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WaterWorks: An Innovative Attempt at Promoting Careers in Environmental Engineering

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Abstract

Water and wastewater utilities are facing acute workforce shortages due to retirements and inability to attract the next generation in the USA. The lack of a diverse workforce in these utilities is also worrisome. As such, there is a dire need to provide innovative opportunities to excite the next generation regarding careers in our water/wastewater utilities. Our USEPA project WaterWorks aims at exposing STEM and other careers in the water/wastewater utilities through innovative sustainable learning modules for students and educators. Sustainable practices in all walks of life are much needed to ensure that we are protective of the environment and planet earth. As such our WaterWorks project aims at embedding sustainability in the curriculum through exciting modules that attract future generations. These include both traditional hands-on activities and contemporary virtual environment learning. WaterWorks, consists of four contemporary core K-12 educational modules titled WaterMobile, WaterTalk, WaterPal and WaterCave. All four components are designed to showcase the diverse needs of the water/wastewater industry and sustainable practices. WaterMOBILE provides an experience for students to receive hands-on experiences about the engineering and science behind water utilities via interaction with a 4-wheeled bin that is easily steered into classrooms. WaterPAL is an innovative mobile app that provides educators with access to learning modules and students with access to a game in which they can virtually live through a day in a water worker's shoes. WaterTALK consists of activities that integrate remote sensing technology and teach the core principles of data collection and analytics. Finally, WaterCAVE immerses students in a virtual reality experience in which they can walk through simulated water utilities and learn how they are endangered by extreme weather events, such as storms and floods, that are predicted to be exacerbated by the looming climate crisis. Collectively, WaterWorks provides K-12 students and educators structured educational programming that increases awareness and knowledge of opportunities in the water and wastewater utilities sectors. The program has been a huge success as evidenced by student/educator feedback.

1 Introduction

1.1 Background

Our project titled WaterWorks is aimed at exposing careers in water and wastewater utilities to K-12 educators and students. This was funded by the USEPA with special focus to sustainable practices. WaterWorks, consists of four contemporary core K-12 educational modules titled WaterMobile, WaterTalk, WaterPal and WaterCave. All four components are designed to showcase the diverse needs of the water/wastewater industry with special emphasis on STEM careers. These four modules were developed to excite the next generation to join our nations water/wastewater workforce with a deep understanding of sustainable practices. Sustainability is crucial for water and wastewater utilities to ensure long-term resource availability, protect ecosystems, and prevent pollution. This includes water conservation, eliminating watershed pollution, optimizing energy use, implementing water reuse initiatives, and planning infrastructure investments strategically. Figure 1 indicates the four-prong approach that was taken to ensure that future generations are familiar with sustainability as it pertains to careers in the water-wastewater industry.



Figure 1: Four prong approach to sustainability in the water-wastewater sector

Environmental sustainability in the water- wastewater sector can include the following:

- *Water conservation*: Reducing losses (e.g., leaks) and encouraging efficient water use.
- *Energy efficiency*: Using energy-efficient equipment, renewable energy sources (like solar or biogas from sludge), and optimizing operations to reduce carbon footprints.
- *Nutrient recovery*: Capturing nitrogen, phosphorus, and other materials from wastewater for reuse in agriculture.
- *Waste reduction*: Minimizing sludge production and finding sustainable disposal or reuse methods.
- *Climate resilience*: Designing systems that can adapt to droughts, floods, and other climate-related challenges.

Economic Sustainability in the water- wastewater sector can include the following:

- *Asset management*: Maintaining and upgrading infrastructure to avoid costly breakdowns or emergency repairs.
- *Rate structures*: Developing fair pricing models that reflect the cost of service while promoting conservation.
- *Cost recovery*: Ensuring the utility can cover operational and capital expenses while remaining financially viable.
- *Innovative financing*: Utilizing public-private partnerships, green bonds, or state/federal grants for sustainable projects.

Social Sustainability in the water- wastewater sector can include the following

- *Equity and access*: Ensuring all populations have access to clean water and sanitation, including marginalized or low-income communities.
- *Public engagement*: Educating and involving the public in water conservation, utility operations, and decision-making.
- *Workforce development*: Training and retaining a skilled workforce for long-term operational sustainability.

