Engineering Sourcing In The Global Economy : Interrelationship Between Math, Science and Pre-Engineering K-12 Education

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Abstract – As the world has become "flat" due to globalization, it is necessary for companies to be able to recruit and retain engineering talent not only from around the globe but also be able to identify talent before they become available in the workforce. Prospecting engineering talent is key for the success of the organization and ensuring the company is able to design, develop and maintain world class systems such as communications devices, transportation systems and complex national defense systems. It is necessary for enterprises to develop the framework in which allows the company to attract talent in the beginning of the "pipeline" by starting to engage with pre-engineering students at the middle school level. It is imperative for companies to develop engineering communities within the organization in which allows a seamless collaboration between academic, professional organizations and the enterprise to attract, develop and retain engineering talent : Engineering Affinity Groups.

Keywords: pre-engineering, engineering sourcing, diversity , full-pipeline, affinity groups

BACKGROUND

The world has become flat [Friedman, 2]. The flat world requires companies to be global in reach and local in presence. In this new environment it is necessary for companies to be able to recruit and retain engineering talent from not only around the globe but also be able to identify talent before they become available in the workforce. Prospecting engineering talent is key for the success of the organization and ensuring the company is able to design, develop and maintain world class systems such as communications devices, transportation systems and complex national defense systems such as Future Combat Systems. Identifying emerging engineering talent requires a framework and an architecture to ensure resources are been spent efficiently to attract engineering personnel that can solve complex problems facing the world today and in the future. Companies need not only to be able to break free geographically to sense engineering personnel and technology but also be able to sense talent locally where the company operates their engineering operations. The key is to look at the engineering recruiting system as interdependent and interrelated to the local education system. In this "flat world" it is necessary to look at primary and secondary education systems and understand the current pre-engineering programs available in the local schools districts. The education system is a complex systems such as the engineering discipline in which has many interrelated systems making up this system of systems including school vocational programs, standards, district approved curriculum and after school programs. It is necessary for companies to baseline the current programs in the school districts where their organizations operate.

The necessity to solve today's world challenges with complex systems that cannot be solved by a single engineering organization has given rise for companies the need to be able to integrate the different systems developed by different organizations around the world into a single system of systems engineering project.

It is necessary for companies to operate in three levels of global competition in the new knowledge economy [Doz, 1]. It is necessary for companies to master three different skills that includes sensing, mobilizing and be able to "compete on the operating plane" to be able to succeed in this new environment in which competition for talent is intense and fluid.

SENSING : PRE-ENGINEERING PROGRAMS

Identifying local emerging engineering talent where the company operates it is not an simple challenge. It is not necessary not only to identify pre-engineering students that has a good grasp of the fundamental disciplines such as math and science but also those that have a vocation to become engineers that are ready to tackle multi-disciplinary projects that involve also people of different cultures around the world. The task of "sensing" for this emerging talent has been historically delegated to the company community relation departments in which might loosely collaborate with the human resources college hiring departments. The task of sensing for talent should involve also the employees, specially the engineering community within the organization. It is necessary for companies to create an environment in which would allow the interaction between engineers and pre-engineering students. Companies can encourage the formation of pre-engineering programs such as Lead The Way Program by having senior management serving on state LTWP Industrial Councils while encouraging employees that are members of professional organizations such as SWE (Society of Women Engineers), INCOSE (International Council of Systems Engineers), NSBE (National Society of Black Engineers) and NSHPE (National Society of Hispanic Professional Engineers) to become involved with the program by volunteering their time to speak to students on LTWP program about engineering and engineering professions. In the sensing role, it is necessary for corporation to help the youth to identify their weakness and strengths and help the school districts to have well rounded programs that can be foundation for students with affinity to engineering to develop into professional careers in the near future. Another way to be able to "sense" for engineering talent and knowledge is to participate on internship and job shadow programs that encompass the full K-12 education life cycle that not only encompass the high school students but also middle school. A new movement in the education system is the Big Picture Schools. In the St. Louis school district the three schools part of this program includes : Elementary - Des Peres (1st to 6th), Middle - Turner (7th to 8th) and High School - Kottmeyer (9th - 12th). The average rate data across the network of school in this programs includes : 94% attendance , 2% drop out, 99% graduates accepted to college. A key part of the program is the strong partnership between the schools and the community. High School students spend 2 days a week on internship opportunities where they gain important experiential experience while middle school students have opportunities for job shadows which enable them to identify their professional vocation. In the lower grades such as elementary students have opportunities to take tours of places that could eventually be their place of work in the future.

