AC 2011-808: PROVIDING OPPORTUNITIES FOR HIGH SCHOOL COMPETITION TEAM: US FIRST ROBOTIC COMPETITION INITIATIVE FOR HOME SCHOOLED STUDENTS

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Terence is the Engineering Science 2+2 Program Chair for Central Piedmont Community College in the Engineering Technologies Division. His main interest is spending time with his family and making sure he is the best dad and husband he can be. Outside his family his working interests include but not limited to: creating opportunities for student innovation, K-12 Engineering Education, and Service-Learning. He believes in growing leaders through Engineering Education. All projects, which Dr. Fagan is a part of, contain either one or more of these categories. Please email him at terence.fagan@cpcc.edu if you want any more information or interested in collaborating on a project or two.

Gerald D. Holt, Project Lead The Way

Gerald Holt began his career as an engineer with Schlumberger in 1991. Among his responsibilities the experience of mentoring junior engineers sparked a passion for teaching, prompting him to leave the Petroleum industry after a nearly a decade to pursue a career focused on education.

Following that passion of inspiring students, Gerald introduced and taught several Project Lead The Way (PLTW) engineering classes to high school students in Charlotte, NC. Through his leadership the pre-engineering program grew quickly at that school and throughout Charlotte schools. Gerald further fostered student achievement by establishing and leading the inaugural FIRST Robotics team in Charlotte to compete in the FIRST Robotics Challenge (FRC). His work was recognized by PLTW, and he accepted the position of Associate Director of Curriculum for Engineering in 2009 to serve a nationwide network of students. Since then he has been part of the PLTW team, developing and supporting curriculum for a nationwide network of over 4,000 schools.

His direct student mentoring continues today. Home school, private, and public school students are provided a unique experience to compete on a FRC team based at the Central Piedmont Community College (CPCC) through his collaboration to innovate a unique FRC team model.

Providing Opportunities for High School Competition Teams: US FIRST Robotic Competition Initiative for Home Schooled Students

Abstract

US FIRST (US For Inspiration and Recognition of Science and Technology) is an organization dedicated to increasing high school students' awareness of STEM careers through project-based learning with a culture of 'Gracious Professionalism.' US FIRST organizes the FIRST Robotic Competition (FRC), which provides high school teams an opportunity to compete regionally, nationally, and internationally in the area of robotics. 'The varsity sport for the mind,' FRC combines the excitement of sport with the rigors of science and technology. Although the competition is well suited to expand the level of knowledge and understanding of STEM fields, competition entry barriers can be challenging to overcome at any high school. These challenges are amplified for home-schooled students and their parents. Two major barriers include a lack of infrastructure and proper training from professionals. This paper describes the initial steps of a unique college initiative that supplies a central location, offers a college infrastructure, and provides hands-on training modules and instruction. The central location acts similarly to 'hacker spaces,' a physical location providing a common place for like-minded thinkers to collaborate on projects. The goal of the paper is to report on a novel collaboration among home, public, and privately schooled students within the context of a US FIRST team. Along with the collaboration hands-on modules are developed and taught by partnering engineers in collaboration with college faculty. The model applies the constructionist learning theory with structured preparation for the competition. In addition the paper presents issues and solutions to implementing an innovative opportunity for home, public, and privately schooled students. This initiative lays the groundwork for future endeavors with the intent to expand and sponsor multiple teams.

Outline

Introduction and Background

The paper presents a Youth Engineering and Technology Inspirations, Inc. (YETI) and Central Piedmont Community College (CPCC) initiative designed to host a US FIRST Robotics Team while providing learning modules based on constructionism theory and then assessing three of the four categories outlined in *Making a Successful Engineering Student*[20, 22].

"The varsity sport for the mind[3]," FRC combines the excitement of sport with the rigors of science and technology. Under strict rules, limited resources, and time limits, teams of 25 students or more are challenged to raise funds, design a team brand, hone teamwork skills, and build and program robots to perform prescribed tasks against a field of competitors. The experience is as close to "real-world engineering" as a student can get. Volunteer professional mentors lend their time and talents to guide each team[16].

