AC 2008-783: THE SEA PERCH CHALLENGE - GENERATING INTEREST IN MARINE ENGINEERING, OCEAN ENGINEERING, NAVAL ENGINEERING AND NAVAL ARCHITECTURE THROUGH HANDS-ON ACTIVITIES

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Susan is responsible for directing the Outreach, Marketing and Communications efforts of the Society. In 2002, she successfully launched SNAME's first-ever Outreach program, including fundraising, design and production of collateral and marketing materials and website, and a volunteer training program.

Due to SNAME's commitment to Outreach, the Office of Naval Research has recently awarded a grant to SNAME which will task Susan with developing the Sea Perch Program, a K-12 Outreach program featuring underwater robotics, into a national program and competition over the next five years.

Susan will partner with industry, academic, professional societies, and school districts around the country to inform and educate them about the possibilities Sea Perch can create.

She holds her CAE (Certified Association Management) credential, granted by the American Society of Association Executives. Past president of the POWER Chapter of the Professional Convention Management Association, a Certified Meeting Professional, past Board member of the Pittsburgh Society of Association Executives as well as various charitable organization boards. She holds memberships in the American Society of Association Executives, the Professional Convention Management Association, the Council of Scientific Society Executives, the Pennsylvania Society of Association Executives, and the International Association of Fundraising Professionals.

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The Sea Perch Challenge
Generating Interest in Marine Engineering, Ocean Engineering and Naval Architecture through hands-on activities

An Innovative Approach to K-12 STEM Educational Outreach

For many years, educators have been faced with the challenging task of teaching STEM courses (Science, Technology, Engineering, and Mathematics.) Presenting the material and generating interest requires creativity and innovation. Introducing students to possible fields of study that they were previously unaware of such as marine engineering, ocean engineering, and naval architecture, has the potential to develop the next generation of professionals, academics, engineers, scientists and industry leaders. Most important, however, is the potential to open the eyes of a student to a larger world of study within the STEM curricula.

This paper will discuss one innovative approach to teaching science and engineering concepts through the use of underwater robotics. The Sea Perch Project provides students with the opportunity to learn about robotics, engineering, science, and mathematics while building an underwater ROV (Remotely Operated Vehicle) as part of a science and engineering technology curriculum. Throughout the project, students learn engineering concepts, problem solving, teamwork, design and technical applications. The project culminates in an end-of-the-term design competition – the Sea Perch Challenge.

The Sea Perch is a remotely operated vehicle (ROV,) or unmanned vehicle operated from a remote location. In the case of the Sea Perch ROV, student, after learning engineering and science concepts related to the project, builds and then operates the ROV under water, while stationed at a pool deck. Using a video game-type controller that the student constructed, they are able to direct the forward, reverse, left, right, and up/down movement of the underwater ROV by sending signals to three thrusters (again, student-built.) The controller is tethered or connected by hard wire to the thrusters.

In addition to the building phase, the curriculum includes discussion of potential careers in technical and engineering fields, as well as related fields of study. The program is used to inform and educate students through a hands-on activity, with the objective of generating interest and enthusiasm for continued science, technology and engineering studies. The Sea Perch Challenge has been a successful event for the past two years, and this paper will discuss the specifics of this event, as well as the plans for developing the Sea Perch Program into a national design competition over the next five years.

Background

One day, five or six years ago, a professor at the Massachusetts Institute of Technology (MIT) was searching for a project to interest his middle-school-age child in science and specifically engineering. He happened upon a book entitled “Build Your Own Under Water Robot and Other Wet Projects,” by Larry Bohm and Vickie Jensen, and he and his child built the underwater robot and took it for a trial in the waters of the Charles River. A high school science teacher nearby noticed the little robot, immediately recognized the excitement such a project could generate within her classroom, and asked the professor where he had obtained the means to build the robot. Sea Perch was born!

The MIT Ocean Engineering Department recognized the value of the Sea Perch underwater robot as a tool for Outreach, and developed the prototype of a program, a listing of the parts required to build the robot, and a rudimentary design plan. The Sea Perch project was introduced to several local high schools in the Boston area, generating immediate interest. MIT sought and received funding from the Sea Grant Program and the Office of Naval Research to expand the program, and one by one, schools became involved with the project.

