WaterMobile & WaterTalk– Teaching K-12 Students about Water through Hands-on Experiments

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Abstract: WaterMobile and WaterTalk are two activities that were developed for K-12 students and educators to assist in workforce development for the water/wastewater utilities. Utilities are involved in many types of water related activities that relate to water treatment, understanding forces of water, measurement of water quality parameters and much more. These two activities specifically bring forth STEM careers relevant to the water/wastewater utilities.

Keywords-water, K-12 education, STEM, workforce

I. Introduction

Inside the confines of the classroom, K-12 students receive little to no exposure to what comprises the water and wastewater workforce and what these essential workers do on a daily basis. At secondary and higher education levels, students often struggle to translate concepts from their coursework to real-life practice. Our current generation of youth is the most technologically savvy to date; as such, they have much to contribute to the drinking water and wastewater utilities sectors given the greater likelihood of integration of technology in the optimization of various processes. The water workforce is at grave risk of an aging workforce that is eligible for retirement [1-2]. There is also a significant lack of diversity in most of the water workforce utilities [1]. Women are significantly underrepresented in the water and wastewater utility sectors, especially in technical roles [3]. As widely known within the education industry, students develop a better understanding through hands-on, interactive learning as opposed to its auditory or visual competitors. The primary goal of our project is to foster awareness about employment opportunities in the drinking water and wastewater utilities workforce via K-12 educational programming. In addition to developing, piloting, and implementing both hands-on and virtual educational activities to inform students and educators about the critical roles that members of the water and wastewater workforce have in their communities, the proposed activities will provide linkages to employment opportunities in the water and wastewater utility workforces. We strive to cultivate and construct an everlasting pipeline connecting diverse members of our nation's youth to employment opportunities.

The instructional design in this project utilizes a cognitive-situative constructivist learning framework [4]. Knowing also necessarily involves making meaning of the learning activities in a personal, cultural context. The learning modules thus incorporate elements of instructional design that are integral to a cognitive-situative framework [5-9]. The WaterMobile and Watertalk activities are two educational platforms to expose students to the world of endless opportunities relevant to the needs of the water/wastewater industry.

II. WaterMobile

WaterMobile is a 4-wheeled mobile learning environment that can be steered into classrooms for demonstrations of activities about forces of water (pumps and pipes), water treatment (removal of pollutants using physical/chemical processes), water pollution, and the role of soils for buried pipes and construction materials, such as concrete for water/sewer pipes. It is a low-cost and simple mobile ecosystem that can be easily adopted by school districts and implemented in classrooms. Each activity will is connected to the New Jersey Core Curriculum Content Standards for science. Cost-effective materials are incorporated so that WaterMobile is easily adoptable by schools, other educational groups, and non-profit organizations. Activities that promote gender equity and are attractive to students from underrepresented groups are also integrated during WaterMobile demonstrations. Some sample activities are presented below.

A. Forces of Water

Two experiments have been outlined to demonstrate forces of water. The first experiment is entitled “Hydropower”. The Hydropower experiment uses an affordable laboratory kit by Thames and Kosmos [11]. The Thames and Kosmos kit includes a variety of experiments and pieces to perform multiple experiments related to renewable energy. After students assemble the waterwheel in the kit, they can place the waterwheel in a sink and apply varying water pressures to the wheel. The waterwheel powers an included LED on the top of the assembly. As the waterwheel is turned by the varying water pressure, students are able to make observations of the brightness of the LED. Students can then identify correlations and relationships between water pressure and power output. In a more advanced setting, students can also mark the water wheel and count how many revolutions it makes in a set time period. Using their gathered data, students can then calculate revolutions per minute, and finally, determine the power of the light in Newton-meters.

The second experiment entails two equal sized plastic tubes, with a tapered nozzle fixed to one end of a single tube. Using equal volumes of water, the students record time on how long it takes for each tube to empty out. To calculate the flowrate, students will use the following equation:

$$Q= V/t \quad (1)$$

Where Q is the flow rate, V is the volume of the water, and t is the time it takes for the tube to empty. Similarly, the equation

$$Q= AV \quad (2)$$

Where V is velocity, and A is the area of the output surface, students can determine the relationship between area of the output and flowrate.

B. Water Treatment

Water treatment is also demonstrated via two simple experiments. The first experiment is titled “Vacuum Filtration”. The Vacuum Filtration lab experiment is designed to show a simplistic wastewater treatment process using a Vacuum Filtration Apparatus and Vacuum hand pump. Students use dirty water samples and filter the water to obtain clean water. The filtering process begins by using the hand pump to pull the water through a filter and into a flask below. After all of the water is filtered, the apparatus can be disassembled and the clean, filtered water can be removed from the flask. Students can take simple water quality measurements such as turbidity, solids and color.

