LASER: Leadership And Science Ensures Results – Evolution of a STEM Partnership Between Industry and Education

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ABSTRACT

The United States' pipeline in Science, Technology, Engineering and Math (STEM) continues to be weak. This crisis was the catalyst for a partnership between Raytheon and McKinney Independent School District to develop LASER (Leadership And Science Ensures Results), a STEM outreach program.

LASER started as a technical and leadership curriculum embedded in the 11th grade Physics curriculum, in 2010-2011. After two years of execution, with many lessons learned, the high school curriculum was re-designed, and the original curriculum was refined to meet the abilities/needs of 6th grade students for 2012-2013.

The program has touched 4500+ high school students over three years and 2250+ middle school students this year. Feedback from students, teachers, and administrators is positive and there are now "LASER Graduates" pursuing STEM education in college. Data indicates the program has caused 42% of the students to consider pursuing a STEM career. In addition, 14% of the participants stated that the program re-affirmed their interest in STEM. That means 57% of the participants have been positively impacted in terms of pursuing STEM careers, which is a start at closing the gap in the STEM pipeline.
Keywords: STEM, Conference Proceedings, K-12 Outreach, Partnering

INTRODUCTION

LASER was developed to address the crisis in the United States STEM pipeline:

- The World Economic Forum ranks the United States 52nd in the quality of mathematics and science education (Schwab, 2011)
- The United States ranks 27th in developed nations in the proportion of college students receiving undergraduate degrees in science or engineering (Organization for Economic Cooperation and Development, 2009)
- There are more foreign students studying in U.S. graduate schools than the number of U.S. students (Task Force on the Future of American Innovation, 2006) and over 2/3 of the engineers who receive Ph.D.'s from United States universities are not United States citizens (Fiegener, 2011)

Raytheon engineers partnered with the McKinney ISD (MISD) Secondary Science coordinator over a period of nine months in 2010, to develop and initially deploy the curriculum. In addition to the STEM focus, leadership components were included since this is sometimes a weakness observed in college-hires. The curriculum applies to all Physics students, from Advanced Placement, to pre-Advanced Placement, to Academic, and even in the alternative schools. The intent was to help all students develop leadership skills and encourage students to consider STEM careers through project-based, hands-on learning that promotes creativity and fun!

After executing LASER in the high schools for two years, with many lessons learned, the high school curriculum was re-designed to include a long term project, rather than discrete activities. This approach is more realistic and aligns with the traditional engineering development lifecycle. The original high school curriculum was refined to meet the abilities/needs of 6th grade students for 2012-2013.

PROGRAM DESCRIPTION

LASER is actually embedded into the MISD's 11th grade Physics curriculum and mapped against the Texas Essential Knowledge and Skills, which governs all Texas school curriculums. The curriculum was designed to leverage elements of MathMovesU (Raytheon developed and promoted project based learning) as the technical foundation while at the same time highlighting specific leadership skills required for success both in the classroom and in post high school careers.

The curriculum takes an innovative approach by using the premise that the students have been selected for an internship at a leading-edge professional think tank organization called Cogitate. Cogitate provides consulting and research services to a variety of government and commercial customers in various scientific and engineering domains. As part of Cogitate, students work with their fellow interns to address customer needs in an innovative, high-quality, timely, and cost-efficient manner. The curriculum is implemented in a series of four class room visits, each with a certain set of technical and leadership learning points, concluding with a capstone activity which includes a presentation to the "Customer". In the original curriculum, the four class visits each included a discrete activity that was completed within that class period. Then, the capstone challenged the students to take one of the previous modules and further build upon it, drawing real-life input from industry.

One significant update made after the initial school year was to remove one of the discrete activities and use the 4th class room visit as a working session for the capstone development. This resulted in more focused capstone projects and higher caliber presentations by the students. The discrete activities, along with both the leadership and technical skills addressed in each module, are captured in Figure 1.

Module Summary			
Module	Title	Leadership Skills	Technical Skills/Concepts
1	A Splinter of Truth	Teaming Communication Diversity	Observation Abstract Thinking Problem Solving
2	Modeling Green	Innovation Goal Setting Critical Thinking Decision Making Problem Solving	Data collection Force and Motion Hypothesis testing Standard Deviation
3	Bob's Benign Bird Ballistics	Teaming Innovation Decision Making Problem Solving Critical Thinking	Motion Root Cause Analysis Standard Deviation Variation

Figure 1: Discrete activities and associated skill sets for LASER modules

Going into year three, the LASER development team redesigned the high school curriculum to have one, long term project, rather than discrete activities. This approach is more realistic and aligns with the traditional engineering development lifecycle. The allocation of LASER modules across the development lifecycle is illustrated in Figure 2. The mission focuses on a proof of concept for a vehicle which will allow space tourists to travel through challenging terrain and details of the mission and requirements can be found in Appendix A. The materials used for the challenge are common and easily accessible. The original high school curriculum was refined to meet the abilities/needs of 6th grade students for 2012-2013.