As the Sea Perch project continued through word of mouth, and as more teachers became involved, a more developed curriculum was required. MIT, and many of the teachers who initially participated in the project, began to create a specific curriculum with a marine engineering theme. Lessons included such concepts as basic skills in ship and submarine design, buoyancy, displacement, motor movement, soldering, vectors, circuits and switches, ergonomic design, measurement of depth, biological sampling, and attenuation of light. The curriculum was designed to meet the National Science Standards Matrix (Attachment 1.)

The parts utilized to make the Sea Perch project include PVC pipe, wire, small motors, film canisters, wax, switches, small propellers, and other items. The students team up in small groups of two to three, and follow the build curriculum, learning concepts as they build, working together, and documenting their experience along the way. They then test their Sea Perch for buoyancy, learn to adjust the weight to attain neutral buoyancy, and then the class can field test in a pool or nearby body of water.

Although the experience of building a Sea Perch was successful for students and educators alike, it was felt that a "culminating event" would be an important way to apply what the students had learned. A competition could enhance the concepts learned, generate teamwork and team spirit, provide an incentive to students to achieve a goal, and allow additional aspects of engineering to be introduced. The Sea Perch Challenge was born!

The Sea Perch Challenge

The Sea Perch Challenge is a design competition that includes middle and high school students from a school district in Philadelphia, all of whom have build a Sea Perch underwater robot to compete in this one-day event. In teams of two, but with full support of their classmates in the stands, students put the Sea Perch through vehicle performance competitions which judge maneuverability and retrieval on a timed basis, and a third advanced recovery competition pits the winners against each other for a "blind" retrieval of an object after fitting their Sea Perch with an underwater camera.

In addition to the timed events, other team members must present their design workbook to a panel of engineers, and must discuss document planning, design, construction, testing, and perhaps most important, must articulate what they learned about working together to solve the problems that arose. In order to incorporate communications skills into the competition, team presentations are conducted as well, with a student sales team attempting to convince clients (judges) that their product is superior in design.

In order to enhance creativity, students are given a fifteen dollar budget for design enhancement, and they are judged on how well the creative designs were incorporated into the vehicle, and whether the design changes positively or negatively impacted their robot and its performance. Finally, team spirit and sportsmanship are also rewarded, with prizes going to those schools showing team spirit through cheering, posters, flags, school mascots, and excitement and pride.

The Sea Perch Challenge, beginning its third year, would not be successful without collaboration of many important partners: Industry, local school districts and administrators, higher education, nonprofit professional societies, and volunteers. The next section of this paper will describe the important aspects of collaboration and synergies that have developed that are crucial to the success of the Sea Perch Challenge.

Education, Collaboration, and Synergy

By providing participating students with the opportunity to interact with engineering students and engineers, tour engineering facilities, visit a major university campus, and experience presenting their product (their team's unique Sea Perch) in a competitive manner to perspective customers, the educational value of the Sea Perch Challenge extends well beyond the program's primary goals. Collaboration and synergy are crucial to meet the educational objectives of the Sea Perch program. The collaboration between government, academia, technical societies and industry has facilitated the synergy that has resulted in parlaying the benefits of the Sea Perch program into a multifaceted educational experience. These benefits will be explained in three sections: the development/build phase, the competition phase and continuing education phase.

Development/Build

The development/build phase consisted of students designing and building underwater ROVs to succeed in the competition. To ensure the development/build phase provided an educational experience, the first challenge for the Sea Perch technical program team was to motivate teams to do more than simply use the online instruction manual to build a working robot. The objective was to have the students consider potential applications for underwater ROV's and to understand engineering concepts critical to the design so they could configure their robot to perform its mission.

A realistic navy mission was developed to capture the imagination of the students and get them excited about the project. The theme of the mission was based upon the identification and/or engagement of threats, or support for salvage, rescue, recovery or repair missions in low visibility, underwater conditions. Teams were provided robot performance characteristics required for this mission (e.g. stable, agile, stealthy, remote video sensor capable, etc.) and challenged to design and build a ROV to meet the mission requirements. To enhance the realistic experience, teams competed for a "contract award" whereby the Sea Perch deemed "best design" is purchased by the Navy for the contract price of $100.

