Developing K-16 Pre-Engineer Learning Communities Through Mentoring: Interrelationship Between Higher Learning Organizations, Industry, After-School Robotics Competition and Pre-Engineering K-12 education.

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Abstract – Mentoring is a key developmental tool for pre-engineer students that will eventually be in the workforce creating, designing, testing and developing complex engineering projects. Developing a framework for mentoring will help successfully transition more students from higher learning into the workforce. The success of mentoring programs hinges on the ability of companies to develop the organization engineering mentoring skills thru training and giving opportunities for the employees to engage with students thru after-school programs such as robotics competitions. STEM (Science, Technology, Engineering and Mathematics) activities geared toward students enable engagement of mentors from industry and higher learning institutions to work with K-12 students. The engagement between adult mentors and student protégés allows mentors to develop their engineering and leadership skills while giving back to the community.

Keywords: pre-engineering, engineering sourcing, diversity, full-pipeline, mentoring, robotics, systems engineering.

BACKGROUND

Mentoring is a key developmental tool for pre-engineer students that will eventually be in the workforce creating, designing, testing and developing complex engineering projects. A mentoring relationship allows mentors to share their real-life experiences with protégés. The sharing of experience will help the student transition from higher learning institution to the workforce. Due to advances in technology (such as the internet) mentoring is not something that can only be achieved ”face to face”. Instead, due to globalization or as some call the “flattening of the world” [Friedman], a successful mentoring environment replicates a relevant industrial environment. A mentoring relationship needs to be nurtured and monitored. Developing a collaborative environment between academia and industry can make a positive impact in the lives of pre-engineering students. Learning Communities provide an opportunity for students and engineers to share interests, interact, learn and become involved. Mentors from industry can provide real-life experience and positive role modeling to engineering students. A Mentoring/Protégé relationship can strengthens the organization by developing the technical and leadership skills of the Mentor. This allows the engineering mentor to be engaged within the community in which the employer operates. The success of mentoring programs hinges on the ability of companies to develop the organization engineering mentoring skills thru training and giving opportunities for the employees to engage with students thru after-school programs such as after-school robotics competitions. Robotics competitions geared toward high school and middle school students enable not only the engagement of mentors from industry but also mentors from higher learning institutions that wish to either be engaged for the first time or give back to the community while continuing to develop their engineering and leadership skills. The key is to develop a framework in which allows “leaders to teach leaders” where not only the mentee is able to grow but also the mentor.

DEVELOPING THE MENTORING FRAMEWORK

Traditionally mentoring has been thought as something that happens privately- "one on one". This type of traditional mentoring can be limiting especially in the case between a pre-engineering student mentee and a mentor from industry where there is not a supportive environment which allows for a natural and a smooth flow of interaction. The key issue of a traditional environment is that there is no "common" framework in which both the mentor and student are able to mutually understand and be able to connect aside from background factors. For example, a mentor is an alumnus from the school the student is attending be it middle school, high school or college.

A lack of a common framework is further exacerbated by the fact that a pre-engineering student usually does not share the same background as the mentor to which they are assigned. Developing a framework where the student can have multiple mentors throughout their pre-engineering experience will increase the probability that their overall experience is good. Input from multiple mentors will diversify the experience and knowledge of the protégé. Technology moves such at a fast pace that some tools learned by a professional engineer are no longer relevant to engineering students today. One example is software programming. Engineers have learned how to program using programming languages as C or BASIC a couple decades ago. Although this type of experience have been fundamental for the professional engineer to learn at first before they are able to learn today's programming languages such as graphical programming, it is not necessary to try to share this type of experience with today's youth since this type of knowledge might not be engaging or relevant to the youth. National Instruments website has training material for students that wish to learn programming using software like Labview on embedded platforms like cRIO. These tools are exactly the same tools used by engineers today to develop mission-critical systems or industrial robots. Mentors should relate experiences that pre-engineering students can use today. The engagement of mentors and mentee on robotics competitions such as BEST (Boosting Engineering, Science, and Technology and FIRST (For Inspiration and Recognition of Science and Technology) robotics allows the development of a mentor-mentee relationship that is supportive and relevant both to professional engineers and pre-engineering students alike.

LEADERSHIP DEVELOPMENT

Mentoring is an opportunity to develop leaders in industry and education [Sosik 3]. The main goal of a mentoring program is to partner industry and education in the development of leadership. To ensure success, mentors must be trained and "certified" before they are allowed to mentor pre-engineering students. Thus ensuring the relationship has a good foundation and can foster a relationship that is sustainable and replicable among mentoring leadership.

FIRST and BEST are two great examples of safe learning environments for both mentors and prospective engineering students. In these programs students are given a "kit" of parts and a certain budget to purchase additional parts as well as a given timeline in which to complete a given task. Replicating this experience for the mentors ahead of time, can familiarize the mentors with potential technical issues as well as help them to better understand the point of view of the students. The key is to develop a framework within the organization where employees have the same opportunity to develop a robot which will closely match the environment for the students they will mentor. There is an opportunity for organizations to sponsor the development of a "demo robot" that uses the same kit of parts that the students use and have it developed by volunteers within the company facilities.