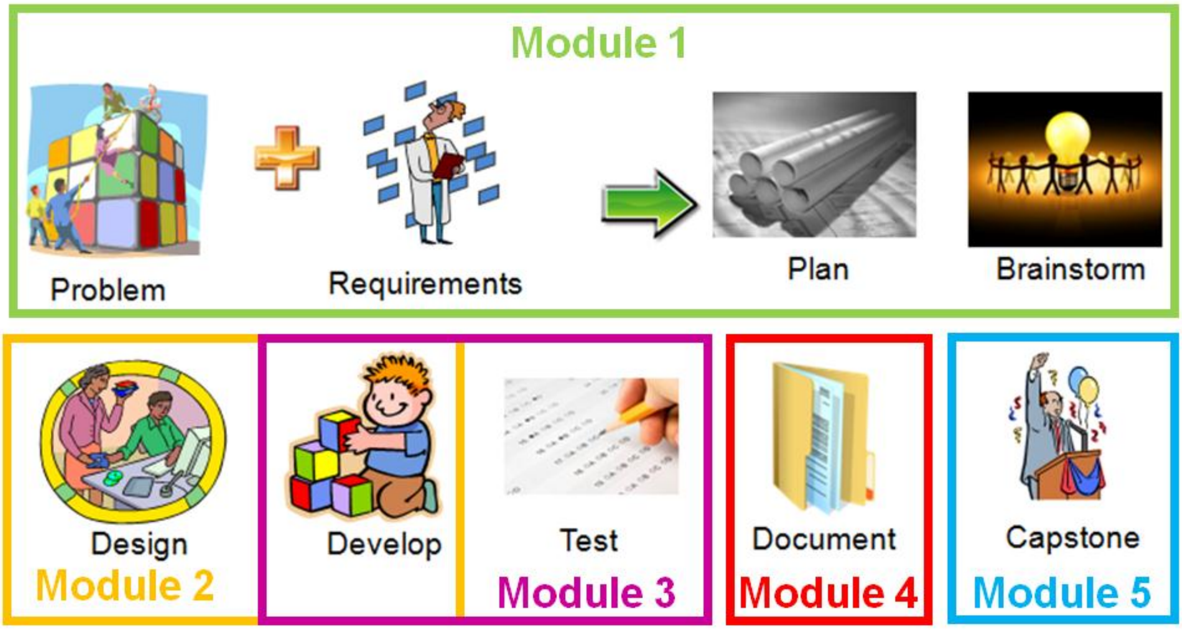

Figure 2: Engineering Lifecycle with LASER Module allocation

A special pilot is also being conducted in 2013 which uses the long term project concept, but with a mission involving Lego NXT robotic kits to create an unmanned search and rescue vehicle. Students are challenged to deliver "medicine", rescue an injured Lego-person, and other tasks within a four minute timeframe. See the requirements and map in Appendix B.

The technical and leadership components in the high school and / or middle school curriculum include:

- ♦ Scientific Methods
- ♦ Characteristics and Behaviors of Waves
- ♦ Teaming
- ♦ Communications
- ♦ Goal Setting
- ♦ Problem Solving
- ♦ Decision Making
- ♦ Mathematical concepts such as Mean and Standard Deviation
- ♦ Concepts and Laws of Force and Motion
- ♦ Concepts and calculations related to Energy
- ♦ Diversity
- ♦ Innovation
- ♦ Critical Thinking

The class room visits were supported by Raytheon volunteers, many of whom are engineers. However, the non-engineer volunteers have also made a great impact by showing the wide reaching importance of math and leadership skills in other careers, such as finance, contracts, human resources, information systems, communications and supply chain.

RESULTS

Although this school year is not over, LASER has made a great impact. The program has touched over 4500 high school students over three years, and over 2250 middle school students this year. There are even "LASER Graduates" pursuing STEM education in college.

Post-module survey and post program survey metrics from the first year of LASER illustrate a strong impact. During year 1, when asked if they would recommend the module activity to others, 88% stated that they would recommend the activity. When posed the statement "I had fun participating in this module," 91% responded positively. The program caused 42% of the participants to consider pursuing a career involving science, technology, engineering, or math. In addition, 15% of the participants stated that the program re-affirmed their interest in STEM careers. That means 57% of the participants have been positively impacted in terms of pursuing STEM careers, which is a start at closing the gap in the United States STEM pipeline. Unfortunately, data from years two and three of the high school program was incomplete, and middle school data is still being collected as the program is on-going.

