Innovative Outreach for Careers in the Water and Wastewater Utilities

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Kauser Jahan completed her Ph.D. studies in the Department of Civil and Environmental Engineering at the University of Minnesota, Minneapolis in 1993. She holds a B.S. degree in civil engineering from the Bangladesh University of Engineering and Technology and an M.S.C.E. from the University of Arkansas, Fayetteville. After completion of her graduate studies, she worked as an environmental engineer for the Nevada Division of Environmental Protection (NDEP). Her research interests include bioremediation of contaminated groundwater and soils; the fate and transport of pollutants in the environment; biodegradation of industrial and municipal wastewaters; physicochemical treatment of water and wastewater treatment; applied microbiology in environmental engineering. Dr. Kauser Jahan has been one of the cornerstones of the College of Engineering at Rowan University. She is a leader and innovator in the area of curriculum development and has become a nationally and internationally known expert in teaching. She has directed four critical programs: the Attracting Women into Engineering Program, the National Science Foundation – Research Experiences for Undergraduates Program in pollution prevention, the Rowan Engineering Clinics for Teachers Program and the Engineers on Wheels program. She has worked at all levels to advance engineering especially the representation of women and minorities. Dr. Jahan is a registered professional engineer and a 2015 Fulbright Scholar. She has received many prestigious awards that recognize her contributions to engineering education.

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Ying Tang received the B.S. and M.S. degrees from the Northeastern University, P. R. China, in 1996 and 1998, respectively, and Ph. D degree from New Jersey Institute of Technology in 2001. She is currently Professor of Electrical and Computer Engineering at Rowan University, Glassboro, New Jersey, USA. Her current research interests lie in the area of discrete event systems and visualization, including virtual reality/augmented reality, modeling and adaptive control for computer-integrated systems, intelligent game-based learning environments, sustainable production and service automation, blockchain and Petri Nets. Her work has resulted in two USA patents, and over 210 peer-reviewed publications, including 73 journal articles, 2 edited books, and 6 book / encyclopedia chapters. Dr. Tang served as Associate Editor of IEEE Transaction on Automation Science and Engineering during 2009 – 2014, is currently Associate Editor of IEEE Transactions on Systems, Man & Cybernetics: Systems, IEEE Transactions on Computational Social Systems, and of Discover Artificial Intelligence, and Editorial Board Member of International Journal of Remanufacturing. She is a Guest Editor for the special section on Cyber-physical Social Intelligence for Metaverses in Cyber-Physical Social Systems in IEEE Transactions on Systems, Man & Cybernetics: Systems, special Issue on Behavioral Modeling, Learning, and Adaptation in Cyber-physical Social Intelligence in IEEE Transactions on Computational Social Systems, the special issue of Intelligent Energy Solutions to Sustainable Production and Service Automation in IEEEE Transactions on Engineering Science and Automation, and the special issue of Advances in Green Manufacturing and Optimization in Processes. She is the Founding Chair of Technical Committee on Intelligent Solutions to Human-aware Sustainability for IEEE Systems, Man, & Cybernetic, and the Founding Chair of Technical Committee on Sustainable Production Automation for IEEE Robotic and Automation.

Jeong Eun Ahn, Rowan University

Jeong Eun Ahn is an Assistant Professor of Civil and Environmental Engineering at Rowan University. She received her B.S. degree from Dongguk University, Seoul, South Korea, her M.S. degree from Georgia Institute of Technology, and her Ph.D. from New York University, all in Civil Engineering. The overarching goal of her work is to develop a sustainable and resilient coastal system, to protect cities and environmental quality. Her research focuses on developing model systems to predict fluid movement and its impacts on the environment. Dr. Ahn is also actively engaging undergraduate students in various research. She has demonstrated commitment to innovation in teaching and engineering education.

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Abstract: A USEPA funded project titled WaterWorks aimed at exposing careers in water and wastewater utilities to K-12 educators and students is currently in progress. WaterWorks, consists of four contemporary core K-12 educational modules titled WaterMobile, WaterTalk, WaterPal and WaterCave to excite the next generation to join our nations water/wastewater workforce. All four components are designed to excite the next generation to pursue careers related to the needs of the water/wastewater industry. There is a dire need for a new diverse workforce as the current workforce is reaching the retirement age. We are partnering with area schools, water and wastewater utilities and non-profit organizations to expose careers via hands on activities, videos, and presentations. Activities are also mapped in sync with the New Jersey Science Standards to assist educators also.

Introduction: Water and wastewater utilities are facing workforce shortages due to retirements and inability to attract the next generation [1-2]. The lack of a diverse workforce in these utilities is also of concern. Women are significantly underrepresented in the water and wastewater utility sectors, especially in technical roles [3]. Although nearly two-thirds of the water workforce is white, similar to the ratio found across all occupations nationally (65.3%), Black and Asian workers only make up 11.5% of the water workforce as compared to 18% of those employed in all occupations nationally [3]. Our current youth are technologically savvy and do not realize that water/wastewater utilities are also integrating contemporary technology in the optimization of various processes and tasks. As such, there is a dire need to provide innovative opportunities to excite the next generation regarding careers in water/wastewater utilities.

Our WaterWorks project aims at exposing STEM and other careers in the water/wastewater utilities via innovative learning modules. These include both traditional hands-on activities and contemporary virtual environment learning.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. 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. 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) [4-9].