Variation in skill level of competing schools ranges from established robotics programs with teams that participate in high school engineering curriculums, Advanced Placement Science classes or Robotics Clubs, to teams with little, if any, experience in science labs, workshops, or advanced science programs. The Sea Perch program allows teams to participate and learn at their own pace, while fun remains a constant. Lesson plans were developed by naval engineers to teach topics such as "Determination of Mass, Volume, and Ballast of a Sea Perch ROV" and "Building a Simple Submarine" which teaches how to use ballast to control Sea Perch buoyancy. The lesson plans were designed to handle the diversity of student skill level and could be accomplished with common household items, thus allowing the teams with minimal equipment to receive the same experience as the teams with full science labs. In addition, the MIT Sea Grant website provided Sea Perch instructional and educational resources and a forum for sharing Sea Perch experiences via their website.

Teacher Training

To further ensure a successful project as well as increase the comfort level of the teacher, a two-day training session provides the opportunity for teachers to interact with naval engineers while building the complete ROV. (Attachment 2) In addition, online resources are discussed and explored, lessons learned from the previous year are explored, and finally, the teachers conclude with a water test of their newly built ROV. The training curriculum allows each teacher, regardless of engineering or science background, to become familiar with the ROV and its engineering principles at their own pace. During the training teachers have plenty of opportunities to ask questions, clarify concepts and receive helpful tips with experienced Sea Perch users. In addition, the teachers have the ability to continue to contact naval engineers for advice during the development/build phase for additional support and guidance.

Mentoring is another important part of the development phase. Having a naval engineer in the classroom helps the students understand the engineering principles as well as get a feel for what an engineer does as part of his or her career. Students can learn about possible careers in the fields of Naval Architecture, Marine, Ocean or Naval Engineering.
An engineer can reinforce the concepts teacher has taught and provide support, especially for teachers new to the project or engineering, and they can be especially helpful on soldering and wiring days.

Creativity

With an appropriate amount of effort, all teams can successfully accomplish most aspects of the development/build phase, since standard kits, instructions and lesson plans are provided. While this approach provides a relatively level playing field considering the varying skill levels of the teams, it also stifles the creative thinking process since teams are limited to the materials provided. A change was necessary to balance additional creativity while minimizing the risk that more advanced teams would significantly outperform their competition. The solution was to allow teams a budget of up to $15 in parts to incorporate design changes, thereby maximizing creativity while limiting the impact on vehicle performance due to disproportionate design changes.

The only restriction was that additional thrusters and/or more powerful motors could not be employed.

Through this additional funding, the desired result was achieved as teams made modest design changes that indicated thoughtful consideration of engineering principles, without development of a super ROV that left the competition in its wake. One example of this was a cone that was added to the bow of one team's Sea Perch to improve the hydrodynamic performance of the forward moving vehicle. While actual performance enhancement was not significant, the critical aspect of this was that students understood and considered the effect of hydrodynamics on the ROV. Other teams demonstrated similar critical engineering investigations by addressing improvements such as variable ballast, improved control, improved materials, resistance reductions, structural changes, and other architectural or engineering improvement strategies.

Documentation

The competition requires teams to complete a design notebook as well as an oral presentation on their development process. A design notebook requirement adds an element of discipline to the development phase and helps expose students to expectations for college level work. The notebook requires students to document their process and experiences and to further explore what they have learned or accomplished, by addressing specific questions regarding challenges, roadblocks, roles, and other aspects of the program. Teams are allowed to interact with advisors or mentors or to address technical questions to naval engineers staffing the program via e-mail.

Communications

The technical professional in today's world must be proficient in many areas, and not just a technical expert performing calculations at his/her computer. They must be effective collaborators, communicators, business people and marketers. An oral presentation requirement allows teams to explore and develop some of these skill sets and to present them in a realistic, technical environment. Teams play the role of a company sales team that must prepare a business case to present to perspective clients represented by a panel of experts from the navy, academia and industry. The goal is to convince the clients that they have an effective team that produced the best-designed Sea Perch at a competitive price. The presentation must address teamwork, design, performance, process, quality, budget, and other aspects including the diversity of their company/team. The result of this exercise is an impressive display of hard work and creativity, which demonstrates that students learned skills beyond building the Sea Perch and that they clearly enjoyed the experience.

Competition Day

In the competition phase, the goal is to make the experience the reward, rather than focus on winning the competition. Students are introduced to a big city college campus at Drexel University where plenty of Drexel student volunteers are there to help direct them to activity locations or to answer questions. The bleachers in the Drexel Indoor Athletic Complex are filled with energy as students cheer and respond to Master/Mistress of ceremony questions. Students watch the ongoing competition on large screens as they prepare for their vehicle performance competition. Teams are directed to other locations for their oral presentation competitions where they interact with the professionals from various walks of life. Fun, educational activities are provided during intermission such as liquid nitrogen, hands-on experiments or an opportunity for students to operate an actual industrial, underwater ROV.

