

Waterworks: An exciting venture to promote careers in water/wastewater utilities

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Abstract

Waterworks is a USEPA funded project that focuses on exposure of careers in water and wastewater utilities to K-12 students and educators. The nation will face a shortage of workers in these utilities due to retirement. As such, there is a dire need to inspire the next generation to contribute to this utility workforce. We are developing four innovative tools as part of our WaterWorks project. These are WaterMobile, WaterPal, WaterTalk, and WaterCave. All four tools are instrumental in exposing the multi-faceted careers in these utilities using modern instruments such as Virtual Reality (VR). We have five partners, three utilities, the City of Camden schools and a non profit the South Jersey Land and Water Trust. We are developing activities to expose careers via hands on modules, videos, and presentations that are shared on an interactive project website. Activities are also mapped in sync with the New Jersey Science Standards to aid educators with their lesson plans and development of course content. This presentation will focus on work conducted to date.

Introduction

Water and wastewater utilities are facing workforce shortages due to retirements and inability to attract the next generation. The lack of a diverse workforce in these utilities is also of concern [1] - [3]. Therefore, the overall goal of the WaterWorks project is to aid in supplementing the need for a diverse workforce for wastewater/drinking water utilities as the current workforce is reaching the age of retirement. This generation's youth are not aware of the opportunities available to them in the water and wastewater industry due to the fact that they have little to no knowledge about what the industry entails. The WaterWorks tools are designed to support teachers through providing virtual and physical labs that help students in exploring and understanding crucial roles members of the water workforce play in the daily lives of their communities. This is necessary because at secondary and higher education levels, students often struggle to translate concepts from their coursework to real-life practice. In order to reach this technologically adept generation, the tools of WaterWorks utilize contemporary technology that is revolutionizing utilities as they try to modernize their aging infrastructure. The focus is on the use of Augmented Reality (AR) and Virtual Reality (VR) for workforce development, along with the use of IoT (Internet of Things). Along with the innovative technology mentioned above, the four educational tools aid in developing digital and print multimedia to ensure transferability of programming for implementation in other geographically diverse areas across the United States. This includes the use of an app in order to make the connection between students, educators, and the important information more seamless. Our five partners include American Water [7], City of Camden Schools [5], SJ Land & Water Trust [8], CCMUA [5], and ACUA [16].

Project Details

The study, design, and construction of this system and related knowledge is currently in development by upperclassmen engineering students at Rowan University alongside faculty and the Waterworks partners. This project is supported and funded by the USEPA. The four pillars of

Waterworks are WaterMobile, WaterPal, WaterTalk, and WaterCave (Figure 1). The curriculums are developed in line with and are connected to the New Jersey Core Curriculum Content Standards for science [9].



Figure 1: Activities for the Various WaterWorks Components

WaterMobile consists of multiple physical models that can be transported on a cart and brought to classrooms in order to promote visual and hands-on learning. Included in the array are models of pumps and pipes, activities relating to water treatment and water pollution, and information regarding sands, clays, and silts relating to underground piping/construction. It is a cheap and effective system of interactive learning that can be used widely and integrated into schooling curriculums without issue. Gender equity is an important dilemma many are faced with today, and WaterMobile tasks itself with destroying barriers such as these and aims to give better representation to promote diversity and leadership in the workforce.

All correlated activities in WaterMobile line up with the New Jersey Core Curriculum Content Standards in the STEM fields, making it easy to follow and apply. One experiment created to demonstrate the applications of forces of water is named “Hydropower” and includes a laboratory kit to aid in teaching topics concerned with renewable energy. A waterwheel is included in the kit, which students can build and use with running water to power on the LED light it comes with to observe and draw conclusions about the relationship between pressure acting on the water and the output of power. The other activity relating to forces of water in WaterMobile is an experiment in which students record the time it takes for water to pass through two identical tubes of plastic with a nozzle on one end.

Students can gain an understanding of as well as apply equations for flow rate in this activity. Also entailed in the WaterMobile set are experiential tools for teaching water filtration and affecting of infrastructure, such as earthquake simulations.