The second activity is to encourage project based learning. The case for project-based learning throughout the STEMcurriculum is compelling. In comparison to traditionally-taught students, students who participate in project-based learning are more motivated, demonstrate better communication and teamwork skills, and have a better understanding of issues of professional practice and how to apply their learning to realistic problems [12-14]. Students are asked to design a water filtration system using simple materials such as a two-liter soda bottle, scissors, a coffee filter, sand, rocks and activated carbon. Students can actively play with water filtration and get first-hand experience with water treatment.

C. Impact on Infrastructure

The impact of written extreme natural events on the water/wastewater utilities is also a part of the WaterMobile activities. Students are exposed to a “Shaker Table”, where they can simulate an earthquake and observe how it could potentially affect underground utilities. For this experiment, a Pitsco Epicenter Earthquake Simulator [15] is used with a sample of sand, PVC Pipe, and water. The PVC sample is sealed on both ends and buried in 3-5 inches of sand. The sand is then saturated with water. Once activated, the earthquake simulator causes the saturated sand to undergo liquefaction, where the soil behaves much like a liquid. During liquefaction, the PVC Pipe rise to the surface. Students can make observations about how much time it takes for the PVC pipe to rise to the surface, as well as draw conclusions about why this phenomenon occurs. Students can also consider how this process occurs and takes its toll on real utilities during an earthquake.

III. WATERTALK

The Internet of Things (IoT) is a network of connected objects equipped with sensors that monitor the surrounding environment and communicate sensory data/control signals via local networks or the Internet. Objects that form parts of the IoT are described as ‘smart’ and extend beyond traditional devices such as laptops, tablets, cell phones smart thermostats, light bulbs, and even toothbrushes. IoT devices are designed to increase efficiency and convenience and are useful for a wide range of applications. In the water sector, real-time remote water and wastewater quality monitoring via IoT smart sensors, (i.e. pH, turbidity, conductivity, etc.) can provide a convenient and accurate means of acquiring vital data. This is shown in Figure 1.

Advantages of smart IoT water technologies include automation, an ability to view variability in real time and at high resolution, and an opportunity to build connections between buildings and sensors via various connection interfaces such as Ethernet, WiFi, and Bluetooth. WaterTALK engages students and educators in a lab-based experience. The participants learn how remote data collection works and how the new technology allows collection of data without a manual presence. A web interface has been designed which translates data remotely collected by an Arduino and a Raspberri Pi. The system remotely measures and records basic water quality parameters that are crucial to ensuring healthy water quality. The system is able to measure pH, temperature, turbidity, oxidation reduction, and dissolved oxygen.

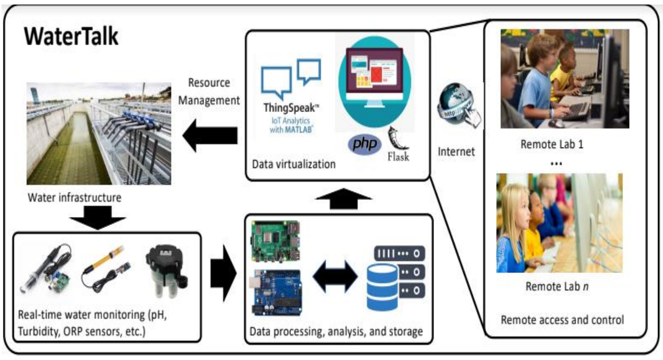

Figure 1: Smart Water Monitoring Flowchart

The system is able to actively communicate with a web server as well as remotely collect data. The Raspberri Pi is programmed to be able to receive and send data from various sensors connected to itself. The Rapberri Pi utilizes multiple languages including raspbian, python, and html. The Raspberry Pi has been programmed to display all sensor data and send collected values to a web server to be viewed by anyone with access. The system is currently capable of displaying a temperature reading on ThinksSpeak [16]. Displayed below in *Figure 2* is a graph taken from ThingSpeak that shows the temperature reading from the remote data collection system.

Figure 2: Temperature vs. Time Plot (Via Remote Data Collection)

IV. Conclusions

WaterMobile and WaterTalk are simple but useful educational platforms to introduce careers in the water and wastewater utilites.

As the infrastructure of America approaches the end of their design life and a growing workforce that will retire, it is important to cultivate interest and promote careers for these very important utilities. WaterMobile is a versatile tool that will have the ability to be implemented in a variety of education levels, with the goal of sparking the interest of the next generation's engineers and utility workers. The WaterTalk system of remote data collection for water parameters is a unique way to display how improved technology can be implemented into the water systems and wastewater systems in not only America but also the whole world.

These educational tools will be hosted on a website [17] using a server at Rowan University, allowing both rural and urban schools across the country to easily access the material. The activities and updates will also be shared via social media. Rowan has strong partnerships with school district educators and guidance counselors throughout the state, making statewide dissemination easily feasible. In areas where school districts or students suffer from digital inequity (i.e. low bandwidth, lack of access to Internet, lack of personal computers/electronic devices, etc.), printed materials will be shared.

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