A demo robot developed by company employees allows employees to become better prospective mentors to students by providing a learning experience that closely matches the one that the students will complete. The

primary goal is to provide an environment that develops leadership within the organization. A secondary goal is to increase awareness of robotics and mentoring opportunities within the company.

TEAM MENTORING: DEVELOPING THE ORGANIZATION

Mentoring occurs when the appropriate environment is established. An environment of trust is key to the development of a mentoring relationship. An environment that closely mimics the high school student environment including a group of around 30 students, one coach and a core team of industry mentors that provide technical and leadership guidance to the team is essential. Team development is not something that happens overnight, it is necessary to have careful planning in developing a strategy. Today's professionals face many challenges not only in the sense of developing their career for the long-term but also prioritizing their work load while maintaining a work-life balance. The engagement of professionals on a volunteer project needs to take in consideration the professional priorities and also their level of commitment to a worthy cause.

Mentors that want to develop a mentor community within the organization need to take into account the company policies in regards to company sponsored volunteering opportunities. A learning community which not only complies with the enterprise policy but also fits the company strategy and overall long-term goals is able to build long-term relationships within the company. The key is to be able to engage a diverse section of the enterprise employees. Employees are likely to volunteer their time to be part of a mentoring community if the opportunity to join the project is advertised thru a variety of communication channels. Team diversity can be ensured by keeping the fundamental message and mechanics the same regardless if you are trying to recruit engineers to volunteer their time to join the team, or estimators from a business background to be involved in building a demo robot. The use of tools, such as an electronic survey, allows an easy way to engage employee's interest while collecting vital information such as the time commitment preference.

MATCHING MENTOR INTEREST WITH PROJECT NEED

Employee availability is one aspect that needs to be taken into consideration when identifying opportunities to get professionals involved on a volunteer project. Other elements to be taken into consideration are the goals and objectives of the given individuals. Employees will volunteer for this type of a project for a myriad of different reasons including:

- Opportunity to learn a new skill.
- Gain experience in a diverse environment
- Be part of a dynamic team without the necessity to change jobs or assignments.
- Career Advancement – Part of Business Objectives and Goals.
- Give back to the community
- Get a Free Shirt

COMMUNICATION PLAN

Projects that depend on volunteers for implementation and leadership should have a well developed "communication plan" to ensure the project viability. In the short-term, it is necessary to engage employees before the project is approved and ready to commence. Voluntary projects tend to get a lot interest from volunteers in the

beginning of the project, but employee engagement starts to dwindle as employees begin to loose interest or have a change of priorities both at work and at home. A detailed communication plan needs to be flexible and also be able to "disseminate" the opportunity to a wide variety of communication channels including company internal newsletters, website and company sponsored lunch 'n' learns. A message that is inclusive in the sense it welcomes all employees to be engaged while giving a sense that the projects needs a specific skill from a given individual to ensure the project is successful will allow the greatest level of engagement within the organization. Communication to the team needs to be constant but within the constraints of company policies to ensure that resources such as e-mail are been used wisely and within the enterprise policies. E-mail is a traditional form of communication in corporations and understanding the benefits of using this form of communication along with its limitations within the corporate framework allows for a success. Project leaders can use e-mail to communicate the current status of the project along opportunities for volunteers to get involved. The key is for project leaders to develop a communication plan that enables relationship building between team members and the leadership. Team building needs to occur early on the project and continue thru the lifecycle of the robot building project while employees are engaged on robot design and development. A communication plan allows for team building to occur while ensuring that team members feel that they are receiving regular project updates is essential for team mentoring development.

CO-OP / INTERN ENGAGEMENT

The purpose of building a robot using the same kit that high school kids use for competition is not only to enable employees to get real-life experience but also enable to engage college students. Voluntary projects should be inclusive:not only engage full-time employees but also temporary employees such as co-ops and interns. Project leaders should coordinate with the company HR department responsible for these programs and insure that project the project communication plan encompasses opportunities to engage seasonal employees in the organization. Many organizations have a new employee orientation specific for co-op and interns. This is a good opportunity for the project leaders to spend 5 to 10 minutes talking about the project and invite everyone to tour the facilities where the robot is being built. Engagement thru project tours is a good way not only to bring awareness of the project to possible team members but also enable current team members to be engaged.

Project tours allows team members that would otherwise not have been engaged, to be engaged by giving them an opportunity to act as "tour guides" and be able to sell the project to prospective members. Due to the seasonal nature of co-op/intern employment, it is necessary to identify activities that can be accomplished in a short-time period while being of benefit not only to the individual but also to the project. Project leaders should organize the project schedule to work with the co-op / intern schedule. Matching the current project phase with the schedule of the temporary employee schedule is essential to the project success. Internships are usually in the summer from May to beginning of August, "enrolling" interns early on in the project allows to make them feel comfortable enough to interact with the members that have been part of the team since conception. Involving temporary employees on the project allow them an opportunity to network with and build a relationship with existing employees while finding out more about work opportunities within the company.