MOBILIZING : VOCATION AFTER SCHOOL PROGRAMS

As the engineers of today work with classroom teachers to identify the engineers of tomorrow, it is necessary that the Industry assist schools districts to provide mobilizing after school programs that not only enable students to develop their leadership and technical skills but also allow them to develop short-term visions in which includes pursuing a higher education in engineering. FIRST Robotics stands For Inspiration and Recognition of Science Technology. The vision for the organization is "To create a world where science and technology are celebrated...where young people dream of becoming science and technology heroes". FIRST organizes regional competitions where teams design and develop a robot in 6 weeks to compete on the competition. It provides the environment in which helps students to find their vocation and inspire them to pursue careers in math and science such as engineering. Companies can help this mobilizing effort and also help enable pre-engineering students to consider their company for future employment by providing an environment that encourage their employees to be mentors on teams. On the enterprise level companies can sponsors regional competition. In these regional competitions teams comprised of students, engineers mentors from the industry and teachers as team coaches are able to work in collaboration with a common vision that is to design and built the best robot that can accomplish a given goal. In this type of framework, students not only are able to use their skills learned on Industrial Art classes such as woodshop but they are also able to use skills learned from their engineering mentors such as doing trade studies, identifying requirements and implementing an engineering design within a budget and time constraint. The FIRST Robotics program is an sport program where students learn how to design complex engineering designs with the mentoring of real engineering professionals. This provides at a critical juncture real-world professional experience to the students where they are able to compete on the global stage. As of 2007 there is 37 regional competition events around the world with teams from Brazil, Canada, Israel, Mexico, Netherlands, U.K and U.S

participating. Although the robot is built in 6 weeks from a common kit of parts provided by FIRST, it gets the students, teachers and engineering community engaged thru the year. This program is scalable and organized to take advantage of the new reality in which the world is "flat". As of 2007 there has been 130,000 students, 10,713 robots and 37,000 mentors participating in this program in which engages students to pursue careers in math and science. It is critical that engineering companies engage and mobilize this emerging talent to remain competitive on the global stage.

FULL PIPELINE STRATEGY

As companies operate on the sensing and mobilizing plane to actively seek and develop pre-engineering students, it is necessary to understand the lifecycle development of an engineer. The emergence of complex projects that cannot be accomplished by a single discipline or organization has given rise to a new engineering discipline commonly known as systems engineering (SE). An academic definition of system engineering is that it is "a multidisciplinary application of analytical mathematical and scientific principles to formulating, selecting, and developing a solution that has acceptable risk, satisfied user operational need(s), and minimized development life cycle costs while balancing stakeholder interests". Unlike electrical, mechanical and many other engineering disciplines, SE is a new discipline where many of the practitioners comes from the industry where their experience and not background education has qualified them as systems engineers. Many SE practitioners believe that you cannot become a good SE without relevant working experience. The current challenge is to identify those practitioners on traditional disciplines and give them the training to become
Systems Engineers. There are currently 11 Bachelors, 27 Masters and 10 PHD programs around the world which are Systems-Engineering-Centric programs around the world [Fabrycky, 3]. It is necessary to get students interest in engineering, especially systems engineering early on when they are thinking about careers. It is necessary to have a pre-engineering program in middle schools that align with high school and higher learning institutions. The idea is that we need to develop a "full-pipeline" for educating engineering students starting at the middle school is a paradigm shared by many in the industry. As the current need at engineering organizations for systems engineers is great, companies working in partnership with educational institutions have been working hard in the development of educational training for those that already have an engineering degree and that wish to gain greater knowledge in systems engineering. The current approach can benefit companies in the short-term but creates a bottle neck in the long term as there is not enough bachelors programs targeted toward those in High School that would pursue a career in systems engineering. Once those with many years of engineering experience no longer needs to enroll on a master/PH.D program due to retirement or other reasons from the workforce, there will be a challenge to keep all those programs without a foundation support from a bachelors and pre-engineering program. This issue will probably be more prominent to engineering companies based in countries where the majority of undergraduate students do not pursue an undergraduate degree related to math, science or engineering.

CURRENT TRENDS

This new environment where the key is to capture "new knowledge emerging all over the world", companies can look for talent at anytime and anywhere. This competition for talent has put pressure on Universities to attract and retain students to their engineering program and in turn fueling an engineering graduating shortage. In one study it has been reported that Massachusetts colleges and universities have seen a drop of 7.2% of enrollment of foreign students [Weisman, 4]. The main concern is that the pipeline is not getting filled by local students, putting programs in jeopardy of been viable in the long turn. As companies are forced to open new research and engineering operations near where the knowledge is available, it will be inevitable that it will impact the growth of their engineering operations at home and making it more dependable on their operations that is dispersed around the world.

