

Arizona Project WET – Arizona Department of Water Resources

Semi-Annual Progress Report

Tucson AMA

January 2019 – July 2019

I. Introduction

Arizona Project WET (APW) entered into a 1-year Intergovernmental Agreement (IGA) with Arizona Department of Water Resources in 2019 to educate K-12 students about Arizona's interconnected water resources and their importance to our future in support of Tucson AMA's statutory goal of safe yield.

The Scope of Work defined in the IGA encompasses a multi-day Engineering Academy for teachers, expansion of existing Direct Student Outreach and Arizona Water Festival programs, and continuation of Equipment Loan Program for classrooms.

Arizona Project WET (APW), an arm of the University of Arizona (UA) Cooperative Extension, develops and delivers targeted programs to accomplish two overarching goals through three pathways. APW develops water stewardship and STEM (Science, Technology, Engineering and Math) literacy by: 1) providing teacher professional development to evolve instructional practices and deepen content knowledge, 2) direct student outreach to deliver or extend classroom learning, and 3) community engagement to effectively involve adults in K-12 education.

II. Teacher Professional Development

Arizona Project WET Teacher Academies offer professional development that evolves teachers' instructional practice and water-related content mastery through STEM integration, student-directed learning, real-world and relevant application, and collaborative work. Academies provide the support that teachers need to adopt instructional practices that encourage students to apply their learning to develop ideas, design solutions, and deliver positive change. As a result of our academies, students will be taught to think critically, gain deeper understanding, and evaluate, prioritize and apply knowledge to find solutions. APW's multi-day Teacher Academies and one-day workshops help teachers meet the goals of the Arizona College and Career Ready Standards and the new State of Arizona Science Standards which include Science and Engineering Practices.

APW delivered the third *Underwater Robotics and Engineering Design Academy* on July 9-12th at the University of Arizona. During the Academy nineteen teachers 1) investigated Central Arizona Project (CAP) operations, 2) gained an understanding of how Remotely Operated Vehicles (ROVs) are used in the water industry, 3) engaged in the engineering design, building and testing of marine ROVs, and 4) developed an understanding of buoyancy, hydrodynamics, forces, energy, electrical circuitry, wiring, soldering and control systems.

Over the course of the academy teachers designed, built and tested a pumping system to deliver water uphill across a distance simulating the operations of the CAP canal; and an underwater ROV to accomplish tasks similar to those performed by ROVs operators on the CAP canal. A portable pool was used for intermediate design testing. On the last day, teachers showcased their designs in a final competition at the University of Arizona Recreation Center pool. The agenda is included in the Appendix. This workshop was delivered using a



Testing CAP Delivery System

combination of curriculum from both APW and Marine Advanced Technology Education (MATE), the underwater ROV design and training company.



ROV Testing



Building the Control System



Final Competition

The teachers posted learning gains in all areas of the workshop as measured using the following equation:

$$\frac{(Post\ Survey\ Avg - Pre\ Survey\ Avg)}{Pre\ Survey\ Avg} \times 100\%$$

Teachers reported an overall learning gain of 127% for the topics related to understanding Central Arizona Project operations and the use of ROVs in the water industry. Other overall learning gains achieved included: 50% on engineering design topics and 60% in Electrical Skills. Details are outlined in the following graphs.

2019 Engineering Design & Underwater Robotics Academy
Rate your skill level in these areas pertaining to Remotely Operated Vehicles (ROVs)