Competitions are high-spirited three day events where teams qualify for the competition finals through a series of events matched randomly with two other teams to form an alliance. Alliances compete against one another in fast-paced two minute competitions. The competition culminates in a series of final matches between alliances formed through selection of highly ranked teams. A team is a multi-disciplined endeavor similar to running a business; therefore, technical and business skills combine with teamwork for success. The competitions provide many opportunities for a team to earn recognition for exemplary performance beyond the direct game play such as web design, outreach, and design excellence.

According to *Tougaw, et. al.,* a college sponsoring a US FIRST Robotic team is challenging and rewarding[1]. Two challenges worth noting include coordinating the efforts of teachers, students, and professional engineers and adhering to tight deadlines. Some of the rewards interesting to note include:

- "Serves as an opportunity for 'college' student organizations to provide community service."
- "Promotes the fields of science and engineering to a group of high school students who are about to make a life-changing decision about their future career.
- "Provides greater visibility for the university within the community."

Furthermore, the ASME "Guide to Starting a First Team" also mentions university and college participation[14].

The US FIRST competition utilizes a hands-on approach to learning. The months prior to the build season provides opportunity for participants to learn about engineering principles using a constructionist approach[15]. Furthermore, the group of students needs a common meeting place to provide the necessary infrastructure and organization. Through this initiative the college provides both. Since some of CPCC engineering classrooms were in the midst of transforming from a more traditional space to a more unique learning environment, this proposed an opportunity to upgrade the college facilities.

Stanford's d-school, short for 'Design School' has been a leader in quick prototyping and hands-on activities dedicated to merging engineering, arts, and business. The d-school K-12 project includes projects that facilitate teacher workshops and classes for non-profits. In addition, the school provides a unique space dedicated to K-12 innovation[19].

In recent years more emphasis has been placed on hands-on and project-based learning[9, 10, 11, 12, 21]; however, this approach has not yet reached a tipping point in most school systems. One reason for the shift is that kids are not acquiring necessary hands-on skills at home as in previous generations[5]. Hands-on and project-based learning originates from constructionism theory[2, 4]. The theory has roots in constructivism "From constructivist theories of psychology we take a view of learning as a reconstruction rather than as a transmission of knowledge[2, 6, 7, 10]." However, constructionism extends the constructivism theory with the idea that manipulating materials to the idea that learning is most effective when part of an activity the learner experiences as constructing a meaningful product[2, 4, 6, 7].

Larry Richards[17] identifies reasons why engineering educators are interested in K-12 outreach. This college outreach attempts to locally aid in the problems in science, technology, engineering, and mathematics outlined by Richards.

Design of the Modules

Although there have been learning modules for US FIRST teams in the past[13], the approach was abstract. One goal of the learning modules developed for this venture was to give students hands-on experience in addition to conceptual theory, which is often missing from traditional school systems and home school [18]. The modules were approximately 1.5 hours long and were taught by CPCC faculty, mentors, and parents with a range of technical and non-technical skills.

Creating modules based on constructionism theory provides students a deeper understanding and appreciation of the world around them and utilizes a more natural learning approach than a typical classroom lecture. The module concepts were varied and included safety grant writing, hand tools, electronics, pneumatics, and public speaking. All modules were designed under the constructionism framework facilitated by the college. The technical modules were adapted from existing courses in collaboration with community college instructors. Selecting key concepts and activities from a full semester course for students to learn during a 90 minute session was challenging. The first iteration of the student module was effective. More development is planned for next season. A unique approach to helping students develop their public speaking skills was accomplished by hiring a theatre coach to train students to project their voices and communicate effectively to large groups.

This effort possessed two key elements: connect students with access to professional engineers and provide hands-on laboratory experiences. This close working relationship between students and engineering students provided students with a more accurate image of engineers as creative and logical professionals.

Providing the Space

The CPCC engineering program decided to transform its own student engineering space from a traditional classroom lab to something more novel and up to date. Most of the old lab equipment was from the early 1980s and was irrelevant to today's engineering education. This gave faculty an opportunity to revise the space. Designers looked to answer several questions, including "how does the space invoke creativity followed by logic" and "how does the school allow for multi-disciplinary collaboration among college students and faculty, K-12 schools, and industry?"

The sharing of resources emerged from asking these types of questions. Furthermore, the infrastructure provided to high school students was shared by the current college engineering program, which provided college students and high school students with communication opportunities. Studies have shown that engineering graduate students have a positive influence on K-12 education. "The active presence of real world, engineering role models in the K-12 classroom improves the quality of math and science content and introduces engineering to teachers and young students as a potential career path[8]."