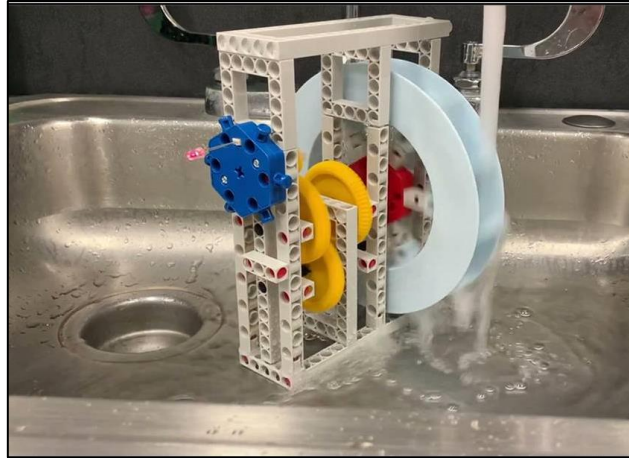


Figure 2: Hydropower using a WaterWheel

WaterPal is an innovative app that is a cornerstone of the WaterWorks project. The app facilitates the implementation of hands-on activities and demonstrations that are mapped to local curriculum standards and is designed to engage both students and teachers in learning about the water/wastewater workforce. For teachers, WaterPal offers a range of modules that correspond to core curriculum content, including videos, lab exercises, and instructional material. For students, the app offers an exciting game that allows them to select an avatar for a water worker and learn about careers in the water/wastewater utilities. The game also exposes participants to the various types of education required for the different types of work available at these utilities. By providing resources that are aligned with specific learning goals and making learning fun and interactive, WaterPal can help inspire the next generation of water and wastewater professionals (Figure 3).

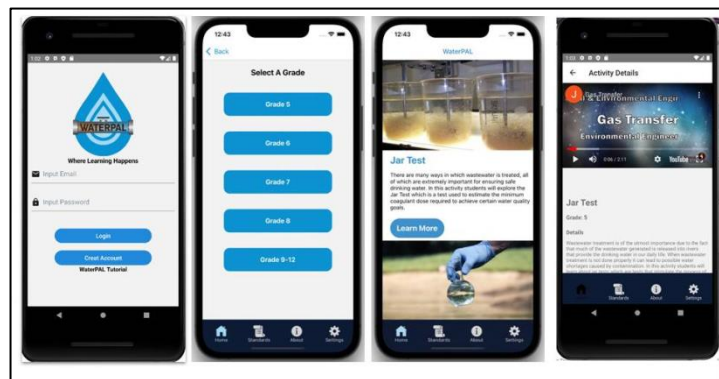


Figure 3: Sample layout for WaterPal

WaterTalk uses the network of the Internet of Things or IOT in order to gain access to a wide variety of data through many different means. This data allows accessibility on all different kinds of devices through a variety of connection methods. This program allows users to access high quality data in real time. Students can use real, live data to see the processes of various water related careers and provide exposure to all of the opportunities [4]. The goal of WaterTalk is to help bring the real world data into the classroom. This can create a more real image for students of the processes of various water related fields. The activity also gives the students exposure to different forms of technology that they may not ordinarily have access to. Regardless of location,

age, or physical condition, students using WaterTalk are able to remotely access the real time data to learn [10]. We developed a remote sensing system for water quality parameters and also a sensor for detecting chlorophyll that is indicative of algal blooms.

The Virtual Reality Center, located off of Route 55 at the South Jersey Technology park at Rowan University is an immersive lab supported by federal and state government and local, national, and international industry partners [11]. The center is equipped with virtual and augmented reality systems and 7-foot high by 40-foot-wide screens in a room large enough to support a development team of up to 25 people. The technology housed in the Virtual Reality Center supports the team of experts in developing VR and AR applications. The WaterCAVE module is currently under development, utilizing both VR and AR applications. This application will give the opportunity to K-12 students and educators to visit the Virtual Reality Center on Rowan University's campus and understand how water and wastewater utilities work via virtual simulation showcasing the multiple roles and tasks in the industry. Field trips to the VR center will be arranged to provide students the opportunity to receive the immersive experience with hopes to facilitate interest in the water and wastewater industry.

Project Dissemination

As a part of public outreach efforts, WaterWorks has partnered with Camden County school districts, water utility companies and the non-profit organization South Jersey Land and Water Trust in order to spread awareness and increase involvement in the program. As part of the WaterMobile portion of WaterWorks, a team of Rowan University students will conduct school visits in order to bring hands-on experiential learning modules to the classrooms of Camden County school districts. This team will be accompanied by water utility representatives that can share their experiences and the significant impact water systems have on our communities.

During the Summer of 2022, WaterMobile activities were conducted during Rowan University's ROPES (Rowan's Opportunity for Post Secondary Education and Success) Program [14]. This program was aimed to introduce rising high school seniors from underrepresented school districts as indicated below to future paths in higher education.



Figure 4: Participating School Districts for ROPES

Students had the opportunity to participate in the hands-on WaterMobile activities and gained experience in experimental set-up, data collection, and analyses of data. After the completion of

the program, a brief poll was taken amongst students to determine the effectiveness of the outreach efforts. The results of this poll asking “Are you aware of career in water and wastewater utilities?” are shown below in Figure 5.