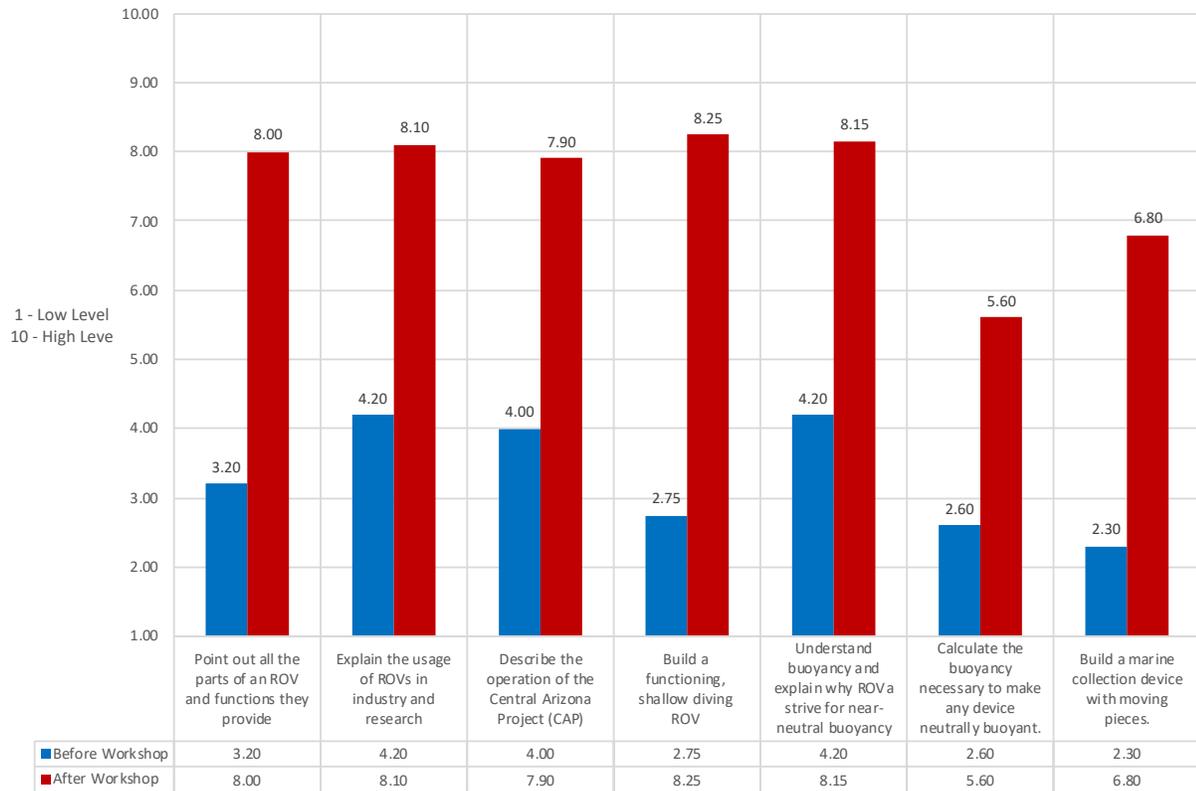


Figure 1 – Understanding of CAP and ROV Topics

2019 Engineering Design & Underwater Robotics Academy
Rate your comfort level with the Engineering Design Process

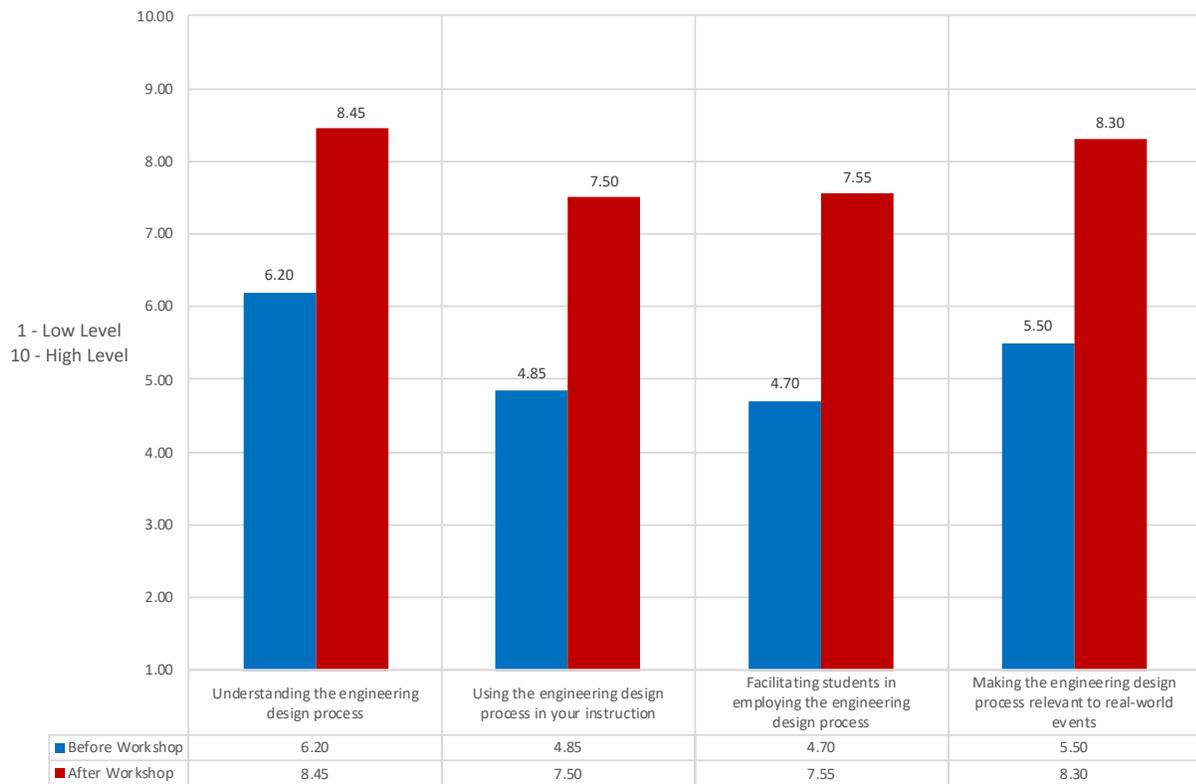


Figure 2 – Engineering Design Process