The issue of institution liability when sharing college infrastructure came up early and took more time to solve than initially planned. After two months analyzing the question of the institution's liability for adolescent students, the school requested that the US FIRST team purchase liability insurance. The liability insurance allows the adolescent student to use the college facilities. One limitation that needed to be addressed was the institution's computer usage, which was solved with the creation of a non-curriculum class. This allows anyone registered in the class access to the college's computer system and software. The authors assume that protocol may differ at other institutions.

Survey

The survey questions were designed using student opinions to use in future iterations of the initiative. The questions/answers captured the experiences of the students. The authors wanted to question if the students felt they learned about what it takes to be a successful engineer. The survey design adopted the framework of Making a Successful Engineering Student[20, 22], excluding "Understanding of What Engineers Do," to assess the initiative. The survey included nine questions broken into four different categories, including:

- Teamwork and communication skills
- Design confidence
- An identity as an engineer
- Other

The questions were designed using a five point Likert scale where one is totally disagree and five is totally agree. The survey was given to 17 out of the 22 YETI team members after all modules were complete.

Teamwork and Communication Skills

The modules developed contained such skills as public speaking and speaking with confidence. Some students have the opportunity to present to corporations. In addition, all of the modules included team activities, some more structured than others. Furthermore, the atmosphere surrounding FIRST is "Gracious Professionalism" which was adopted into the educational environment with the intent of building a community around the team.

The survey measures student feedback on their experiences, ability to orally communicate, ability to present to an audience, ability to work in a team environment, and perception of whether a sense of community was created within the group.

Design Confidence

The survey captures students' design confidence, not their ability to design. The approach taken to measure design confidence was to ask students about their understanding of engineering principles, with the belief that understanding engineering principles leads to design confidence. Furthermore, the students were asked about their hands-on ability with the same notion that perception of hands-on ability will lead to design confidence.

An Identity as an Engineer

Certain characteristics are associated with an engineer, some true and some false. The true traits include but are not limited to problem solving skills, logical thinking, and strong math and science skills. Some traits are not usually associated with engineers but are nonetheless typically true, one such trait being creativity. The survey aimed to determine whether students understand the characteristics of an engineer and whether they identified with engineers and the engineering profession. Furthermore, the survey attempted to ascertain whether the interaction and personal contact with engineers made students identify with engineers.

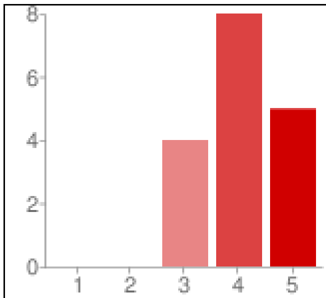
Other Experience

The Other section outlines local question that the authors chose to explore in order to aid in further initiative development. This section offers a more broad sense of the learning experience as a whole and provides feedback for CPCC as a central location to the unique experience.

Survey Results

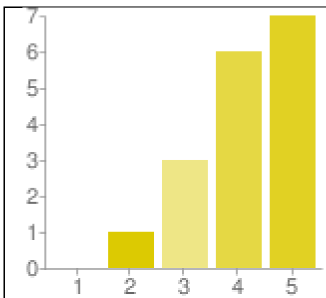
The survey results presented are in the same order as outlined above in the Survey section. Six out of nine questions are shown due to their relevance to the paper. The results are shown in two forms: the graph form represents the number of students on the vertical axis and the Likert scale on the horizontal axis. The graph provides both visual and numerical data representation. The table represents the same data in percentage form to give the reader the actual percentage numbers.

Teamwork and communication skills



1 - TOTALLY DISAGREE	0%
2	0%
3	24%
4	47%
5 - TOTALLY AGREE	29%

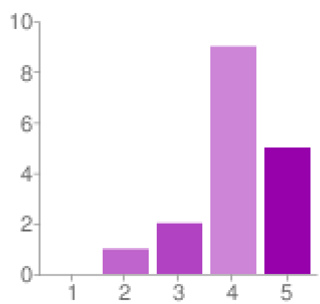
Figure 1. Shows data pertaining to students' answers to the question *Has the experience been helpful in your ability to work in a team environment?*