Innovation focuses sustainability in the water- wastewater sector can include the following

- *Smart water systems*: Using sensors, IoT, and AI to optimize operations and detect problems early.
- *Water reuse and recycling*: Treating wastewater to high standards for non-potable or even potable reuse.
- *Decentralized systems*: In some areas, small-scale treatment systems reduce the need for large infrastructure

1.2 Project Objectives

The primary goal of the WaterWorks proposal is to foster awareness about employment opportunities in the drinking water and wastewater utilities workforce via K-12 educational programming focusing on sustainable practices. K-12 students and educators are not familiar with the needs of these utilities and the jobs that are available. At secondary and higher education levels, students often struggle to translate concepts from their coursework to real-life practice. The focus is on the use of contemporary technology that is revolutionizing utilities as they try to modernize their aging infrastructure. Activities are mapped in sync with the New Jersey Science Standards to assist educators also. Our goal was to develop innovative educational activities that will raise awareness and increase knowledge of opportunities in the water and wastewater workforce among K-12 students and educators. Most importantly, we are focused on use of contemporary technology that is revolutionizing these utilities as they try to modernize their aging infrastructure. The use of Augmented Reality (AR) and Virtual Reality (VR) for workforce development is already transforming the industry along with the use of IoT (Internet of Things).

The overall objectives were to:

- Engage K-12 students (Grades 5-12) via innovative educational programming about opportunities in the water and wastewater utilities sectors emphasizing on sustainability
- Increase awareness and knowledge about the water workforce among K-12 students
- Support teachers and students in exploring and understanding the crucial role members of the water workforce play in the daily lives of their communities
- Integrate WaterWorks programming into K-12 curricula at select schools
- Develop digital and print multimedia to ensure transferability of programming for implementation in other geographically diverse areas of the U.S.
- Serve as a national model for other undergraduate institutions in integrating WaterWorks programming in K-12 education
- Increase the participation of students from underrepresented populations in the water and wastewater utilities sectors

2 Implementation

The project spanned over three years with all modules being developed from the start. The following sections briefly describe each of the WaterWorks modules.

2.1 Project Partners

WaterWorks marks an innovative partnership between Rowan University, Camden City School District (CCSD), and other established organizations in Camden to educate posterity about their future opportunities so that they are empowered to take responsibility for the well-being of not only themselves but also their community members. Our collaborative has brought together key stakeholders from many areas. Four partners were selected with great care as they each have an excellent reputation in addressing the USEPA educational priorities. Partners include 1) CCSD, 2) American Water, 3) the Camden County Municipal Utilities Authority (CCMUA) and 4) the South Jersey Land & Water Trust (SJLWT). The Atlantic City Utilities Authority (ACUA) was also selected as an external partner to test the transferability of the WaterWorks programming. These partners were essential to the success of this project.

2.2 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. WaterMOBILE is a low-cost and simple mobile ecosystem that can be easily adopted by school districts and implemented in classrooms. Each activity is connected to the New Jersey Core Curriculum Content Standards for science. As such, it is complementary to other WaterWorks programming and especially suited to our WaterPAL app due to its ability to provide exciting and dynamic hands-on experiences. Cost-effective materials were chosen 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 utilized during WaterMOBILE demonstrations. We added nine WaterMobile activities with lesson plans/videos etc on the webpage with linkages to the NJSS standards. These activities include:

1. Jar Test-Chemical Treatment of Water
2. Gas Transfer- Physical Treatment of Water
3. DIY Water Filter- Make your own water Filter
4. Water Wheel-Making hydropower
5. Water Tank- Understanding head, pressure and forces of water
6. DIY Watershed-Understanding watersheds and pollution/protection
7. Water Fountain- Water Pressure
8. Falling Water- Water forces
9. Testing Water Quality- Understanding water quality parameters

Figure 2 shows the different activities and the WaterMobile cart.