2019 Engineering Design & Underwater Robotics Academy Rate your skill level in Electrical Knowledge

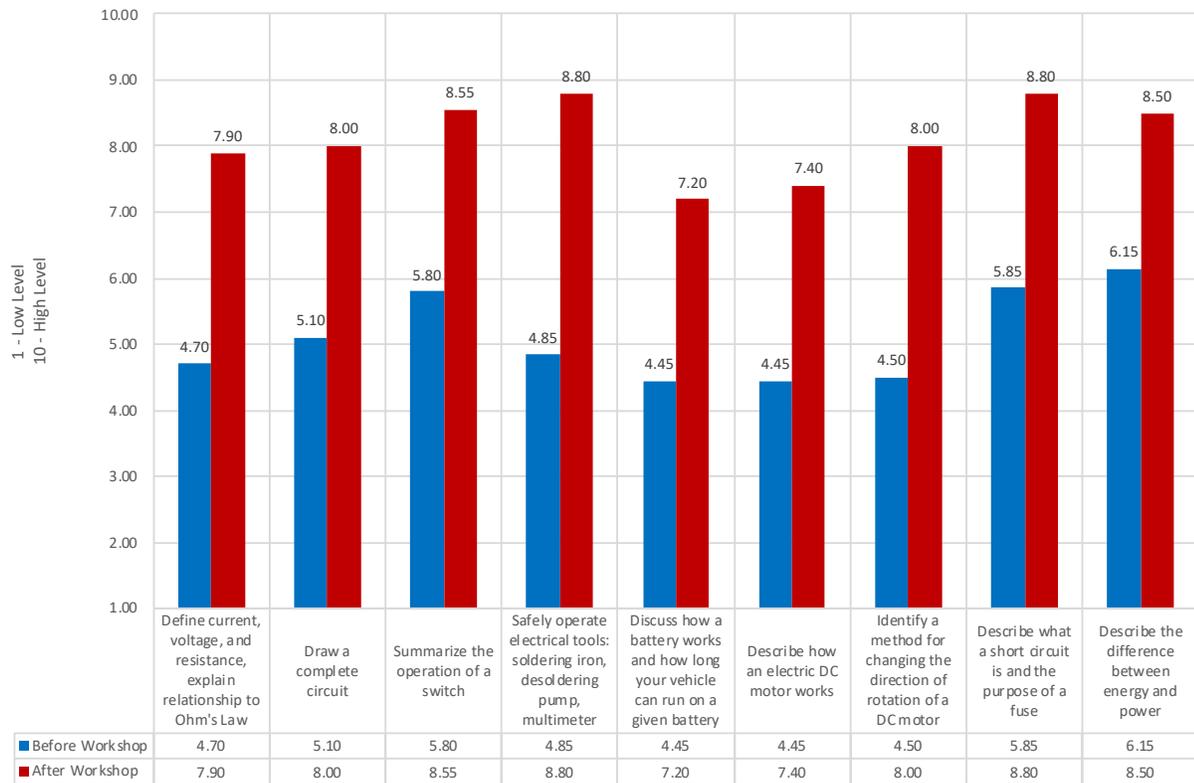


Figure 3 – Electrical Knowledge

2019 Underwater Robotics & Engineering Design Workshop Evaluation Results % of Responses "Strongly Agree/Agree"

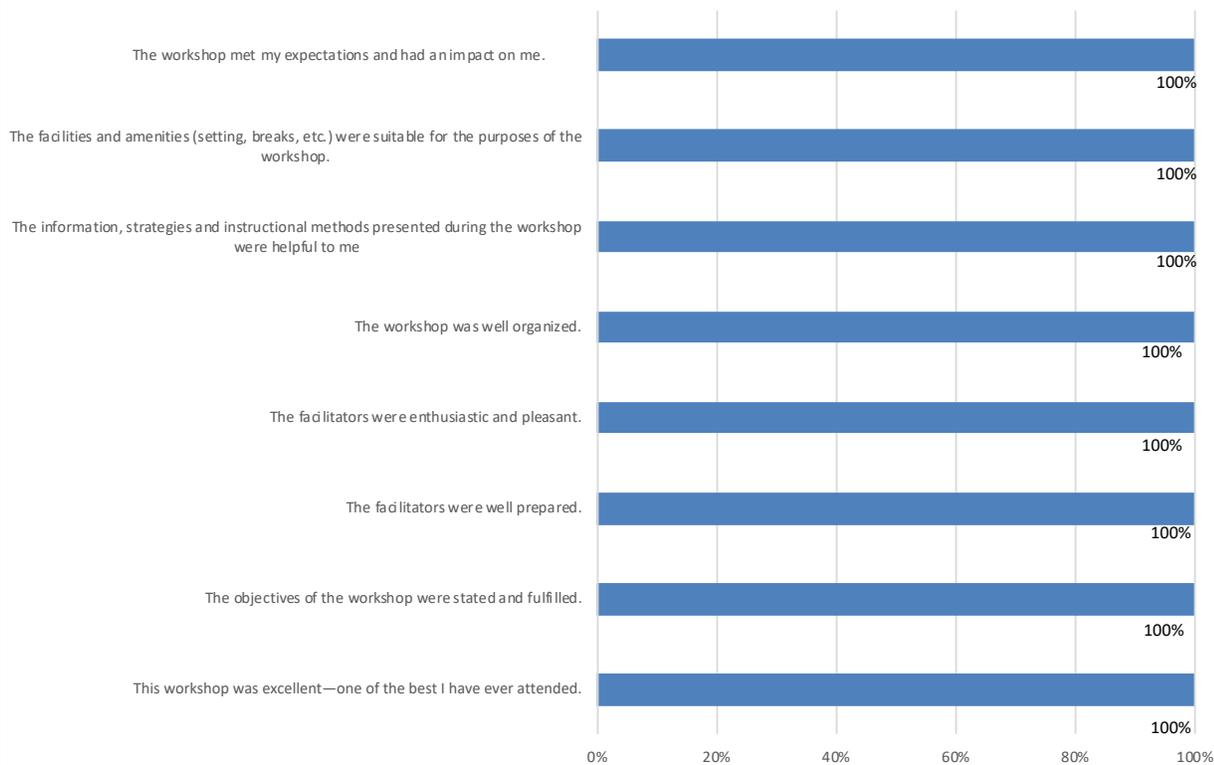


Figure 4 – Workshop Evaluation

Overall, the teachers deemed the academy a huge success! Post-academy, APW requests that teachers evaluate the workshops utility and efficacy using a standard set of questions rated on a Likert scale from 1 (strongly disagree) to 5 (strongly agree). **In this workshop, all the questions received 100% responses of “Strongly Agree” or “Agree.”**

