies are also acting at K-12 level with science days, outreach, and teacher education and by sponsoring programs like FIRST Robotics and other robotics programs including BEST Robotics, Robocup, ROBOCON, and ROBO-ONE. They also play a critical role in university level programs like PACE, EcoCAR, and others. Engineering software companies are important partners in these programs because of their software, know-how, training, and mentors.

Partner to Develop the Workforce of the Future

The educational system will take a long time to adjust and industry can't wait. None of the groups above can solve this problem alone. But there are passionate individuals at universities that want to help, potential investment from governments, and engineering software vendors that can provide assistance and expertise. Manufacturers need to take the lead to set up partnerships that provide the rising workforce with the practical experience they need.

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Forward-thinking manufacturers are leading the way with partnerships. "*Our goals are to help raise the 'waterline' of education for all, staring from pre-K and following through the collegiate and university level for all US citizens, especially minorities and underrepresented groups*," says Vass Theodoracatos of GM. "*We also want to help increase the pool of engineers for hiring talent and improve our human capital and the next generation of our workforce*." GM does this by supporting multiple programs, including:

- AWIM
- PLTW
- FIRST Robotics
- EcoCAR
- PACE
- Buick Achievers Scholarship
- Summer camp support for various underrepresented groups

GM and others are reaching out to younger generations to get them interested and keep them interested throughout their education by creating partnerships that augment and enhance the current educational experience. These partnerships provide value for the companies involved through positive industry perception and by creating a pipeline of

known individuals while also helping the industry at large. In addition, participating manufacturers benefit from lower recruiting time and expense and reduced time and money needed to train new employees.

Manufacturing involvement in programs also adds job satisfaction and contributes to retention by providing existing employees opportunities to be involved as mentors. "*Volunteers have long days, sometimes in the pouring rain, and then thank us for it when they see what the students have achieved*," reflects Greenpower's Mike Howell. "*It's amazing. They can't get enough of it, and it still surprises me that they keep coming back for more*." But the primary reason to participate is to develop students into productive members of the workforce.

We need to have students experience engineering through making products and competing rather than have them as observers of STEM principles.
Vass Theodoracatos, Program Manager GM Vehicle Engineering STEM Outreach

What makes a good program? The participants in this research all pointed out the value of providing the hands-on experience that isn't found in most educational environments. "*We need to close the gap between education and practice by showing the exciting careers they can have as STEM graduates through experiential learning versus boring them with reading long chapters*," says GM's Vass Theodoracatos. "*We need to have students experience engineering through making products and competing rather than have them as observers of STEM principles*." The most successful programs apply learning to real-world problems in an engaging manner. "*In EcoCAR, we try to introduce the important tools they will use when they graduate, the ones that companies like GM use*," says Kristen De La Rosa of Argonne National Lab. But real-world experience requires investment from the industry to provide strong champions, make employees available to share expertise as mentors, and contribute financially to the partnerships.

Listen to the Student's Perspective

Before delving into the details of some successful programs, it's important to share the perspective of the future workforce, today's student. This paper shares the experience of Lucas Shoults, a Master's Student at Virginia Tech. Like many he enrolled in engineering school because he could, not because he knew what he wanted to do. "*My guidance counselor said because I was good at science and math I should go to engineering school*," Lucas recalls. "*For the first two to three years I didn't really enjoy engineering*." Lucas was not very engaged and lacked exposure to real-world experience.

For the first two to three years I didn't really enjoy engineering.
Lucas Shoults, Master's Student, Virginia Tech

Lucas joined EcoCAR because of a friend on the team. The program sparked his interest in engineering. It also gave him valuable, applied experience with real-world processes and tools. Lucas became the CAD and FEA expert for his team. "*I spent hundreds of hours with FEA. When we had the subframe built and put it into the vehicle it was the highlight of my undergraduate career*," Lucas said. "*It was great to see something I spent hundreds of hours designing come to fruition*."

One of the most refreshing statements Lucas made highlights the difference between learning in a realistic environment in addition to a lecture hall. "*We got to experience the transition from virtual to real. We had a CAD model of the engine bay but the real thing has a lot more connecters and wires*," he recalls. "*Now I understand why when something built in CAD gets to the assembly line it doesn't always work, because I have spent time with a hammer and a grinder*." Lucas clearly gained realistic industry expectations and experience to complement his theoretical knowledge.

We used a lot of the same processes and technologies that GM uses, so we can just fit right in.
Lucas Shoults, Master's Student, Virginia Tech

Lucas and his teammates learned more than just engineering. The comprehensive nature of the EcoCAR program gave him experience in the business of developing a product. He explains that he was able to learn from others including communications and business majors on the team. The bottom line is that the program made him job ready. "*I will be able to be an immediate contributor, not due to my technical skills and knowhow, but because of the ability to decipher problems on my own*," Lucas explains. "*We used a lot of the same processes and technologies that GM uses, so we can just fit right in. We can get thrown into a project that is too big to handle and can break it down into manageable parts and get it done*."

