SeaPerch: How a start-up hands-on robotics activity grew into a national program

Susan Giver Nelson[1]and Kelly B. Cooper[2]and Vladimir Djapic[3]

***Abstract*—**

The world is changing. Innovations transform our nation, creating whole new industries and occupations. Every job of the future will require a basic understanding of math and science. Science and technology careers exist in a culture of inspiration, discovery, and innovation. Advances in technology will have a meaningful impact on the lives of every American. This paper will discuss an issue, which has come to the forefront in the United States over the past ten years, the lack of students studying Science, Technology, Engineering and Mathematics (STEM) subjects and its ramifications and will suggest one possible solution: SeaPerch. Beginning with the story of SeaPerch and its journey to become a national K-12 STEM outreach program, this paper will describe the program, including its curriculum. It will also discuss the competition, share statistics, metrics and the results of seven years of research. Finally, this paper will share some feedback from participants.

Although STEM workers drive our nations innovation and competitiveness, US businesses say there not are enough of them [1]. In fact, STEM occupations are projected to grow by 17 percent by 2018, compared to 9.8 percent growth for non-STEM occupations [1], and almost all of the 30 fastest growing occupations in the next decade will require at least some background in STEM [2]. However, student interest in STEM is declining. ACT, the only US nationally standardized entrance exam that covers science and higher-level math, says, over the past ten years, the percentage of ACT-tested students who said they were interested in majoring in engineering has dropped steadily from 7.6 percent to 4.9 percent [3].

STEM jobs are not just for those with college degrees, and in fact, with the expansion of advanced technologies and processes into more and more fields, the STEM economy is much bigger than many imagine and the barriers to entry are also lower than most think [4]. Consider the math skills required by a plumber, the science knowledge required by an electrician, or the physics required for work in plants. These occupations are good-paying jobs, and can help propel a worker into the middle class [4]. Chevron has been hiring younger workers aggressively due to the upcoming retirements looming in the oil and gas industry, says Gary Yesavage, president of manufacturing at Chevron. Finding bachelors-level chemical, electrical and mechanical engineers is hard, and hiring enough trained technicians is an even bigger challenge [4].

In order to fill the projected STEM pipeline, the immediate need is to get students excited about the possibilities of a career in a science, technology, engineering or mathematics (STEM) field. In fact, ACT recommends including parents, teachers and counselors in outreach programs that help them learn about STEM professions so they can encourage students to go into those fields [3]. The SeaPerch program is a K-12 Outreach program designed to do just that.

SeaPerch is an innovative underwater robotics program that equips teachers and students with the resources they need to build an underwater Remotely Operated Vehicle (ROV) in an in-school or out-of-school setting. Students build the ROV from a kit comprised of low-cost, easily accessible parts, following a curriculum that teaches basic engineering and science concepts with a marine engineering theme. The SeaPerch Program provides students with the opportunity to learn about robotics, engineering, science, and mathematics (STEM) while building an underwater ROV as part of a science and engineering technology curriculum. Throughout the project, students will learn engineering concepts, problem solving, teamwork, and technical applications.

Building a SeaPerch ROV teaches basic skills in ship and submarine design and encourages students to explore naval architecture and marine and ocean engineering principles. It also teaches basic science and engineering concepts and tool safety and technical procedures. Students learn important engineering and design skills and are exposed to all the exciting careers that are possible in naval architecture and naval, ocean, and marine engineering. Students learn best by doing, and during the process of building SeaPerch they follow steps to completely assemble the Remotely Operated Vehicle (ROV). After the SeaPerch robot is constructed, students are encouraged to test their vehicles, deploy them on missions and compete in a culminating event, the SeaPerch Challenge, on a local, regional and perhaps national level.

SeaPerch began as one project in a book entitled "How to Build an Underwater Robot," by Harry Bohm and Vickie Jensen. There were many projects in the book, and SeaPerch captured just two pages, with a parts list and instructions on how to assemble the vehicle. Years later, Professor Thomas Consi at the Massachusetts Institute of Technology (MIT) developed a curriculum around the SeaPerch as a way to grow the Ocean Engineering Program at MIT. Seeing the possibility of using SeaPerch to train teachers, MITs Dr. Chryss Chrystostomedes sought funding from the Office of Naval Research (ONR) and the MIT Sea Grant office and began to train teachers in their area and beyond.

[1]Susan Giver Nelson is with the SeaPerch Program, AUVSI Foundation, susan@seaperch.org [2]Kelly B. Cooper is with the Office of Naval Research kelly.cooper1@navy.mil [3]Vladimir Djapic is with SPAWAR Systems Center Pacific vdjapic@spawar.navy.mil

978-1-4799-8736-8/15/$31.00 ©2015 IEEE

Several years later, this author, Susan Giver Nelson, was working for The Society of Naval Architects and Marine Engineers (SNAME) and learned about the SeaPerch vehicle. Realizing that what had begun as two pages in a book and a teacher-training program had the potential to be much more, this author submitted a proposal to partner with the Office of Naval Research (ONR) to turn SeaPerch into a national K-12 STEM Outreach program. A research component was built into the grant, to enable SNAME to test and evaluate various models of delivery.