In addition to the quantitative results, anecdotal feedback from students, teachers, volunteers and administrators also provides insight into the impact of the program:

"….I was completely unaware of any possibilities to explore such a field. After only one visit from Raytheon, I had a completely new perspective on what I could do in the future…. …" R. Johnson, Student.

"At the beginning of the program this year, my students were typical teenagers taking a general population science course: "Physics is hard, it's too much math, I want to be a dancer, I want to be a professional baseball player, etc." After a few of our LASER sessions, and with the positive influence of the engineers from Raytheon, a great number of my students are now expressing a desire to pursue a career in the sciences. Several have decided to try becoming engineers." F. Wiatroski, Physics Teacher.

"….(LASER) is reaching scores of students with engaging, exciting content with real-world connections." S. Biles, Physics Teacher.

"Raytheon's work with our school district has been Fantastic. They have been able to fill a void in our curriculum that has been needed for a long time. Our students have gained a great amount of insight into the Engineering Field. They are the best!" J. Crumpton, Physics Teacher.

"It's a great feeling to know that you are helping to shape the next generation of leaders. To see the excitement on the students' faces when they know that we are coming is exciting for us too. The best part is asking the question at the end of the school year "So how many of you think you might want to be an engineer?" and the number of hands raised is more than when we started. That's how I know that we are adding value." D. Martin, Raytheon Volunteer.

"High school - I love to see the "A-ha!" moments with the kids when they realize that LASER is about something so much bigger than puff-mobiles and presentations. During presentation day, more than once I heard this - if it wasn't for this program, I wouldn't have gotten to know my classmates, worked with them, and understand and appreciate our different approaches to solving problems! Middle school - I had one boy, after the statapult day, ask me where I went to college. Then he said "I want to go there, too!" It's like he figured out that engineering can be so much fun, and he's thinking that he has to go to the same university I did to catch the "engineering is awesome" bug! E. Hogan, Raytheon Volunteer.

"My wife and I were in a restaurant and a man came up to our table as he was leaving. One of the students had recognized me and told his dad that he really liked coming to school on Raytheon day and that he thought it was a great program. I thought it was something if he would tell his dad that." J. Meiseman, Raytheon Volunteer

"The fact that teachers and students alike are already discussing ways in which the program could be expanded for future years speaks volumes about the impact it has had." K. York, Science Department Chair and Instructional Specialist.

Equally exciting as the above feedback is the interest that we are hearing from younger students. Several 10th graders have heard about the LASER program from 11th graders and are now anxiously looking forward to participating next year. This "pull" from the student community shows the success of the program will continue in the future. We also have 12th graders who have taken the time to circle back around to our volunteers because they want to know how the program is progressing.

LESSONS LEARNED

Lessons learned from LASER fall into two main categories: technical and administrative.
On the technical side of things, there are content issues such as:

1. The original 4th module of the curriculum focused on measuring the temperature difference between the visual portion of the electromagnetic spectrum and the infrared portion of the spectrum. This module was removed after year 1 because it was difficult to implement and it was determined that students needed more time to focus on the capstone activity. Having the 4th classroom visit as a working session allows the students time to explore the possibilities with interaction from the volunteers.

2. Using sticky notes as marker for "statapult" shots helps visually illustrate the concept of standard deviation. When the students collect their first set of data, the statapult is in a sub-optimal set up. After making updates to the configuration, the student collects a second set of data, and the second set of sticky notes should visually illustrate a smaller standard deviation.

3. The transition from discrete activities to a long term project for the high school curriculum increased the challenge for the students, made the project more realistic, and allowed the introduction of more project management concepts.

4. After this year, the need to find the balance between the project management concepts (creating plan, organization chart, cost estimation, etc.) and driving to the hands on portion of the project was recognized. For the robotics pilot, students are only required to show the project management documents at the beginning when they are initially created, and then at the end of the project when they should be updated, if necessary.

On the administrative side of things, there are issues regarding the execution of the LASER program such as:

1. Maintaining a sufficient volunteer base is a challenge, especially with the expansion into middle school. Ideally, we would like to have two volunteers for every class, but with 67 high school classes and 92 middle school classes (per visit), this is a challenge, even though many volunteers cover more than one class. The difficult business environment is putting more stress on our volunteers, and travel, customer meetings, illness, and retirements have impacted our volunteer pool. The volunteers are critical to the program—they make LASER happen—but for next year, consideration will have to be given regarding the volunteer pool and how we can best use these precious resources.