Learn from Success Stories – Greenpower

Let's take a deeper look at some successful programs and partnerships. Researching successful STEM education partnerships uncovered a common thread – the value of experiential learning and hands-on experience. Greenpower is an automotive competition that takes this to heart. As Mike Howell of Greenpower laughs, "*How more real can you get than designing and building your own car, and then getting in it and racing it*?"

Researching successful STEM education partnerships uncovered a common thread – the value of experiential learning and hands-on experience.

The program started from local government in West Sussex because local companies were looking for skilled workers. There is quite a big aerospace manufacturing hub in

Sussex, which is close to Gatwick, and a lot of aerospace engineering with Lockheed and BAE close by. The government recognized the problem that people don't have the right skills and wanted to do something through their business links. The program is now a private charity and gets a lot of support from industry mentors and volunteers at the events, in part from the Institution of Mechanical Engineers who get a lot of other companies on board. Today the biggest sponsors are Siemens and the Institute for Engineering and Technology, and others such as Cummings, Delphi, and Riccardo have been on the periphery.

One girls' school in NW reports that 15 girls went through and went on to get mechanical engineering degrees – that's a pretty high strike rate.
Mike Howell, Ambassador and Growth Project Manager, Greenpower

The program starts for students at a young age, 9 years old, with a kit car to build in school. "*Many have never picked up a screwdriver or spanner before*," Greenpower's Howell shares. In junior schools teams can have up to 12 drivers with others on the pit crew. Teams average 20 people, some of whom work on non-technical tasks such as sponsorship programs or IT. Senior teams have a minimum of 3 drivers, need a minimum of 4 to make changes in the pit, and sometimes have 16 to 17 or more on their team. The program has had quite a bit of success and recognition. "*We are now up to 500 schools in the UK, with 10,000 pupils*," states Mike Howell proudly. In addition, the program has successfully focused on gender diversity with 30% female participants.

The bottom line is that the program gets young people engaged in working on cars.

The bottom line is that the program gets young people engaged in working on cars. The program has also produced qualified, engaged engineers. "*We have some really good data*," shares Mr. Howell. "*One girls' school in NW reports that 15 girls went through and went on to get mechanical engineering degrees – that's a pretty high strike rate*." Greenpower has clearly exceeded their early goals as a one-off program for local schools in Sussex. "*We also have at least four people currently working in Formula 1*," he adds humbly.

Learn from Success Stories - EcoCAR

Another successful government-initiated program is EcoCAR run by the US Department of Energy (DOE). Like Greenpower, the program is a successful partnership that includes both industry and academia. EcoCAR is part of the Advanced Vehicle Technology Competition (AVTC) series, a program that has a long track record and has been running for over 20 years. It's a comprehensive, multi-year program where student teams design,

build, and compete by modifying production vehicles. The university teams spend the first year designing the modified vehicle, the second year acquiring new components and technology from various companies, and the final year getting the vehicle to work better than the original.

We emulate the auto engineering experience. We use real processes, real tools, and real cars.
Kristen De La Rosa, Director of the DOE Advanced Vehicle Technology Competitions, Argonne National Laboratory

The program has seen many changes. The first competitions were focused primarily on mechanical engineering in what program director Kristen De La Rosa of Argonne National Lab calls "the monster truck years." Now, she explains, "*Vehicles cross into electrification and computer science, there are more microcontrollers in the common vehicle than the space shuttle*." The program has changed to stay current with technology by including hybrid technology, electric vehicles, electric drive technology, and other advanced automotive designs. The most recently announced competition, EcoCAR 3, provides teams with a GM production vehicle - a Chevrolet Camaro - and tasks them with stripping out all of the existing powertrain components and converting the car to a high-performance hybrid vehicle.

This partnership between industry, government, academia, and the engineering software industry is a great example of how partnerships can augment theoretical education with real-world industry experience.

The program gives student teams experience working on more environmentally sustainable vehicles. It also gives them real-world industry experience. "*We emulate the auto engineering experience*," De La Rosa explains. "*We use real processes, real tools, and real cars*." The processes and tools include industrial-strength design tools provided by another partner, Siemens PLM Software. In the 1990's the program adopted model-based design techniques, incorporating engineering software into the heart of the process. They have also adopted systems product development approaches. In addition to the car, teams also get full CAD models of the car and other fundamental software tools used in industry including FEA, CFD, Matlab, and Simulink. As Lucas Shoults' story confirms, this partnership between industry, government, academia, and the engineering software industry is a great example of how partnerships can augment theoretical education with real-world industry experience. In fact, many EcoCAR graduates go on to work in the auto industry.

