

Twiddlefish STEM activity inspired by Research for Teachers Opportunity

Carrie Lewis

Spending a summer in the biomechanical engineering laboratories with M3Lab researchers gave teacher, Carrie Lewis, an insight to current challenges and methods being applied to create an autonomous underwater vehicle based on sting rays. She used the university engineers' research processes to transfer the learning at an elementary level modeling in fish. Instead of building robots out of welded metal, the students are using Lego rods and Mindstorm® Motors.

What an exciting moment it was when I was selected to be part of the University of Virginia's Research Experience for Teachers (RET) Program by the UVA Center for Diversity in Engineering for Summer 2010. Being a 60 year old woman definitely made me a minority in the field of engineering! I have always loved science and been an active inquirer, encouraging my students in elementary and middle school to do the same; so it was with much anticipation that I headed off to join the ranks of young folks participating in RET last summer (2010). Little did I know that every day I'd be energized by all I was learning and affirmed by the active roll I took in ongoing research in the Bio-mechanical Engineering M3 lab.

The researchers at the Multi-scale Muscle Mechanics (M3) Lab were working in conjunction with the bio-inspired Engineering lab to study the form and function of sting rays and develop a robotic model emulating their movements. The robot design goal included being easily maneuverable, energy efficient, and quiet.

From the first lab meeting, when the PhD candidates took the time to describe their different pursuits, I thought, "The kids would love working on a project like the sting ray!" However, I knew that using actual sting rays was out of the question for practical reasons at Dearington Elementary School of Innovation (DESI) in Lynchburg, Virginia, where I teach STEM and serve as a math resource. However, study of fish would be possible, so the idea was born. I took each step of the UVA researchers' processes and mirrored them in a unit created for young students, giving it the title: *Twiddelfish Robotics*.

The unit was planned with levels of inquiry, since all our K-5 students come to STEM lab. Figure 1 compares and aligns the Twiddlefish activity with the higher level engineering research being pursued at UVA's M3 and Bio-inspired Labs. Supplies were collected for use during the unit and a price list was created so other teachers could duplicate it. Some of the components purchased were,

- Lego Mindstorms© Motors

- NXTBrick®, an acrylic
- water container longer than the standard aquarium,
- soft plastic polymer,
- dye for plastics
- clay
- bendable wire
- many long Lego axles and connector cables.

Other items used are normally available around homes ; a single-burner hot plate, spare plastic soda bottles, styrofoam scraps , waterproof tape, wire cutters, small Glad® disposable sandwich size containers, and cool temperature glue guns.

Figure 1

BioMechanical and Bio-Inspired Engineering	DESI Stem Unit
Study of Sting Ray in vivo	Visit aquarium, observe movement, close look at many fish, including measurements and determining body/fin/tail proportions
MRI of Rays to see inside	View fish skeleton x-rays, measurements of length
Determining movement and motion trajectories	Journaling about movement: linear? "s-shaped", backwards? And determining what body part is providing the energy for motion
Creation of computer model, both static and moving	Designing the ideal fish molding from plastic, testing movement in water by twiddling. Pick of best shape from class
Designing robotic ray fin	Re-creating prototype of fish, installing Lego rods for hookup to motor. Design water vehicle to house motor safely
Collaboration with Wood's Hole researchers	Skype with UVA M3 lab researchers
Making a program to move robot	Using Lego Mindstorms to program movement. Limited to variations of speed, frequency, degree of movement, or rotation
Test and record data of performance	Test and record performance data
Create charts and graphs of data	Create charts and graphs of data
Consider data and re-design or make improvements	Consider data and re-design or make improvements
Communicate discoveries and invention to others	Presentation /video Show for parents, PTO, school community

Using the glue guns, cutting bottles and Styrofoam with Exacto® knives (adults only), and heating of the polymer for the plastic all dictate careful attention to safety. When the fish were molded, the class went outside in fresh air, wore goggles, used hot mitts, and stirred with high temperature spatulas, all under close teacher supervision.

During *Twiddlefish* experiences students integrate the processes and content from many State and National Science standards as they investigate, experiment, do background research, and observe fish.