The concept of team integration is a concept seen often on high school robotic teams where students get engaged on the project at different times and with different level of involvement thru their robot building cycle due to competing priorities such as other after-school activities and sports. Students might be interested in helping out the team in fundraising in October but not able to be involved with the team in the beginning of the year due to other commitments. Co-Ops and Interns that might be working full-time while taking classes in the summer while trying to deal with the experiences of holding a full-time job for the first time while still trying to experience the college experience might have the same experience as High School Students participating on after-school activity such as a robotics team. A benefit of having co-ops and interns on the team includes that it adds diversity and enthusiasm to the team but also those individuals can become crucial ambassadors for the company once they return to campus and share with their classmates their experience participation on a robotics team. A company that sponsors building a demo robot as an after-work project is not only helping build the technical and leadership skills of its employees but developing a good framework to attract new employees that will not only have the academic background to succeed in the company but hands-on experience in working in teams within the organization.

PROJECT ESTIMATING

Robotics teams need to raise money to compete and be a viable team. Expenses could be nominal such as snacks for the team when they meet or extensive such as travel expenses to the competition venue. The cost of a corporate robotics team can be even larger once it is considered the time resources necessary to acquire the necessary commitment from the organization to have a corporate robotics team that will build a demo robot to bring awareness of Science, Technology, engineering and Mathematics (STEM) within the organization and in the community where the organization operates. The success of a community relations project will depend on the support within the organization and if it is deemed such a project is worthwhile and it engages a broad enough section of employees. A business case will have to be developed which explain the current situation and what will be the value of implementing such a project in a way that can be measured. Estimating the cost of such a project might be difficult if there is not a solid methodology. Historical data will be needed to substantiate the cost of such endeavor. Project leaders should identify the methodology and be able to summarize the data in a concise effort making it portable enough to add to a presentation to prospective project sponsors within the organization.

EXECUTIVE SPONSOR ENGAGEMENT

The current state of the global economy makes it more than ever necessary not only to have a project that can show a good Return On Investment (ROI) but to have a project champion that can help the team overcome roadblocks. A feasible company robotics team should not only have leaders, members and mentors but also an executive sponsor. Company executives usually have many commitments not only within the company but outside; it is not uncommon to see company executives serving on boards of other organizations. It is incumbent to project leaders to develop a business case that can be taken to company executives and be able to be reviewed in no more than 15 minutes. Many student led robotics teams do presentations to service organizations and chamber of commerce meetings with the goal to get sponsors within the community, those presentations consists usually of 5-6 electronics slides projected on the screen. This is a good proposal format that can be modified to fit the corporate setting within the organization. The process of engaging an executive can be time consuming and it is necessary to have a good strategy and account it on the timeline of the project. The first step is to be able to make an appointment to meet with a prospective project sponsor and get a commitment to sponsor the project, sometimes the executive might not be a good fit at given circumstances but she or he would be willing to review the proposal and give feedback that can be valuable in developing a solid proposal.

EXPERIENTIAL LEARNING COMMUNITIES

As the engineers of today work in building demo robots to bring awareness of STEM in the community and within the organization, it is necessary to understand that the development of engineers that can serve as mentor for robotics teams needs to happen in a community environment. It cannot happen in a vacuum or in an environment which does not reflect the environment faced by K-12 students who participate on robotics competition and look for industry mentors for guidance. Mentors need to be given an opportunity to participate in authentic learning environments within their organizations in which mostly closely mimic the environment in which they will face when they become team mentor for student led robotics teams. An experiential learning community allows the formation of a “team” that has a goal and purpose while having a semi-flexible structure allowing a collegiate environment to thrive. This type of environment allows for mentors, prospective mentors, executives, employees with children participating in robots competition and many other individuals to become involved in a way that does not interfere with their other business and personal commitments. The project of build a demo robot provides the experience necessary for mentors to understand the engineering process that students goes thru while the purpose of doing demos using the robot allows the development of an authentic community in which is engaged and which is flexible enough to welcome any new members at anytime of the project phase.

SUMMARY

In the fast pace of the internet age where ideas are now a commodity, professionals need to be engaged real-time with pre-engineering students that are gaining tremendously valuable engineering experience before going to a higher learning institution by participation on robotics competition. Professionals that want to give back to the community need to have the relevant skills and authentic experience necessary to be able to effectively mentor student led robotics team. This experience can be obtained by participating in an experiential learning community where individuals of different background, experiences and skill levels work together toward a common goal such as building a demo robot with the support of their company. An experiential learning community allows the formation of a "team" that has a goal and purpose while having a semi-flexible structure allowing a collegiate environment to thrive. The success of an experiential learning community hinges on the ability of companies to develop the organization engineering mentoring skills thru training and providing opportunities for the employees to engage with students thru after-school programs such as after-school robotics competitions. Robotics competitions geared toward high school and middle school students enable not only the engagement of mentors from industry but also mentors from higher learning institutions that wish to either be engaged for the first time or give back to the community while continuing to develop their engineering and leadership skills.

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