Teachers were very enthusiastic about this academy. ***“Fantastic job. I have never been to a workshop where I walked away with the equipment and expertise I needed to begin creating an afterschool program for my students. Thank you all very much.”***

“Betsy, Holly and Lauren were very knowledgeable and helpful throughout the whole process. Thank you for your time and energy to help other teachers use ROV's, successfully. you rock!”

Teachers are moving forward with the integration of underwater ROVs in their instruction. APW provides demonstration ROV equipment for teachers to use with their students as an introduction to the material. The teachers are providing authentic hands-on learning for their students, ***“Great workshop! I enjoyed participating in the workshop and feel encouraged to delve into more projects allowing my students to get hands on!”***

The next step is for teachers to create teams of students to participate in the ***2020 Arizona MATE Regional Competition*** in April 2020. This exciting program engages students in the engineering design process while building valuable STEM and problem-solving skills within the context of understanding water resources and management in Arizona.



A Successful Week!

III. Direct Student Outreach

3rd Grade Sweetwater Wetlands Water Festival

The Sweetwater Wetlands Water Festival is an event designed to synthesize students’ conceptual understanding of the entire water unit. The Sweetwater Festival consists of lessons on the Water Cycle, Water Conservation Technology and Watersheds, which have been adapted from the Arizona Water Festival model. During the fourth lesson, students explore the wetland ecosystem and reflect on the

uniqueness of the place. In the Spring Semester of 2019, **APW Tucson provided 8 Sweetwater Wetlands Water Festivals reaching 484 3rd grade students from 8 schools, and 22 classes.**

Teachers administer pre-assessments to students prior to their Sweetwater visit. Pre-assessments are provided to teachers when APW educators come in to deliver the groundwater flow model presentation. The corresponding post-assessment is administered during the festival after each lesson via a booklet that students wear around their neck on a lanyard. Copies of the assessment instrument are available in the attachments section. **Overall, student learning increased 52% as measured by the percentage of correct responses in the pre- and post-assessments.**



*Students Exploring Watershed Model
At Sweetwater Wetlands*

This years' assessment, as in the past, showed that 3rd grade students often understand how individual actions can conserve water prior to the water conservation lesson. The lesson was modified three years ago to introduce the use of technology as a means of saving water. **Students showed a 138% gain in learning about using technology to conserve water, compared to an average 4% learning gain for the concept that individual actions can conserve water.**

An average learning **gain of 230%** was recorded for the concepts that a "*Watershed is a **land area** that drains to a **low point**, and water in a watershed moves because of **gravity**.*" Students gained **175%** in understanding the concept that, "*The wetlands provide food, shelter and water.*" **Understanding of the water cycle increased by 87%.**

6th Grade Groundwater Presentations

Arizona Science Standards incorporate earth science and water concepts into the middle school curriculum. APW Water Educators provide a 1-hour groundwater presentation to middle school classrooms as an integral part of their science curriculum. The science standards were written to have older students spiral back to important concepts to build on the foundational knowledge acquired in earlier grades. For APW, first and foremost, that content is groundwater, the least understood and least taught part of the hydrologic cycle. **In Spring 2019, APW Water Educators facilitated 10 classroom presentations, reaching 185 students and 3 teachers in 3 schools in the Tucson area.**

The lesson was revised this year to add local relevancy requested by teachers, emphasizing the use of the groundwater system as a tool for managing CAP water and the work of Tucson water to treat TCE water in addition to the key concepts that are core to understanding groundwater: 1) *Groundwater is in the pore spaces between sand grains, gravel and other particles*, 2) *Groundwater flows, because gravity works below ground just like it works above ground*, 3) *Groundwater is part of the water cycle*, 4) *Groundwater and surface water are connected*, and 5) *We use groundwater in our homes*. Students use *ThinkBlocks®* to build a conceptual model of the groundwater system including the parts of the system, labeling inputs and outputs, describing the relationships of the parts of the system, and connecting the groundwater system to other systems.

