Developing K-12 Pre-Engineering Curriculum Through: Interrelationship Between Higher Learning Organizations, Industry, After-School Robotics Competition and Teacher Professional Organizations.

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Abstract – STEM (Science, Technology, Engineering and Mathematics) education for the future does not only includes textbook learning but also relevant experience gained from participating on activities such as high school after-school robotics competition. A company sponsored robotics club in partnership with a local teaching association works together to develop training material for teachers engaged in coaching after-school robotics competition teams. The training material developed in collaboration with industry and educational institutions can be delivered either online at a self-paced mode or as part of teacher training in chunks that can be delivered interpedently covering topics such as how to identify good industry mentors for the teams to technical topics such as how the engineering process in the industry might differ from engineering process taught in the middle school, high school or at a higher learning institution. The creation of teaching modules includes a variety of media including video clips of those involved in robotics competition addressing different topics addressed on a given module. The key to education in 2016 is the delivery of content that is pulled instead of pushed to those that consume new learning materials.

Keywords: pre-engineering, interactive media, full-pipeline, curriculum development, robotics, systems engineering.

BACKGROUND

In today's environment where diversity of thought and experience is a key component to ensure engineering competitive edge, the material to create the next generation of curriculum to educate the Engineering Educator of 2016 it is not solely on education textbooks but it also includes the experience of students , mentors, teachers and higher learning faculty that participated on after-school that focused on STEM (Science, Technology, Engineering and Mathematics) activities such as high school after-school robotics competition. A company sponsored robotics club in partnership with a local teaching association works together to develop training material for teachers engaged in coaching after-school robotics competition teams. The training material is developed in collaboration with practicing engineers, mentors, teachers , faculty and students who are engaged in real-time engineering activities on a daily basis. The material to be developed should engage the learner, develop a sense of community within the learner and ultimately the video should be able to instruct the learner on a new skill or process. The creation of 3 distinctive teaching modules allow for learners to be engaged progressively as they become more engaged in their learning process and their involvement . The key to education in 2016 is the delivery of content that is pulled instead of pushed to those that consume new learning materials. Materials that can be produced natively within the learning community allows for a sense of ownership and engagement within the learning community.

SITUATION

Traditionally curriculum has been developed in which is consumed linearly by the students and which involved the student to check periodically for understanding. This type of traditional learning can be limiting in the sense that today's engineering environment has changed from the past in the sense that the problems to be solved do not exist in a well defined boundary such as a quadratic mathematical equation but they are part of an ecosystems in which requires not only an understanding of theory but experience to understand the nuances of the problems to be solved. The key issue of a traditional curriculum is that the problem is not within a context . For example a unit about frictional force does not account for how much potential energy in a battery is necessary to power a given motor to make a vehicle to go forward without skidding. It is necessary that the curriculum of the future not only include real life examples in which many good textbooks already include but also share experiences from professionals that has tackled the given problem. Also today's problem has many solutions and the right solutions is the "balanced solution" given factors such as time and money allocated to solve such a problem. In the past providing this type of learning to the student required bringing a professional from the industry to share his or her experience. The curriculum of the future should include 3 types of videos as shown on Figure 1 : demonstration videos , learning community status videos and learning modules video.