However, the critical learning occurs when these future scientists, engineers and architects have the opportunity to accomplish the real world task of assessing the performance of their vehicle as compared to the competition. Some evaluate how they can tweak their design to perform even better in the future while others must consider whether a total redesign is necessary. There are life lessons as well as technical lessons that are learned where the rubber meets the road or in this case, where the propellers meet the water.

During oral presentation to clients/judges on competition day, students participate in a realistic experience that cannot be achieved in a traditional school environment. The clients are poised to provide positive feedback and to ask questions that stimulate students to elaborate on design methods used on their product. When necessary, the clients facilitate an open and positive environment and ensure all team members participate in the discussion.

Continuing Education

Lastly, the continuing education phase involves increasing the naval engineering knowledge throughout the K-12 community. This phase requires collaboration and synergy between K-12 schools, industry, academia and the Navy to achieve its continued success. Drexel University, through its summer engineering program for high school teachers, works with the Navy to arrange tours of the Naval Surface Warfare Center (NSWC), Land Based Engineering Complex. Here, teachers experience firsthand the unique, engineering facilities that encompass a broad range of general engineering disciplines. When teachers return to the classroom, they use what they have learned to present students with real life engineering applications, in this case, naval applications. Sea Perch teachers/advisors are encouraged to arrange for students to visit NSWC facilities or to have naval engineers visit Sea Perch schools for career day presentations.

In addition, four other local universities are working with Sea Perch in various ways: Villanova University uses engineering students to mentor Sea Perch K-12 students in Villanova Engineering, Science, Technology Enrichment, and Development (VESTED) program. Synergy continues as some of the Villanova volunteers are also members of the ASNE-DV student section, while others complete internships at NSWC; Temple University uses IEEE student members to mentor local teams participating the Sea Perch Challenge; Widener University has teamed with NSWC to present the Sea Perch program at Widener's summer education program for high school teachers; and Rowan University is working with a local high school to develop an autonomous version of Sea Perch.

Furthermore, the collaboration and synergy continue through a variety of additional activities: The school district of Philadelphia works with the Navy to provide presentations at various educational forums such as the national Science, Technology, Engineering and Math (STEM) conference. ASNE-DV invites student teams to participate in major technical symposia such as the Intelligent Ships Symposium (ISS) VII held at Drexel University in May 07, where students displayed their Sea Perch, presented their accomplishments to an audience of over 300 engineers and scientists, and interacted with engineers and exhibitors displaying their technology.

Distinguished, senior level naval engineers and scientists were awestruck to hear a group of middle school students address the large, technical audience as each student articulated his or her role in designing and building their Sea Perch. There is no better demonstration of value of the program in motivating and educating youth. Audience members were so impressed that they asked to schedule a Q&A session with the students in a separate room so the dialogue could continue. This event increased the visibility of the program, which parlayed into offers of sponsorship and volunteers by industry, academia and government attendees.

Synergy and collaboration plays a key role in the continued success of the Sea Perch program. Figure 1 depicts the interactions between key players in the Philadelphia area program:

Figure 1: Philadelphia Sea Perch Challenge Collaboration & Synergy

Introducing Sea Perch to students by providing a kit and instruction manual can provide a fun learning experience to any classroom. However, our vision extended far beyond that goal by providing a multifaceted educational experience facilitated by collaboration between students, educators, and technical professionals. The major partners in this effort included the Office of Naval Research, Naval Surface Warfare Center (NSWC) in Philadelphia, American Society of Naval Engineers-Delaware Valley Section (ASNE-DV), Drexel University, the School District of Philadelphia Office of College and Career Awareness, and the teacher/advisors and students from various high schools and middle schools in Pennsylvania, New Jersey, Delaware, and Maryland.

This became a "perfect storm" of collaboration since each element of the team has a different motivation for reaching the common goal of providing a fun and unique, science and engineering oriented, educational experience for students. The focus of the Navy (ONR, NSWC and ASNE) is to increase awareness and interest of naval architecture and naval engineering as a career field; Drexel University promotes engineering as an academic choice for college along with recruitment goals; the School District of Philadelphia promotes student interest in science and math with a focus on attending college; teachers create a unique classroom experience which promotes learning and teamwork; and the students have fun without realizing how much they are learning.