The assessment was modified to allow students to demonstrate their understanding of the groundwater system by adding to pre-created drawings. Through the drawings, students were able to show that *groundwater is in the pore spaces underground*, that it moves, that *groundwater is connected to surface water*, and that *we manage our water supply through the groundwater system*. **The students, taking the new assessment, averaged a 68% increase in overall learning.**

3rd Grade Groundwater Presentations

A one-hour classroom presentation facilitated by APW Water Educators is an integral part of the 3rd grade water curriculum in Tucson and Flowing Wells Unified School Districts. Using the individual groundwater

models, Water Educators build foundational knowledge by asking questions and facilitating learning. Students learn that: 1) Groundwater is between the grains of sand and gravel, 2) Groundwater moves through sand and gravel due to gravity, 3) Groundwater is connected to surface water, 4) Groundwater is part of the water cycle, and 5) We use groundwater. Students are directed through a hands-on exploration of each of the concepts and then directed to a whiteboard to understand the visual representation of the concepts in a 2-D model. Lesson scripts are available upon request. **APW Water Educators conducted 19 in-classroom presentations for 447 3rd grade students and 20 teachers at 8 schools.**



*3rd Grade Students Interacting
With Groundwater Model*

The assessment covers the main ideas of the lesson and requires students to make connections between illustrations and the text as outlined in the Arizona English Language Arts/Literacy standards. The assessment is administered before and after the lesson. **Overall students' knowledge gain averaged 63%.** (Appendix, Figure 18) The highest gains in learning were for the concepts, *Groundwater is connected to surface water*, 92% gains, and *Groundwater moves through sand and gravel due to gravity*, 87% gains.

Water Scene Investigation Program

The Water Scene Investigation (WSI) program offers students an opportunity to apply their learning and skills regarding water audits and water efficient technology at home. Water Scene Investigators measure the average flow rate of their bathroom faucets before and after the

installation of a new water efficient aerator, and interview family members about their water use patterns. Back in the classroom, they file their report online and compare their water savings to others at the WSI Reporting Portal <https://arizonawet.arizona.edu/node/add/report-water-savings>.

APW facilitated the WSI curriculum at 5 schools for 287 students. Seventeen students installed a water efficient aerator on a home bathroom faucet and reported a projected water savings of 100,794 gallons/year on APW's website.

Discovery Program

Participants in the Sweetwater Wetlands Discovery Program utilize an iPad App to explore the wetlands through the lens of a hydrologist, botanist, ornithologist or wildlife biologist. Students build a sense of place as they travel through the wetlands doing various scientific investigations. APW fine-tuned the program this year, melding the four science journeys into one larger path that allows students maximum time for investigation and discovery while decreasing their walking time. Students physically measure the depth to groundwater and compare that measurement with data from a data logger (installed with Tucson Water's assistance). They also record phenology data and sample and identify macroinvertebrates.