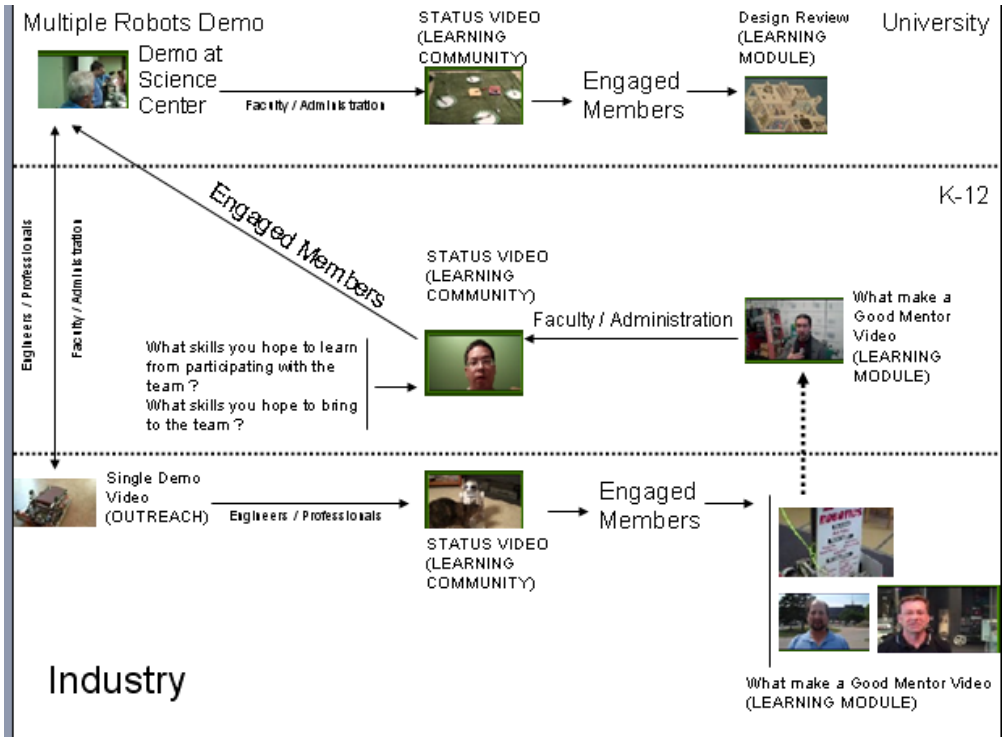

FIGURE 1 : VIDEO CATEGORIES

Demonstration videos are videos that show the outcome of the learning such as working robots to individuals within an organization that are thinking in becoming involved , while learning community status videos shows individuals already engaged such as professionals, faculty, teams leaders describing their community and the

engagement of given community. The last category of video is the learning module videos that teach a technical or a soft skill to those new in the learning community that just have become engaged in the learning process.

CHALLENGES

There are many challenges in trying to bring practicing engineers to the classroom to enable of sharing of their experience with the students. The issue is not the desire for professionals to make a contribution to the education of the youth who will become the professionals of tomorrow, rather is physical barriers such as geographical location differences between where the employee is located and where the education institution has a need, the temporal availability of the practicing professional against the school schedule and calendar , and also the background differences between professionals and students.

Geographical barriers is one of the greatest challenges facing some teachers wanting to bring industry experience to the classroom. Although having a practicing engineer to come speak at his lunchtime to a group of students enrolled on a pre-engineering program may not seem an issue for schools within a 10 miles of the workplace, it is a specially daunting task for teachers where the school is not located close by areas where engineers practice their trade. An example would be an institution located in Carbondale, IL which provides education to adolescents and young adults with complex learning disability that has a robotics curriculum. It might not seem feasible to ask a robotics engineer in St. Louis, MO which is more than 2 hours away to come and visit with the students during the school year, but using video clips and on-line surveys is possible to have the professional take a half-day out of their schedule for an initial visit, and do follow-ups by using video clips produced using a low-cost camera and uploaded for viewing using free internet media sharing websites.

Although the school calendar year is very predictable with the exception of snow days, the schedule of a professional engineer can be dynamic and unpredictable due to the nature of the industry and also changing personal and professional priorities of the individual. It is also necessary to understand that educators are faced with many daily challenges in the classroom while at the same time asked to cover a certain amount of curriculum, making it more of a challenge for teachers to integrate “professional visitors” into their curriculum in a way that fits perfectly with the schedule of the professional engineer willing to come visit the classroom to speak with the students. Videos allows professionals to record their experiences and teachings that can be not only accessed at anytime but also in a manner most appropriate deemed by the teacher that fits with the curriculum currently been covered. An example would be a Community College Professor that teaches an Engineering Overview Class and which invites engineers from Professional Organizations to speak at both of his classes that he teaches. Instead of trying to coordinate 3 engineers from the same professional organization for a panel discussion, the professor can invite one engineer to make a presentation and also bring video from his colleagues talking about engineering process topics such as “Trade Studies”.

Video Clips can be incorporated into learning modules in which allows professionals not only to bring their experiences to the classroom like showing them working in solving a particular engineering problem but also bring to the classroom the experience of their peers. To engage students, it is necessary for them to experience leadership that is inspirational, talented, shared and committed (Habrowski). The same way President Barack Obama continues to inspires many students by having his September 8, 2009 remarks directed toward K-12 students available on video and uploaded on the White House website. Many engineers specially engineers in senior leadership of their organization can inspire and share their talents by having their remarks featured in a video clip and shared. A example would an engineer that is mentor for a rookie high school robotics team that comes to address students and parents on a pre-season kickoff. The mentor can go to a professional organization website which it’s mission is to mentor students in robotics, and video stream a previously recorded video from a fellow Field Engineer in which answers the questions why robotics competitions are important and what makes a good mentor. The viewer can then use the video as a baseline to produce a video in which the mentors for the given team can share their own insights of what they believe makes a good mentor and share the video with the students. This category of video enables to provide a learning to the students and enables the student to get “exposure” to professionals and university students early in the learning process.