1 - TOTALLY DISAGREE	0%
2	6%
3	18%
4	35%
5 - TOTALLY AGREE	41%

Figure 2. Shows data pertaining to students' answers to the question *Has the experience created a sense of community within YETI?*

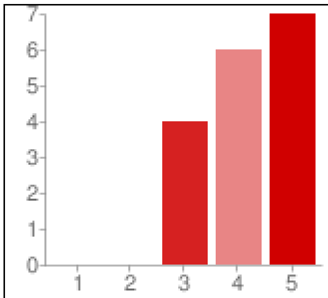
Design confidence



1 - TOTALLY DISAGREE	0%
2	6%
3	12%
4	53%
5 - TOTALLY AGREE	29%

Figure 3. Shows data pertaining to students' answers to the question *To what extent does the hands-on approach aid in your understanding of engineering principles?*

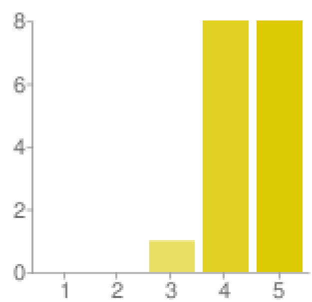
An identity as an engineer



1 - TOTALLY DISAGREE	0%
2	0%
3	24%
4	35%
5 - TOTALLY AGREE	41%

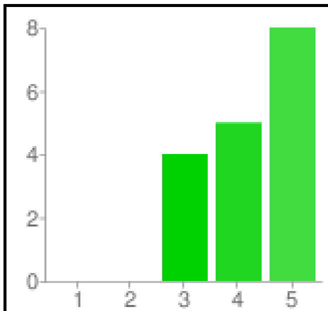
Figure 4. Shows data pertaining to students' answers to the question *Have you identified with engineers due to the interaction with engineering professionals?*

Other experience



1 -	TOTALLY DISAGREE	0%
2		0%
3		6%
4		47%
5 -	TOTALLY AGREE	47%

Figure 5. Shows data pertaining to students' answers to the question *Has the opportunity been helpful in your learning experience?*



1 -	TOTALLY DISAGREE	0%
2		0%
3		24%
4		29%
5 -	TOTALLY AGREE	47%

Figure 6. Shows data pertaining to students' answers to the question *Has the central location for YETI been good for you at getting involved in engineering?*

Discussion of the Results

The major finding in the initiative is that a central location at CPCC for students can be achieved through the dedication of students, mentors, parents, and college faculty. Furthermore, the modules designed aided most of the students' learning of teamwork and communication, design confidence, and identity as an engineer.

This initiative lays the groundwork for future endeavors with the intent to expand and sponsor multiple teams. The data is significant in that it acts as a baseline. The initiative can use this baseline data to fine-tune the strategy.

This initiative not only sponsored a team[1] but also hosted a team in the college itself. Although the data set is relatively small, the data tends to lean toward an understanding of engineering principles through hands-on training. Furthermore, the study expands on the more theoretical learning modules for the US FIRST teams[13].

Some alternative explanations for the findings may include biasing due to the fact that the survey was taken at the college and not in the privacy of the students' own homes. Some of the students could have misinterpreted some of the survey questions and/or could have been influenced by other students.

This study and its findings have relevance to colleges looking to host and/or sponsor a US FIRST team or another competition team. In addition, this study is relevant to students who are thinking about engineering as a career and/or looking for support outside of their own high school.

The authors want to point out the data set is too small to draw major conclusions and generalizations; however, the survey results present a baseline and provide some navigation for future plans.

In addition, it was observed that the college students who dedicated time to the initiative were inspired to do better in school and took on leadership roles outside traditional classes. For future studies a thesis may include 'how the initiative affected college students from an outreach or inspirational perspective?' or 'how does the initiative benefit mentors?'

Lessons Learned

The initiative provided many lessons learned to not only the students but to the faculty, mentors, college students, and administration.

- According to Figure 1 the majority of the students felt the experience improved their ability to work in a team environment.
- The initiative created a sense of community within YETI.
- The modules may need to include more design elements if the initiative is to aide in students' design confidence.
- Students identified with engineers due to the interaction with engineering professionals.
- The initiative offered the opportunity for young adult learning experiences.

- The college provides opportunities to home school students who would not necessarily interact with each other and public and private schooled student.
- Although not shown in the paper, planning for issues such as liability and equipment use were more involved than expected.

Resources

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