Due to the diverse abilities and resources of each partner, it would be extremely difficult for any single entity to create a similar experience, thus collaboration is paramount to success.

Program Assessment

Assessment of the Sea Perch Challenge Program, now entering its 3rd year, is mostly empirical at this early stage. From the Navy perspective, program goals include increasing awareness and interest in naval architecture and naval engineering and promoting those disciplines as career fields. In the Delaware Valley, literally thousands are now aware of naval engineering and naval architecture, directly attributed to the Sea Perch program. Included in this population are Sea Perch student team members, their classmates, family, friends, and teachers; the School District of Philadelphia Office of College and Career Awareness and school district teachers and administrators in well over 40 schools; University staff, administrators, student volunteers, and mentors; local robotics club members and administrators; Delaware Valley Industrial Resource Center and their partners; participants in STEM conferences and other science and engineering focused initiatives where Sea Perch Challenge has been presented; listeners of a local radio station programs on the Sea Perch Challenge; and readers of partners and participants' websites, billboards and newsletters where the Sea Perch program is discussed.

While it is too early to track student participants' career fields, at least two college interns who supported the Navy as Sea Perch program volunteers, have graduated with engineering bachelors degrees and are now working at NSWC Philadelphia full time as naval engineers. Furthermore, other undergraduate engineering students active as volunteers for Sea Perch have sought co-op positions at NSWC.

Another source of empirical data is feedback from Sea Perch K-12 students and teacher/advisors. Teachers report that students are motivated by this program and can't wait to get to school to work on it. Similarly, when used as an after school program, teachers report that students are equally excited to extend their school day. Teachers have commented the Sea Perch program provides an invaluable educational experience to their students and has advantages over other robotic programs such as F.I.R.S.T. or **B.E.S.T.** because the time investment is flexible depending on the skill level or desired level of sophistication that the team decides to pursue. This qualitative data of teacher feedback along with the quantitative data of Navy new hires, validates the Navy is achieving its goal.

Figure 2: Middle School Team at Philadelphia Sea Perch Competition

It is predictable that students appreciate any lab experience providing a break from the traditional classroom lecture, and historical education data supports that a student will learn more when they are interested and motivated. Furthermore, we can make inferences from reading the expressions on students' faces, experiencing the excitement during competition day, the growth of registrations, high retention rates of schools competing each year, the increasing interest and support of the engineering community, and other similar acknowledgements of the success of the program. However, the best indicator that we have on the value added to students' education is the quality of the product (Sea Perch, oral presentation and design notebook) each team develops.

In parallel with Navy metrics, Drexel University and School District of Philadelphia are developing metrics to capture progress towards their specific goals which are more broadly focused on STEM, and not specifically naval engineering and architecture example, Drexel University tracks the students involved in Sea Perch that attend their high school engineering summer programs and are working on methods to track those that later attend Drexel University as engineering students.

Much needs to be done to effectively capture meaningful data to objectively assess this program and to optimize our ability to meet the ultimate Navy goal, which is graduating engineers and architects selecting careers in targeted naval disciplines. Unfortunately, tracking individual students requires significantly more resources than the current program can support. In addition, much of the data is difficult to assess. For example, while a student may have participated in the Sea Perch program, the student may have been interested in a naval engineering career prior to Sea Perch due to a family member in naval engineering or another event that sparked their interest. Until the process matures, we must rely on empirical data, which tells us we are making a difference by motivating students' interest in science and engineering, and increasing awareness in naval engineering and architecture career fields.

The Future

The success of the Sea Perch Challenge, as well as the success of MIT in introducing many high schools to the program in the New England area, convinced the Office of Naval Research, MIT, and The Society of Naval Architects and Marine Engineers to attempt to develop the program further, utilizing the successful Sea Perch Challenge model developed by the American Society of Naval Engineers. The goal will be to grow the Sea Perch Program into a national program within the next five years, beginning with the Washington, DC area in 2007/2008, and expanding throughout the U.S. regionally, as interest grows.

Several components are crucial to begin to develop a program within a geographical area. First and foremost, a champion is necessary. That person who will be responsible for moving things forward, bringing people together, energizing them, and knowing the right people to engage. The other components required to begin a Sea Perch program are: An interested school district, local industry willing to support the program, a local university or college interested in partnering and hosting the competition, committed teachers, and of course, parents willing to support the program. Without any of these components, the model does not succeed, but when these important components are present, great things can happen.