INDUSTRY AND HIGHER EDUCATION IMPLEMENTATION

Video clips can be very useful to show to students involved with robotics competitions the process used by professionals to design, develop, manufacture and test a robot. The video clip should show processes such as engineering brainstorming is done in a way K-12 students can replicate the same process. The process to be documented should not only be carefully selected but also the video should be done in an environment in which the production period the video clip is short and not much resource is necessary other than a low-cost video camera. An example would be filming the "design review process" that a team of university students goes thru in a senior design class. The senior design experience at the Department of Electrical Engineering of St. Louis University includes a preliminary design review, a critical design review and also a final design review (Roobik). These three engineering design review process are the same processes that many professional engineers go thru when developing engineering solutions. The advantages of producing a video of design review process done by a team of university students includes ease access to projects with a given well bounded schedule, the process will more likely be more realistic for K-12 students to follow rather than process from the industry that might be particular to a given sector and also proprietary to a given company and finally the opportunity for industry and high education institutions to collaborate on interactive media development. Videos can be interactive by including a link to an electronic survey in which students can provide feedback or information. An example would be after the students watch a video on teamwork, they can provide feedback on the skills they hope to contribute to the team and also skills they hope to learn. Table 1 shows the response from a robotics team in Carbondale,IL . This type of videos allows the building of learning communities between K-12 and mentoring organizations.

What skills you hope to learn from participating with the team ?	What skills you hope to bring to the team ?
I hope to learn how to program a robot and make it move. I also would like to learn how to construct a robot so that it works properly on what i want it to do. I also hope to learn how to work better in team work and how to communicate my ideas to the team so that they understand what I am trying to say.	I hope to bring my knowledge on construction and design. I also hope to bring my creativity and my knowledge on programming. I also hope to bring my work ethic and helpfulness.
I would like to learn a lot about mechanics and electronics. Teamwork in a real life situation is also something that I value as a skill.	I would like to share my leadership, ideas, teamwork, attitude, and mechanical knowledge.
I hope to learn more about building robots and working more with a group.	I feel like I can help by taking photos and also helping with the building of the robot.
perseverance, programming skills, and just having fun while making robots.	knowledge and enthusiasm
I hope to learn skills related to: Engineering; mechanical and others, and design, as well as building stuff too. In other words the actual physical process.	I hope to bring to the team an intellect to be reckoned with, and a will to learn that is thirsting for knowledge as ever. I also hope to bring to the team a great ability to plan, design, and brainstorm for problems at hand, specifically these.
leadership skills, more knowledge and skill in mechanics, electrics and programming. anything else is a bonus	determination, passion, willing to learn, computer skills, not to mention past experience from robotics.

TABLE 1: LEARNING COMMUNITY STATUS VIDEO STUDENTS RESPONSES

Learning Communities are established by engaging the industry and higher education to engage on a common goal and be able to document this engagement thru the use of video clips. This type of videos allows the building of learning communities between K-12 and mentoring organizations. The use of video clips should be used within a curriculum context and not as a stand alone entity. Special thought should be given when developing and deploying video clips and ensuring it fits within the curriculum framework and allow 2-way communication between the different learning communities in which make up the larger learning community which encompasses higher learning organizations, industry, after school robotics competition and teacher professional organizations.

VIDEO PRODUCTION FRAMEWORK

Engineering education and curriculum in a K-12 environment can be done in different venues. It is necessary to understand which of those venues will be targeted before producing videos and the framework to distribute them. Engineering curriculum which usually take form of pre-engineering curriculum in high schools, middle schools and elementary schools will usually fall under a STEM outreach effort. It can include " technology education curriculum through a co-curricular STEM-related club, or a combination of both" (Kressly). Videos should complement already developed curriculum and be developed in a way that uses the framework already in existence, an example would be schools that have robotics competition teams would benefit of a video geared toward teachers on what are the qualities of a good mentor, instead of a video of an engineer showing how to evaluate different embedded systems for robotic platforms given the fact that most K-12 robotics competitions does not allow teams to use a different embedded system than the one provided to the team as part of a kit.

VIDEO DEPLOYMENT

The 2016 Engineering Professoriate will not only have to be able to cover engineering theory but be able to demonstrate the implementation thru theory using media technology such as video clips in which shows professional engineers putting theory into use to solve real world problems. Another challenge will be able to deploy in a way that those seeking the information is able to access given the large amount of engineering curriculum available on the internet. Today's student are able to access a variety of video courses thru the internet for free from many renowned engineering education institutions. Engineering curriculum has become a commodity, where the premium is how the information is delivered and how much the learner want to invest to have the material available for consumption . A song today from a popular musician can be listened for free on the internet, bought over a retail store as part of a CD, or listened in live on a concert. The same way that music has different commercial value depending on the platform is been derived, curriculum marketability will also depend on the platform and support systems available with the given material. It will be necessary to use "video clips" to market the curriculum and be able to use it to generate demand for the engineering curriculum such as K-12 Robotics. The goal is to develop a curriculum that in the end reach out to engineers that would like to become engaged as mentors for high school teams engaged in robotics competition.

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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