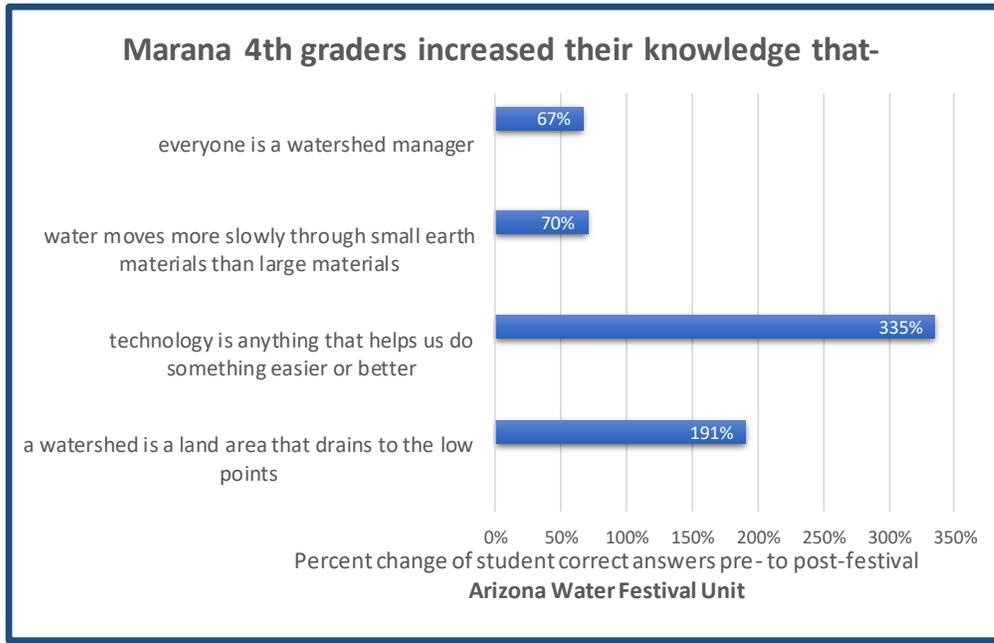
In the spring of 2019, 175 students from 9 classes in 4 field trips participated in the Discovery Program.

IV. Arizona Water Festivals

Arizona Water Festivals (AWF) instill a deeper understanding of water in the earth system and Arizona's water resources through a community water festival event, teacher professional development workshop, and extensive volunteer and community involvement. The AWF program first engages teachers in professional development that builds understanding about water and water resources, knowledge not covered in a primary grade teacher's preparation. After attending the workshop, teachers implement the standards-aligned curriculum modeled in the workshop, which prepares students for the water festival. The curriculum also deepens students' investigatory learning subsequent to the water festival. The one-day Community Water Festival has trained volunteers from the community engaging up to 1,000 children

in an interactive and fun exploration of the groundwater system, watersheds, water conservation technology, and the water cycle.

The water festival program in the Tucson metropolitan area reaches school districts that do not bring their students to Sweetwater Wetlands as part of their curriculum in 3rd and 4th grade. In its fourth year, the Marana Water Festival will be held on November 14, 2019 at Crossroads Park. The Marana Water Festival serves students in Marana School Districts not reached by the Sweetwater Wetlands Water Festivals. Last school year a total of 470 students, 18 teachers and 49 parents participated in the Marana Festival which was delivered by 18 volunteer facilitators. Learning gains are depicted in the table below.



IV. Water Quality Testing

APW provides support to teachers who implement drinking and riparian water quality testing with their students. Training on the use of the drinking water kits is offered at the Tucson STEM Academy. Teachers check out testing kits to use and report back as to their use with their students. Tucson Water Quality reports, data tables, directions, and APW's *How To* videos are available for drinking water kits. **APW supported 12 classrooms and 4 teachers in the use of the water quality kits totaling 313 students.**

V. Conclusion

Strategic support for APW provides effective educational opportunities to an extensive network of educators, young adults and children. We appreciate your partnership in helping to ensure that Arizonans understand their interconnected water resources, are conservation savvy and are prepared to help ensure a safe reliable water supply.

Appendix

**Underwater Robotics and Engineering Design Academy
Arizona Project WET
Using MATE Summer Institute Curriculum SeaMATE ROV Building
July 9-12, 2019**

Classroom & Shop
University of Arizona Agriculture Technology Education Center
4101 N Campbell Ave. Tucson, AZ 85719