Learn from Success Stories - Others

There are numerous other programs that help promote STEM interest and involvement in K-12 education and in higher education. These programs are not limited to the automotive industry. For example, Boeing's Michael Richey shared information on programs involving unmanned aerial vehicle (UAV) development, 3D printing, and more. There are also numerous robotics competitions that provide real-world design and production experience.

PACE provides a global, multi-cultural, multi-lingual, collaborative experience that closely resembles today's industrial environment.

One final program worth mentioning directly is PACE, or Partners for the Advancement of Collaborative Engineering Education. The program, sponsored by industry and software companies, includes 62 universities. Like EcoCAR, the program uses industrial-strength 3D modeling which allows engineers to analyze their designs mathematically using simulation software. One of the unique characteristics of PACE is that while students in most programs collaborate as a school team, PACE teams include multiple schools from around the world collaborating together from design through manufacturing. In fact, the latest winning team was a partnership from six universities! This type of collaboration extends the real-world process and tools experience to better reflect the real-world organization and supply chain. PACE provides a global, multi-cultural, multi-lingual, collaborative experience that closely resembles today's industrial environment.

Conclusion

The technical skills and workforce gap is well documented and recognized by industry, academia, and governments around the world and action is underway. There are many programs in place to help spur more interest in STEM education at the K-12 level. Others are attempting to make significant changes to correct the disconnect between the skills demanded by industry and candidates produced by the academic system. This problem is systemic, however, and will take a long time to fix. Industry needs to act sooner than academia can address the issue.

Partnerships and programs that provide experiential learning are a viable solution.

Partnerships and programs that provide experiential learning are a viable solution. Successful programs like EcoCAR, PACE, Greenpower, and others show that manufacturers can effectively partner with academia to offer real-world challenges, processes, and tools to provide engaging and valuable training opportunities that produce

job-ready workers. There are a number of keys to successful programs, chief among them is real-world experience. "*In my opinion, an important driver behind STEM education is external engagement*," offers Nathan Hartman of Purdue. "*Getting outside the ivory tower and finding out how the world works. It's incredibly important to STEM disciplines*." As EcoCAR graduate Lucas Shoults puts it, "*It bridges the gap between book smarts and street smarts. We have worked on a GM vehicle all the way from design to delivery of a hybrid*."

Successful partnerships benefit from software grants, training, know-how, expertise, and mentors from the software industry.

Successful partnerships benefit from software grants, training, know-how, expertise, and mentors from the software industry to complement contributions from academia and industry. Graduates are more job-ready when they have experience with real-world tools. "*It's important to expose students to real tools so they are already value add when they walk in*," explains Argonne National Lab's Kristen De La Rosa. Successful partnerships also need leadership, support, and investment from government, industry, academia, and manufacturing. Manufacturers must provide resources to make these programs successful. "*One of the key success factors for STEM partnerships is getting the endorsement of people higher, whether it is industry, the academy, or government. They have to believe it's a good idea*," suggest Purdue's Nathan Hartman. Mike Howell of Greenpower puts it succinctly, "*Manufacturers need to get properly involved. That includes funding, but also allowing employees to spend time and engage with the students*."

You have to understand that there is a business value to donating products and services at a K-12 and higher education level. It will pay for itself when they get into the workforce.
Kristen De La Rosa, Argonne National Laboratory

As a final note, it's important to point out to manufacturers that investing in the future workforce is investing in their business. As Vass Theodoracatos of GM shares, "*We contribute substantial funding and volunteer resources to help impact the future STEM workforce. Through STEM funding, our goal is to help our GM communities attract students, especially underrepresented groups in the STEM areas, to increase the pool of qualified engineers for our human capital needs*." As Kristen De La Rosa of Argonne National Lab recommends, "*You have to understand that there is a business value to donating products and services at a K-12 and higher education level. It will pay for itself when they get into the workforce*." Now is the time for manufacturers to act to ensure an adequate pipeline of job-ready candidates to help support the manufacturing industry of tomorrow.

Recommendations

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

- Introduce STEM disciplines and recruit early to make technical jobs attractive and attainable
- Augment theoretical knowledge with practical, real-world problem solving and experiential learning programs
- Consider sponsoring internships, co-ops, or apprenticeships to provide practical experience and develop relationships with potential future employees
- Partner with academics, industry, government, and software vendors to develop engaging programs
- Provide real, industrial-strength processes and tools to develop a job-ready workforce
- Invest in the workforce of the future by supporting these partnerships with time, talent, and finances.

About the Author

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