The Primary level students learn from a variety of SOL's in Math, Science, and technology:

VA SOL Science 2.1,3.1 Scientific Investigation
VA SOL Science 3.2 Simple Machines Science
VA SOL Science 3.3 Physical characteristics
VA SOL 3.4 Science Physical adaptations Science
VA SOL Math 2.15, 2.19 Creating and interpreting bar graphs
VA SOL Math 3.9 Estimate length and use measuring devices
VA SOL Math 3.17 Organize data

Intermediate students learn both process and content in the following Virginia State SOLs:

VA SOL Math 4.11 Lines of symmetry and transformations
VA SOL Math 5.8 Measuring and converting to equivalent measurements
VA SOL Math 5.16 Measures of central tendency
VA SOL Science 4.1, 5.1 Scientific Investigation
VA SOL Science 4.2 Characteristics of moving objects
VA SOL Science 4.5 Structural adaptations
VA SOL Science 5.4 Compounds, solvents, solutes & solutions
VA SOL Science 5.6 Ocean Environments

The National Science Standard concerned with **unifying concepts** is fulfilled as the children identify relationships between form and function. Students document **change and consistency** using their measurement data too. *Twiddlefish Robotics* integrates National Science Standards in these content areas;

Standard A .Science as Inquiry – as the students become independent inquirers testing the efficacy of their fish

Standard B. Physical Science- position and motion (K-1), Motion and Forces (5-8)

Standard C. Life Science- Characteristics of Organisms (K-4) Structure and Function in Living Systems (5-8)

Standard D. Science and Technology- all levels participate in stating a problem and designing a solution

Student assessment during *Twiddlefish* is four-fold. 1) Teacher anecdotes are compiled as formative assessment of skills such as collaboration, grasp of new concepts, connections realized, and creation of Mindstorm® programs to be implemented are all noted. 2) Reflective journals kept by the students are read and class discussions, similar to the M3 Lab meetings, are held every several weeks. 3) Students have rubrics to assess their own skill in collaboration, and note new discoveries rating how their designs work or don't work. In our class experience, it was amazing how the kids all jumped in to make suggestions as to program changes when one child's fish only spun in a circle! This was indeed a process of trial and error for the children, but each trial provided more learning and improvement. Additionally, they learned from each other, and began to value the information presented /taught at the introduction of the lesson, now realizing that their designs should reflect prior research from living creatures that can and do move. 4) The ultimate assessment was whether their fish could propel the vehicle a distance in the water trough.

From a teacher's perspective, we hit a few unexpected snafus. There were absolutely no fish markets in the Lynchburg area who sold fish complete with heads! Apparently, these days, they are shipped already headless and gutted. Fortunately, a DESI colleague volunteered to fish in the James River for me, and another friend brought fish back from a beach trip packed on ice for our measurements and proportion studies. Filling the water tanks was no problem, but emptying them was a different story. Too heavy to pick up, the kids experienced gravitational pull and siphoning first hand, in order to drain the water out and refill with clean water for continued testing. The wires originally inserted in the fish needed angle adjustments, necessitating the re-molding of some teams' fish and slowing our timeframe a bit.

Once the students were introduced to the *Twiddlefish*, they were instantly hooked. Their focus and interest was riveting; many begged to be allowed to come in during recess or more often than the class was scheduled. There were frustrations when the Skype® cameras had difficulties, or the Mindstorms downloads ran into bureaucratic red tape, but the interest held and determination to figure out what to create, how to create, and how to test their fish was contagious. As we have almost completed the first cycle of classes to experience *Twiddlefish*, others are clamoring for a chance too! The children are realizing that that they **can** and **are** doing engineering.

There was much parent interest too. Folks would come to school to see what their child was making. As one girl said, “This is the most fun and yet most scary thing I’ve ever done in school.” When asked to explain, she said she realized she could plan and do what she wished as far as making a fish, boat, and computer program; but it occurred to her that in the end, she was the only one responsible, and if it flopped she would be mortified. I pointed out that was like all learning. In the end, she needed to own the responsibility for her learning in any subject!

Carrie Lewis is a S.T.E.M. and math teacher at Dearington Elementary School in Lynchburg, VA. She can be reached at CSLewis5819@aol.com.