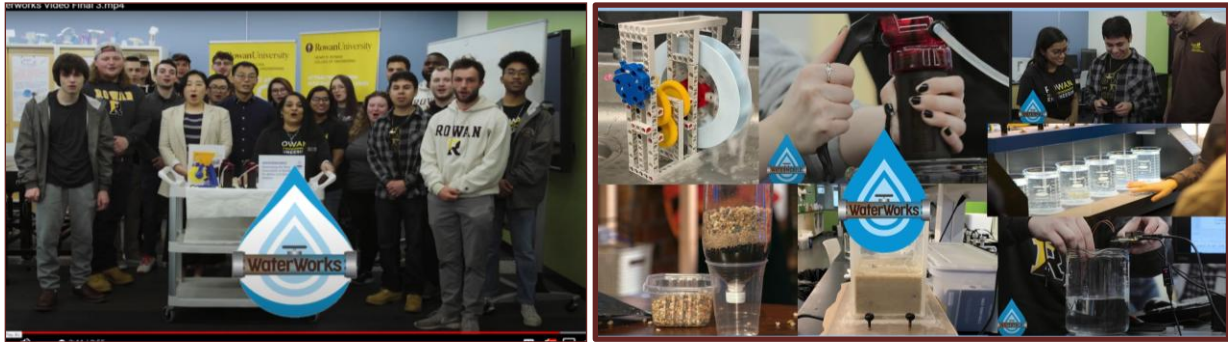


Figure 2: Images from our WaterMOBILE activities

2.3 *WaterPAL*

The second cornerstone of WaterWorks developed to energize students and teachers about the water and wastewater workforce includes our innovative app, WaterPAL. WaterPAL facilitates the implementation of hands-on activities and demonstrations that are mapped to local curriculum standards. The New Jersey Core Curriculum Content Standards for science provide detailed learning goals for subjects including Physical Science, Life Science and Earth Systems Science for grades 2-12. WaterPAL has a dual interface that caters to educators and students. Educators are able to quickly navigate to modules that correspond to core curriculum content that includes videos, lab exercises, and instructional material. Students are able to use WaterPAL to engage in an exciting game in which they are able to select an avatar for a water worker (i.e. pipefitters, steamfitters, construction laborers, system operators, installers, pipelayers, managers, hazardous waste removal workers, septic tank servicers, meter readers, machinery mechanics, office administrative assistants, engineers, legal assistants, lawyers etc). Upon selection, they will spend a day in the life of this water worker to learn about the roles and responsibilities related to the position. Specifically, the game allows students to learn that these utilities require a broad range of skillsets and levels of education (high school, two-year associates, four-year college, professional degrees, such as PhD, JD, MPH, MBA).

2.4 *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. 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 convenient and accurate means of acquiring vital

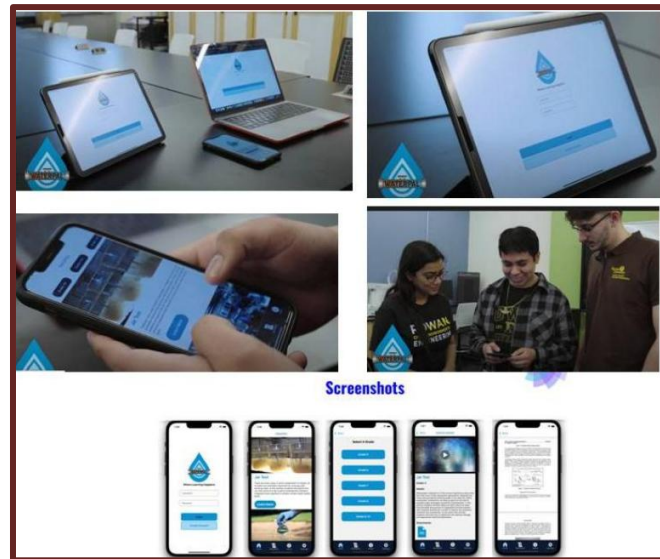


Figure 3: Images from our WaterPAL activities

data. 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 designed to measure water quality remotely at a local water body in Camden. This allows participants to learn how remote data collection works and how new technology such as SMART sensors allows for the collection of data without a physical presence.