With support from ONR, SNAME designed a model that was built to scale up incrementally, ultimately resulting in a national K-12 outreach program. This program plan included the development of an actual kit and tool kit, a website, training materials, an organizational infrastructure, an inventory and ordering system and a marketing plan with supporting materials. Perhaps most importantly, a network of committed individuals was begun to help implement the program.

The efforts began to take root, and the SeaPerch Program expanded rapidly, becoming the U.S. Navys designated K-12 Outreach program. By the end of 2014 the program had expanded to include all 50 states and 10 countries, and had exceed 230,000 student participants and 16,000 mentors/educators. In 2010 the first National SeaPerch Challenge was created, with just 33 student teams participating. In 2014, over 120 student teams competed, with close to 1,000 attendees at the event.

To capitalize on the SeaPerch programs rapid growth and the need for additional STEM offerings, in 2011, SeaPerch partnered with the Association of Unmanned Vehicle Systems International Foundation (AUVSIF) to assume management of the program. This afforded SeaPerch the opportunity to offer student participants the next step in the STEM pathway, with AUVSIFs RoboBoat, RoboSub and RobotX competitions offering new challenges for high school and college students.

The first step requires a teacher or mentor willing to take on the program. Training the teachers was an important component of the program initially, but as funding tightened, a web-based training video series was developed, which showcases the build in basic steps from beginning to end [5]. Other video resources were included on the website as well, making the site a complete resource for users.

Our research suggested that the program was effective in many settings. Schools, after-school programs, volunteer clubs such as Scouts and 4-H and home school settings all proved to be valid venues for the utilization of the program. In fact, the ability to participate in a SeaPerch build in many situations contributed to the growth of the program.

Another important piece of the programs success was the existence of a curriculum, which could be mapped to national science standards. Including topics such as buoyancy, displacement, motor movement, circuits and switches, ergonomics and attenuation of light, the curriculum can be applied to science, physics, math and technology classes. Our research suggested that the existence of a robust curriculum, mapped to standards, was another key factor in the programs growth.

Having a competition was deemed critical to the programs future success, and the National SeaPerch Challenge was started in 2010 with 35 teams. In 2014, 120 teams competed, with close to 1000 attendees. The Challenges events measure vehicle performance, innovative design and team presentations. Each year there is an obstacle course, but the second in-water event features a mission, which changes yearly. This mission ranges from capping a simulated oil well to a marine salvage mission to a deepwater challenge, and the students are able to modify their ROVs to meet the mission, with a budget of $20. Finally, as we all know, one can have the best design in the world, but if not properly communicated, it will fail. Hence, the National Challenge features a poster competition, in which the students communicate their design challenges and experience to a panel of judges, including professional engineers and Navy personnel.

Our core strategy driving the collection of metrics was fourfold: 1) Increase the number of participating programs, 2) Create a community of volunteers, mentors and sponsors, 3) Increase the relevance and sustainability of SeaPerch to all stakeholders, and 4) Continue to innovate to improve awareness, access to and adoption of the program. These items were measured internally and externally. The collection of a definitive set of metrics was challenging due to regulations about collecting data on students and also funding.

Pre and post student surveys were developed to gather data on student interest in STEM-related subjects and activities before and after completing the SeaPerch activity. There were challenges related to the data collection based on the availability of technology and other school-related issues, including student absences and other classroom management issues. However, when the data was collected, the results showed a significant increase in student interest and efficacy in STEM subjects. In one program, 82% of students indicated a new interest in pursuing STEM in college after completing the SeaPerch activity.

Throughout the seven years implementing the SeaPerch program, ongoing research was conducted to determine what methods worked best in individual situations as well as what worked technically with the vehicle. Improvements to the vehicle were made throughout the years to continually improve its operation based on lessons learned in the classroom. Also, classroom delivery and classroom management concepts were refined based on what was learned in the research. Research showed that there were four critical components to the success of a program, including: Frequent access to a water source, small working groups, flexibility and teacher enhancements to the established curriculum.

One important component of the programs success was the involvement of the U.S. Navy, specifically the Office of Naval Research. Without its commitment and funding, the program would not have scaled so rapidly. The ramp-up of SeaPerch coincided with a U.S. Department of Defense initiative called the National Defense Education Program, which provided funding for military lab and technical personnel to perform outreach activities in their local communities. These mentors were a valuable resource to help bring SeaPerch to the

community, and were an important part of the programs growth.

Student and teacher/mentor feedback to the program has been overwhelmingly positive, with some teachers saying it has been the best thing they have ever done in their classrooms. Students indicate that this program has generated interest in a STEM or engineering career. The ultimate goal of the SeaPerch program has been to generate awareness of possible STEM careers, interest, and ultimately pursuit of a STEM career, and feedback shows that this goal has been met.

REFERENCES

[1] "Economics and statistics administration website," http://www.esa.doc.gov/Reports/stem-good-jobs-now-and-future, viewed 12/14/14.

[2] "Change the equation website," http://www.changetheequation.org/stemtistics, viewed 12/15/14.

[3] "Act, developing the stem education pipeline," http://www.act.org/research/policymakers/pdf/ACT_STEM_PolicyRpt.pdf, 2006, viewed 12/17/14.

[4] "The atlantic.com website," http://www.theatlantic.com/sponsored/chevron-stem-education/the-jobs-of-today/196/, viewed 3/15/14.

[5] "Seaperch website," http://www.seaperch.org/videos, viewed 3/23/15.