Day 1	Tuesday July 9, 2019	Location	Presenter
TIME	ACTIVITY		
8:30 – 9:15 am	Goals for the course and logistics <i>Participant Expectations: What do you want out of this?</i>	Classroom	Betsy
9:15 – 9:45 am	Engineering Design Process	Classroom	Betsy
10:00 – 12:00 pm	Pump it Up! – Engineering the CAP canal	Classroom	Holly
12:00 – 1:00 pm	LUNCH		
1:00 – 3:00pm	What is an Engineer & Exploring different designs with ROV in a Bag	Classroom & Outside	Betsy
3:00 – 3:30 pm	ROV 101 and Mission Brief (based on CAP)	Classroom	Lauren
3:30 – 5:00 pm	Review frame section and design your frame Tool Bags	Classroom	Lauren

Homework:

Entrepreneurial Exercise: Come up with a company name, ROV name, and tagline. Develop a project management schedule.

Day 2	Wednesday July 10, 2019	Location	Presenter
TIME	ACTIVITY		
8:30 – 9:00 am	Share company name, ROV name, and tagline	Classroom	Holly
9:00 – 10:15 am	Electronics: <ul style="list-style-type: none"> ▪ Multi-meters ▪ Simple Circuits ▪ Batteries, fuses, and power 	Shop	Betsy, Holly, Lauren
10:30 – 12:00 pm	Soldering Skills <ul style="list-style-type: none"> ▪ Basic soldering of wires and waterproofing <ul style="list-style-type: none"> ○ Power System ▪ Soldering Components to a PCB 	Shop	Betsy, Lauren
12:00 – 1:00 pm	LUNCH		
1:00 – 1:30 pm	Team Building – Roles for Competition	Classroom	Lauren
1:30 – 2:00 pm	Soldering MATE Practice Board	Shop	Betsy
2:00 – 5:00 pm	Building Your Control Box	Shop	Everyone

Homework:

PhET:

- <https://phet.colorado.edu/en/simulation/circuit-construction-kit-dc>
- <https://phet.colorado.edu/en/simulation/ohms-law>
- <https://phet.colorado.edu/en/simulation/resistance-in-a-wire>

Review MATE Competition Tech reports. <http://www.marinetech.org/tech-reports/>

Day 3	Thursday July 11, 2019	Location	Presenter
TIME	ACTIVITY		
8:30 – 8:45 am	Questions and Comments	Classroom	Everyone
8:45 – 9:00 am	Introduction to System Integration Design	Classroom	Betsy
9:00 – 11:00 am	Finish building the ROV	Shop	Everyone
11:00 – 12:00 pm	Hydraulics	Shop	Betsy, Lauren
12:00 – 1:00 pm	LUNCH		
1:00 – 1:30 pm	Shroud Design	Shop	Betsy, Lauren
1:30 – 4:30 pm	Buoyancy and Ballast Testing ROVs	Shop	Everyone
4:30 - 5:00 pm	ROV Safety Check	Shop	Everyone

Homework: Density, Buoyancy, and Force Diagrams - PhET Lab

Parking at Mansfield Middle School 1300 E 6th St, Tucson, AZ 85719

Competition at UA Student Recreation Center Pool 1400 E. 6th Street, Tucson, AZ 85719

Day 4	Friday July 12, 2019	Location	Presenter
TIME	ACTIVITY		
7:30 – 7:45 am	Check-in and Competition Overview	Student Rec Center	Holly
7:45 – 9:30 am	Competition	Student Rec Center	Everyone
10:00 – 10:30 am	Travel Back to Agriculture Technology Education Center	Classroom	Everyone
10:30 – 12:00 pm	Troubleshooting <ul style="list-style-type: none"> ▪ What to do when something goes wrong? ▪ Troubleshooting exercises 	Classroom	Betsy, Lauren
12:00 – 1:00pm	LUNCH		
1:00 – 2:15 pm	<ul style="list-style-type: none"> ▪ The MATE Center ▪ MATE ROV Competitions ▪ SeaMATE Store and Kits ▪ Student Learning Outcomes 	Classroom	Betsy, Holly
2:15 – 3:00 pm	How to get started – classroom implementation – funding – equipment	Classroom	Lauren
3:00 – 3:30 pm	Wrap-Up & Post-Evaluation	Classroom	Everyone

Funding Provided by:



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