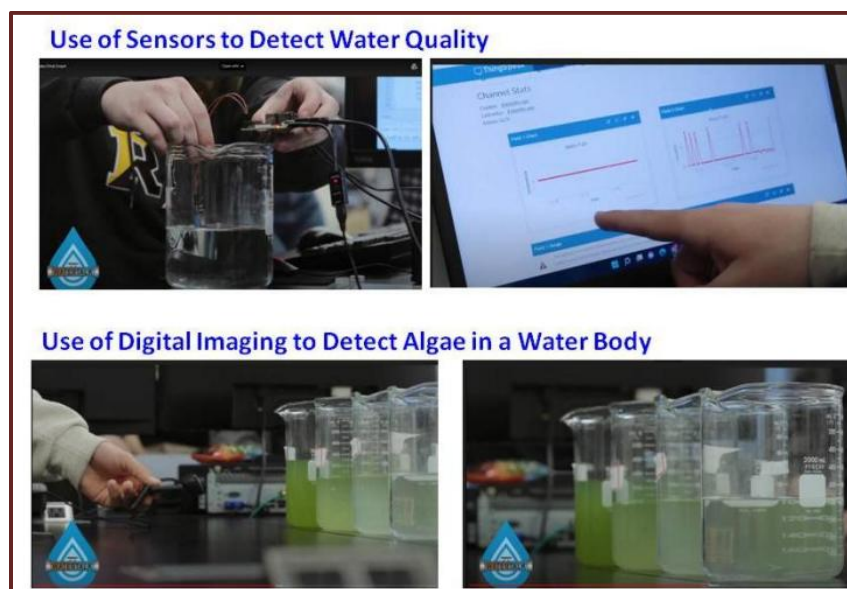


Figure 4: Images from our WaterTALK activities

2.5 WaterCAVE

The VR AR (Virtual Reality and Augmented Reality) Center at Rowan University is an enterprise funded by federal and state government and local, national, and international industry. It consists of a team of experts who develop innovative VR and AR applications. The Center aided in the development of an educational experience titled, WaterCAVE, that allows K-12 students and educators to understand how water and wastewater utilities work. Students and educators can virtually visit a water-wastewater utility and experience opportunities to receive immersive experiences with hopes to foster curiosity. The WaterCAVE experience includes a virtual simulation of water utilities and WWTPs as well as the ability for students to pick avatars that correspond to those in WaterPAL and follow along the day in the life of the water worker. Most notably, a feature of WaterCAVE includes a function to simulate extreme storm and flooding events, which are expected to increase in frequency and intensity in the southern NJ area due to climate change.

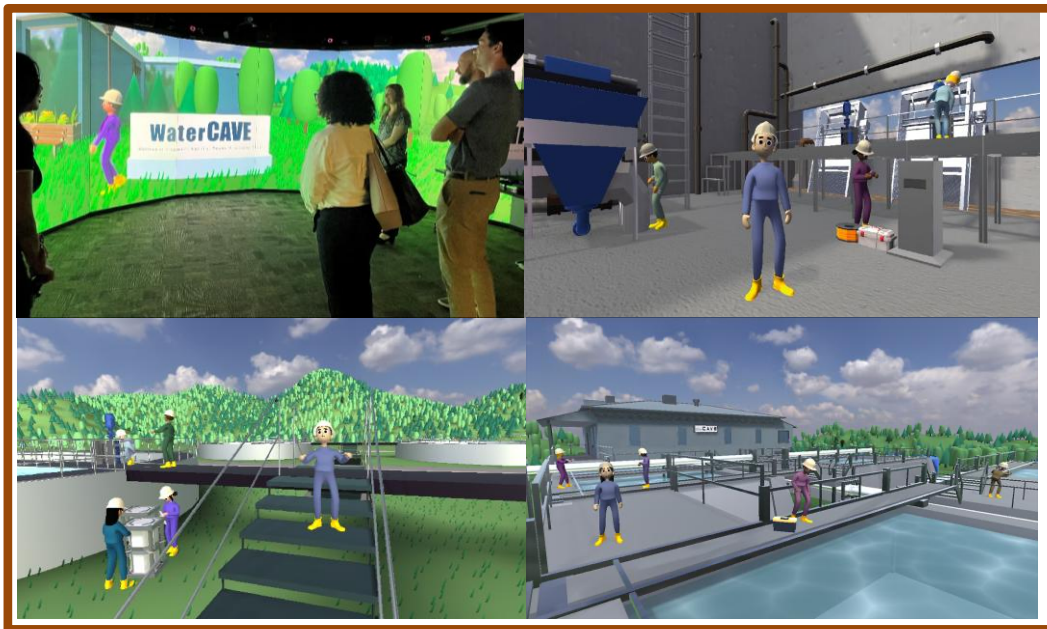


Figure 5: Images from our WaterCAVE tour

3 Assessment and Feedback

The modules were tested via school visits and teacher workshops. Feedback was obtained via anonymous surveys to gauge the impact of our modules. Survey results were very positive and indicated that the use of innovative technology coupled with traditional hands-on activities allowed participants to understand the futuristic nature of work conducted at water-wastewater utilities. Participants indicated that they could foresee themselves with jobs at these facilities.

4 Conclusions

Efforts such as our WaterWorks project are much needed to develop a stellar workforce as the water/wastewater utilities in the USA face worker shortages. We have developed some contemporary tools to excite the new generation, and our assessment results indicate that our activities are exposing STEM and other careers to K-12 students and educators while emphasizing sustainable practices.

5 Acknowledgement

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