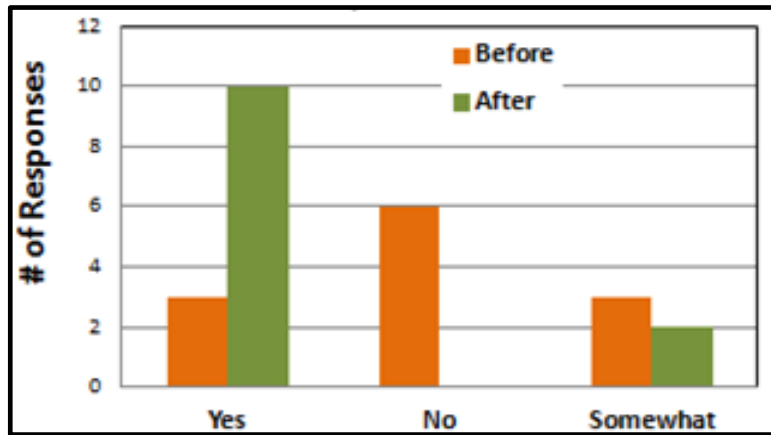


Figure 5: Response on Career Awareness

In addition to a hands-on approach with students and educators in surrounding communities, a media production titled *WaterWorks: Attractive a Diverse Workforce* highlighting the WaterWorks program was submitted to the national STEM for ALL video showcase [12]. An interactive website has been established for information dissemination [13]. The website is updated regularly to add new developed content on the four innovative tools. It also provides basic information on careers in the water/wastewater utility sector as indicated below:



Figure 6: Careers in the Water/Wastewater Utility Sector with Levels of Education

As part of broader dissemination, the grant has allowed the ACUA to hire interns to work at their wastewater facility. Two interns (IT and Engineering) are already working at the plant and their work is outlined below:

IT Intern

- Updated computer software on end user PCs

- Various tasks including troubleshooting email, resetting electronic sign/bulletins, and replacing uninterruptible power supplies
- Troubleshooting/repairing a network issue that stopped scanning via copiers
- Troubleshooting an issue with the front gate
- Updated Inventory Management log
- Worked on updating team site

Engineering Intern

- Assist Staff Engineers with field surveying of wastewater collection system assets.
- Assist Staff Engineers with locating wastewater collection system assets using various tools including Ground-Penetrating Radar (GPR), metal detection, historic plan data, drones, etc.
- Perform database entry and organization of collected survey data.
- Perform design plan edits using Computer Aided Design (CAD) software.
- Assist Staff Engineers with routine mark outs for the NJ One-call system.
- Assist Staff Engineers with maintenance of electronic record files, scanning documents, and filing.
- Assist Staff Engineers with inspection of active construction projects.

Conclusions

Efforts such as the Waterworks project are needed to facilitate interest in the water/wastewater utilities in the younger generation to combat USA worker shortages in the industry. We have developed concurrent resources to inspire K-12 students and facilitate interest in utilities and preliminary data signifies that these activities are exposing STEM and other careers to K-12 students and educators. These activities are aimed to help further achieve the overall goal of WaterWorks in spreading awareness and inspiring involvement in the water & wastewater industry for the upcoming generation.

Acknowledgements

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References

- [1] <https://www.brookings.edu/wp-content/uploads/2018/06/Brookings-Metro-Renewing-the-Water-Workforce-June-2018.pdf> Accessed March 1, 2021
- [2] <https://www.njfuture.org/2020/06/12/bolstering-the-water-workforce-during-covid-19-recovey-current-programs-in-new-jersey/>
- [3] <https://www.awwa.org/Resources-Tools/Resource-Topics/Workforce>
- [4] Khatri, Punit & Gupta, K. & Gupta, Raj. (2019). “Raspberry Pi based Smart Sensing Platform for Drinking Water Quality Monitoring System: A Python Framework Approach.” *Drinking Water Engineering and Science Discussions*. 1-17.

10.5194/dwes-2018-35.

[5] <http://www.camden.k12.nj.us/>

[6] <http://www.ccmua.org/>

[7] <http://www.amwater.com/>

[8] <https://www.sjlandwater.org/>

[9] <https://www.state.nj.us/education/aps/cccs/science/>

[10] K. Jahan, N. Wang, N. Matarazzo, M. Ignarri, J. Bell, G. Brunetta, P. Marshall, and R. Petzitto (2022) "WaterMoblie & WaterTalk - Teaching K-12 Students about Water through Hands-on Experimentation", *Proceedings of the IEEE EDUCON Conference, Tunisia* (March 2022).

[11] <https://research.rowan.edu/officeofresearch/vr/>

[12] <https://stemforall2022.videohall.com/maps/2303>

[13] <https://research.rowan.edu/research-areas/engineering/usepa-waterworks/>

[14] <https://research.rowan.edu/research-areas/education/ropes/>

[15] K. Jahan, (2022) "Promoting Careers in the Water/Wastewater Utilities to K-12 Students and Educators." *Presentation at ASEE Midatantic Fall Conference,*

[16] www.acua.com