OPERATIONS : ENGINEERING AFFINITY GROUPS

The key is for enterprises to be able to attract, develop and retain a skilled engineering workforce which is organic in the sense the workforce is sensed , mobilized and operational locally but part of a system in which is global in reach. It is necessary for enterprises to develop the framework in which allows the company to attract talent in the beginning of the "pipeline" by starting to engage with pre-engineering students at the middle school level. It is imperative for companies to develop engineering communities within the organization in which allows a seamless collaboration between academic, professional organizations and the enterprise to attract, develop and retain engineering talent.   The key to create the relationships with external organizations to be able to be effective in supporting a pre-engineering development strategy. Engineering Affinity groups provides the framework in which allows the formation of such groups. Affinity groups is a organization model that allows autonomous operation within the enterprise in which is coordinated and interdependent. It is a systems of systems that is clustered within the organization with the specific task of developing the engineering workforce, specially by been involved with the community at large in the development of pre-engineering students. Enterprises that are able to be engaged on pre-engineering programs such as Lead The Way and FIRST Robotics thru employees involvement on an Engineering Affinity Group will be the ones leading in innovation and assuring long term success for the enterprise. The challenge of ensuring the enterprise has the best engineering talent relies in looking at from a system thinking perspective where the issue is looked holistically thru the lifecycle of the challenge and not as a piece-meal problem to be tackled in the short term.

Affinity Groups allows individuals with similar backgrounds and or interest to be able to relate to each other [Warren, 5]. It is necessary to create an organization structure that allows employees to be involved by attending events coordinated by the group, volunteering to outreach events sponsored by the affinity group or running for office. This type of organization allows engagement by the employees while at the same time allowing employees efforts to be aligned within the enterprise strategic goals. Although the involvement of employees is sponsored by the enterprise, the participation is volunteer and it is structured in a way that allows different levels of involvement from the employees from just attending a speaking engagement by another fellow engineer on Engineering Week to provide the opportunity to mentor a FIRST Robotics Team. The key is to ensure this initiative is well integrated with the overall company and that it has support from the senior executives. It is necessary to look across other industries to see what type of initiatives can be implemented in conjunction with affinity groups to help develop communities.

A good industry to look is the healthcare industry where they have the need to identify, develop and retain healthcare professionals. Professionals such as doctors and nurses are also in shortage and hard to recruit the same way it is hard for engineering companies to recruit and retain engineering staff. Barnes-Jewish Hospital in St. Louis, MO has created a Center for Diversity and Cultural Competence. The center was created in collaboration with the Barnes-Jewish Hospital Foundation in which funded $1.56 million to make the center a reality. One of the center initiatives is to develop programs for middle school, high school and college students to expose them to health care and science careers. The center takes a "full-pipeline" approach by looking at professionals in K-12 thru their outreach program while also overseeing activities that promote recruitment and retention of a multi-cultural staff. The key in this global environment is to understand the diversity within the organization and also understand how that it relates to the customer. The center helps to look it as a holistic way by "Promote diversity and cultural competence initiatives and programs throughout the hospital, Washington University Medical Center and the St. Louis community". Engineering companies that look at example such as the Barnes-Jewish Hospital diversity initiative will be able to develop communities that will allow for the recruiting, development and retention of a strong engineering staff. It is necessary to approach the challenge from a holistic perspective while looking it as an issue that encompass the lifecycle of the development of an engineer from "conception" to "retirement". Companies that fail to see it as a "pipeline" issue will encounter bottlenecks in the development of their staff that could impair their growth or make it inefficient as an organization. The development of engineering staff is a organic process that needs to start when individuals are finding their vocations, and that starts in the middle school. It is in middle school that we are more likely to learn a new skill with ease. It is also the time when we might not have as much responsibilities as compared to adulthood, making it easier for K-12 students to focus on certain things such as their vocation in which can be the building block for their future careers.

SUMMARY

It is necessary for professional engineers in the industry to be involved and engaged with the education community where they live and work. As the engineers of today work with classroom teachers to identify the engineers of tomorrow, it is necessary that the Industry assist schools districts to provide mobilizing after school programs that not only enable students to develop their leadership and technical skills but also allow them to develop short-term visions in which includes pursuing a higher education in engineering.

The key is for organizations to engage their workforce is to attract, develop and retain a skilled engineering workforce which is organic in the sense the workforce is sensed, mobilized and operational locally but part of a system in which is global in reach. It is necessary for enterprises to develop the framework in which allows the company to attract talent in the beginning of the "pipeline" by starting to engage with pre-engineering students at the middle school level. It is imperative for companies to develop engineering communities within the organization in which allows a seamless collaboration between academic, professional organizations and the enterprise to attract, develop and retain engineering talent. The key to create the relationships with external organizations to be able to be effective in supporting a pre-engineering development strategy. Engineering Affinity groups provides the framework in which allows the formation of such groups. Affinity groups is a organization model that allows autonomous operation within the enterprise in which is coordinated and interdependent. It is a systems of systems that is clustered within the organization with the specific task of developing the engineering workforce, specially by been involved with the community at large in the development of pre-engineering students

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