2. It is difficult to collect meaningful data from the students. The program has a pre-LASER survey, post-module surveys, and a post-LASER program survey. Different methods have been used to collect the data, such as scantron sheets and on-line surveys. Compliance is challenging as some students are more conscientious than others, and some teachers have been more successful at data collection than others. It is also difficult to balance anonymity and the students not taking the survey seriously. Data collection is something that we continue to explore.

3. Keeping LASER "sold" with the teachers/administration is also a challenge. Initially, there were some teachers who were not as supportive of the program as others. In order to address this, careful consideration was given to the pairing of teachers and volunteers. As the program progressed, and the Texas teaching requirements changed, some teachers felt more pressure and became less supportive of LASER. This was not an across the board issue, but something that we did work to address by working with the Science Coordinator and the school principals. Fortunately, both were very supportive of the program, as was the superintendent of the school district, but as we look toward the 2013-2014 school year, this will be something that we consider as we make refinements to the program.

Although we have learned some big lessons and continue to work to improve LASER, it is gratifying to see the impact that we have made in the students' lives. A quote recently received from a teacher captures it well. He noted that one student brought this up, but the entire class seemed to share in the observation, regarding this year's LASER project:

"With any other project our teachers gave us in the past, they threw a bunch of supplies at us, and maybe a set of directions, and told us to put it together. This one was hard, because we had to consider budgets, we had to develop operating procedures, we had to document everything, <and> we had to make presentations. It was hard."

Her comments made the teacher smile. He noted, "Real life is not a playground. Thanks for giving our kids the opportunity to see that they will need to leave the playground behind as they grow up into responsible, contributing, and prosperous members of our community."

Although the full impact of the program cannot be easily measured, in our own small way, LASER is making an impact on the STEM pipeline by combining project-based learning, technical skills, and leadership skills to pull students from an observer role into a participatory role. This increases engagement in STEM and builds students' confidence in the possibility of pursuing STEM, thereby adding to the U.S. STEM pipeline.

ACKNOWLEDGMENTS

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LASER was made possible due to the creative and dedicated efforts of the development team including Jill Brooks, Elyse Hogan and Jodi Roepsch of Raytheon, and Chaurcley Cook of McKinney Integrated School District.

APPENDICES

Appendix A

Mission: Although the U.S. Space program has suffered with the shutdown of the Space Shuttle Program, there are several private companies which are aggressively pursuing space travel and reconnaissance. These companies want a vehicle that will allow scientists and future space tourists to navigate challenging terrain and have the ability to collect and preserve critical data.

Cogitate must work diligently on this proof of concept in order to demonstrate the company can meet the Customer's needs and win the down-select with a high quality design, low cost, and operational vehicle.

Requirements:

1) Body of vehicle shall be a plastic, translucent bottle that is no longer than 13 inches

2) Size and weight
    a. Length shall be no greater than 13 inches
    b. Width shall be no greater than 12 inches

3) Shall achieve the greatest distance from the starting line as measured from front of the vehicle within one minute

4) Once the vehicle crossing the starting line, the vehicle shall not be touched until the Customer authorizes collection of the vehicle and any materials

5) Vehicles shall use two methods of propulsion

6) If the first propulsion method triggers the second without human intervention, extra points shall award

7) All vehicles and associated materials shall be removed from the test track with 1 minute of the Customer's signal

8) Electronic parts shall not be used

9) The vehicle shall be mechanically operated

10) No animals shall be used in the development, testing or deployment of vehicles