The Society of Naval Architects and Marine Engineers, through funding from the Office of Naval Research, has dedicated a staff person to work directly on this Outreach effort. This staff person has the responsibility to find and locate potential areas of interest, help bring the right people to the table, help them organize and plan, provide the marketing and public relations to support the effort, and to provide them with a number of Sea Perch kits and tool kits to assist them in the early stages of their efforts. The long-term goal of is to make the individual programs self-sustaining, as Philadelphia's Sea Perch Challenge is, which makes the industry support so vital.

If the program is successful, in five years, there will be a national Sea Perch Challenge, attended by schools across the country, and the awareness and excitement about potential careers in naval architecture, marine, ocean and naval engineering, will produce the next generation of scientists, engineers, academics, and technical experts so vital to the security and infrastructure of our nation.

Conclusion

The educational debate continues over the accuracy of statistics used in assessing the "engineering gap" between the United States versus China and India, along with predicted consequences of outsourcing and a reduced American standard of living. However, most will agree that it is desirable to increase the amount of students oriented towards STEM fields of study. When considering naval architecture and naval engineering fields, failing to produce a base of qualified, technical college graduates to fill these positions could impact national security, as these positions perform the design, acquisition, production and lifecycle support of our national naval assets. The Sea Perch program provides a fun, educational and challenging way to reach out to students in middle and high schools and get them interested in STEM fields, with a focus on naval architecture and naval engineering. Early indications demonstrate the program is effective.

As the Sea Perch team seeks to capture more meaningful metrics on the effectiveness of the program, we rely on feedback from Sea Perch participants who are excited about their involvement in the program and indicate that interest is growing. As the program attempts to expand into a national level, we must rely on community involvement whereby academia, industry and government work together towards the common goal of measuring and optimizing the benefit of the program for each stakeholder. This means nationally, all involved with Sea Perch must share lessons learned on the tools and techniques that make the educational aspect of Sea Perch more effective. The Sea Perch community of practice must develop new and innovative ways to make the Sea Perch not just a self-contained program, but a foundation for expanding the interest of students in STEM related fields of study.

The dedicated teacher/advisor is the key to success, for no matter how great, interesting or well supported the educational program is, it is the advisor that has the task to translate that program into one that works as an in-class or after class activity. As program visibility and momentum builds, the natural expectation is it becomes self–perpetuating, with more academia, industry and government agencies become involved. Whether developing the next innovative lesson plan/experiment, providing in-class support to the advisor as a team mentor or guest speaker, sponsoring or participating as a judge in the competition or coming up with an innovative way to engage the students in a STEM related activity complimenting the Sea Perch program, it is ultimately this community of educators that will determine the program's success.

For hundreds of students in the Delaware Valley, the Sea Perch program has already demonstrated that naval architecture and naval engineering can be an interesting, challenging and rewarding career field. In addition, Sea Perch has provided a positive classroom experience to both advisors and participants. This includes significant participation from schools with diverse demographic populations, which the Navy concludes will provide a significant source of future employees. Expanding the program to a national level will have a positive impact on students, on Navy goals, to the academic, industry and government community, and to our American society in general.

Bibliography

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3. Office of Naval Research and The Society of Naval Architects and Marine Engineers website, www.seaperch.org

1.0 National Standards Met Through the Sea Perch Project

National Science Standards Matrix for Sea Perch Project

Activity	Grade Level	National Science Content Standard							
		U	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Building the Frame	9-12	X	X				X		
- measurement - design - buoyancy									
Building the Motors	9-12	X	X	X			X		
- motor movement - vectors - soldering - water proofing									
Building the Control Box	9-12	X	X	X			X		
- circuits and switches - reading wiring diagrams - ergonomic design									
Experiments/Field Use									
Buoyancy Activity	9-12	X	X	X			X		
Student Design Modification	9-12	X	X				X		
Measurement of Depth	9-12	X	X				X		
Biological Sampling	9-12	X	X		X		X	X	X
Exploring the Sites and Sounds of Underwater	9-12		X		X		X	X	X
Making a Circuit	9-12	X	X	X			X		
Attenuation of Light	9-12		X	X			X	X	X

KEY: Content Standards:	
U = Unifying Concepts and Processes	D = Earth and Space Science
A = Science as Inquiry	E = Science and Technology
B = Physical Science	F = Science in Personal and Social Perspectives
C = Life Science	G = History and Nature of Science