11) No fire, explosives or flammable materials shall be used

12) Any food items used shall be purchased in a grocery store

13) Liquid shall not be released from your vehicle

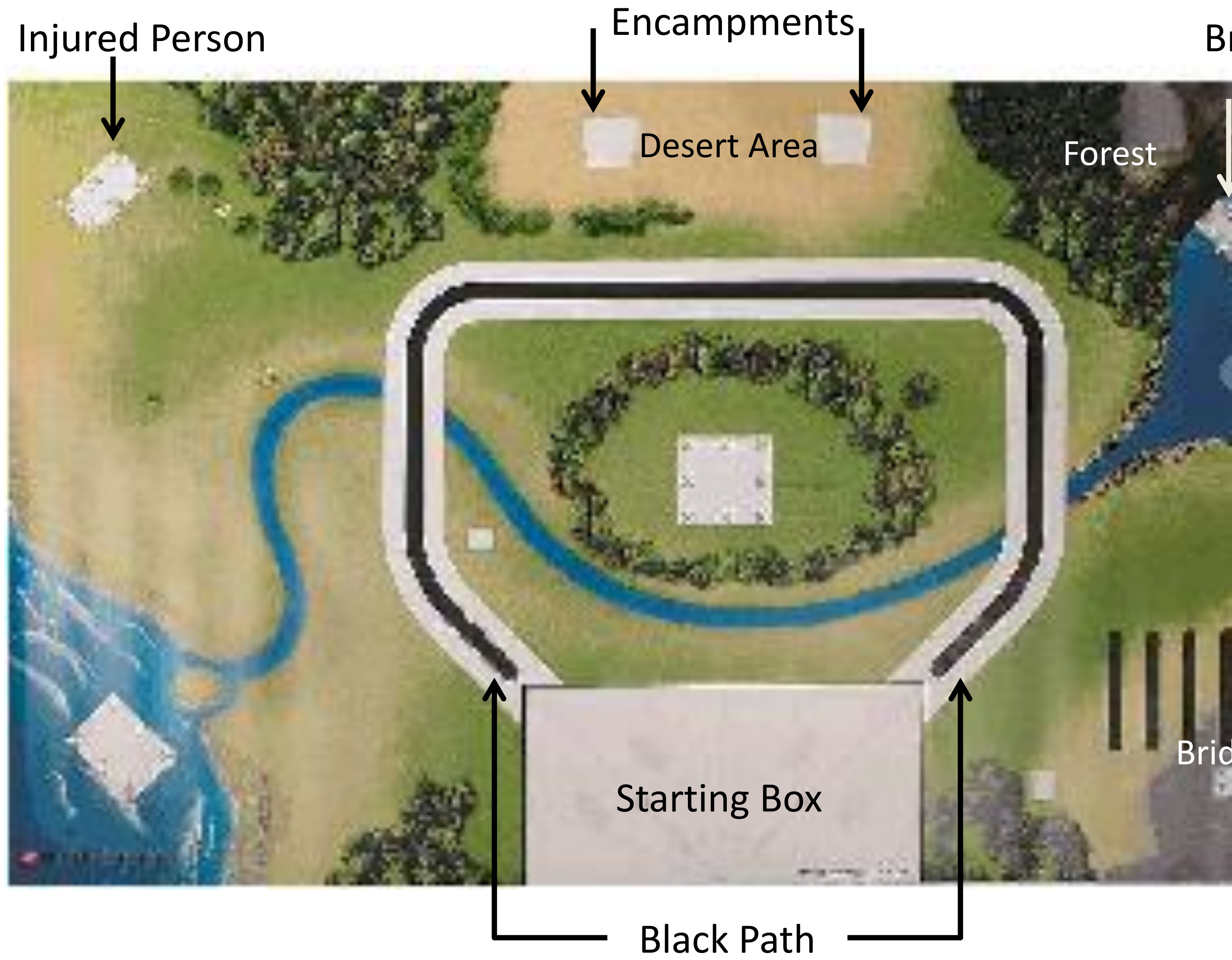
14) Any materials not provided by the Customer shall be pre-approved before use by the Customer

15) Team shall define what contribution each propulsion source makes to the energy to move the vehicle (calculation to be validated by teacher)

16) Operation of the vehicle shall not endanger any team members or observers

17) All Customer furnished materials that are not used, shall be returned to the Customer in original condition. Anything not returned, or return damaged shall be charged to the team

Appendix B



Requirements

1) The vehicle shall begin in the Starting Box.
2) All parts of the vehicle shall be completely within the Starting Box before beginning the challenge.
3) The vehicle shall use “follow the line” programming in order to follow the “black path” from the Starting Box across the river.
4) The entire vehicle shall be across the river before the vehicle can diverge from the black path.
5) The vehicle shall deliver the blue medicine rations (the Lego kit blue ball) to either encampment in the desert section of the map.
6) The vehicle shall collect the injured person from the North West quadrant of the map and transport the injured person back to the Starting Box.
7) The vehicle may not throw any objects.

8) The vehicle shall return to the Starting Box within the 4 minute time limit.
9) Wireless functionality shall not be used.
10) All programming shall be stored within the memory of the robot.
11) Only the Lego robotic kit sensors and parts provided shall be used for the challenge.
12) Optional tasks for extra points: Collect the bridge beam from the South East quadrant and take it to the broken bridge in the North East quadrant. Points will be awarded for depositing the bridge beam in either Forest area or for depositing the bridge beam onto the bridge pillars so that the beam is touching both bridge pillars.

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