This is a USEPA funded grant for three years and we just completed our first year. 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 project 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. In order to be able to disseminate effectively, we are also collaborating with area school districts [10], two wastewater utilities [11], one water utility [12] and a non-profit organization[13]. These partners are presented in Figure 1.

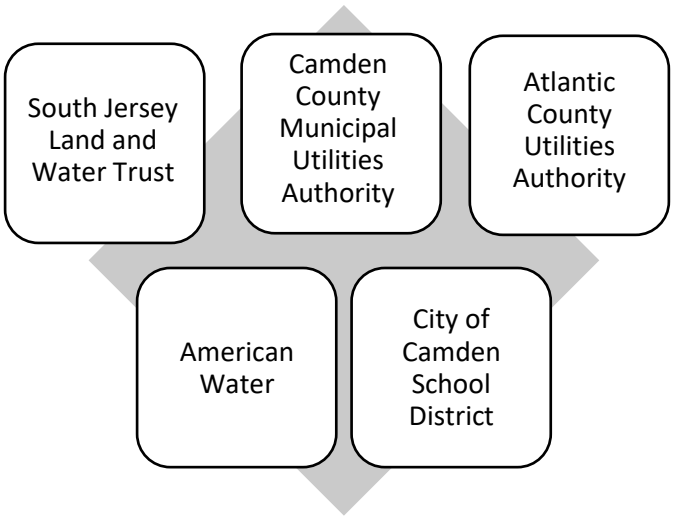

Figure 1: Partners for the WaterWorks Project

Project Details: WaterWorks consists of four educational tools: 1) WaterMOBILE, 2) WaterPAL, 3) WaterTALK, and 4) WaterCAVE. These tools consist of traditional exposure methods along with use of novel technology, such as VR, AR, and IoT. A brief description of each tool is provided below:

WaterMOBILE: WaterMOBILE is a low cost 4-wheeled mobile learning environment that can be brought into classrooms for demonstrations of activities that are relevant to water/wastewater utilities. These activities include the following topics:

- Water treatment (removal of pollutants using physical/chemical processes)
- Water pollution in watershed.
- Forces of water (head, pumps and pipes)
- Generating hydropower
- Behavior of pipes buried under soils during earthquakes
- Concrete tanks for the water/wastewater utilities

Each activity is connected to the New Jersey Core Curriculum Content Standards for science [14]. As such, educators can easily connect the activity to their curriculum. These activities are also connected to our WaterPAL tool described next.

WaterPAL: The second cornerstone of WaterWorks is our innovative app, WaterPAL [15]. This app facilitates the implementation of hands-on activities and demonstrations that are mapped to local curriculum standards. WaterPAL has a dual interface that caters to educators and students. Educators are able to use modules that correspond to core curriculum content that includes videos, lab exercises, and instructional material. Students can use WaterPAL to engage in an exciting game in which they are able 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.

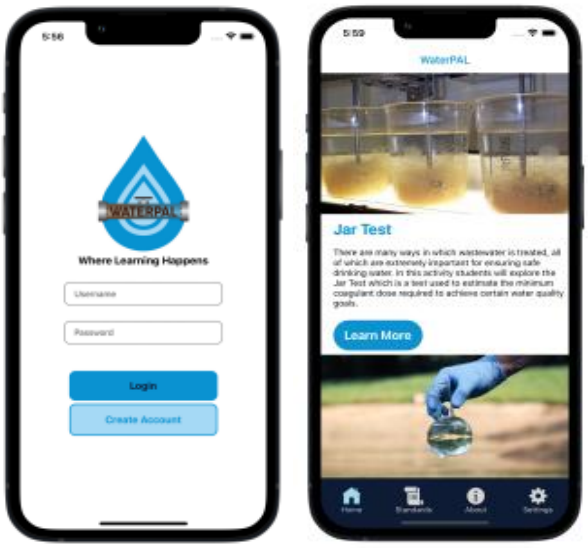

Figure 2: Layout of the WaterPal app (login screen and activity sample)

WaterTALK: The Internet of Things (IoT) is a network of connected objects equipped with sensors that monitor any environment and relay sensory data/control signals via local networks or the Internet. 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. WaterTALK engages students and educators in a lab-based experience designed to measure water quality remotely at a local water body. A web interface has been designed which translates data remotely collected by an Arduino and a Raspberri Pi [16]. This system allows remote measurements of water quality parameters that are crucial to ensuring healthy water quality. Participants also learn how remote data collection works.

WaterCAVE: The VR Center at Rowan University is an enterprise funded by federal and state government and local, national, and international industry [17]. It consists of a team of experts who develop innovative VR and AR applications. The WaterCAVE module under development currently, will allow K-12 students and educators to understand how water and wastewater utilities work via a virtual simulation of a utility. Field trips will be arranged to visit the Camden VR facility to provide students opportunities to receive immersive experiences with hopes to foster curiosity.

Project Dissemination: We have disseminated some of our early work via K-12 student/educator workshops and also via participation at the national STEM for ALL Video Showcase. A video titled “WaterWorks: Attractive a Diverse Workforce” was developed for the showcase and it received the Public Choice Award as indicated below in Figure 3.

Figure 3: 2022 STEM for ALL Video Showcase, Public Choice Award, May 2022 [18]

A two-week summer workshop was also conducted for fifteen-area high school rising seniors from school districts with a high percent of underrepresented students. These students were primarily exposed to our WaterMOBILE activities. Students conducted the hands-on activities in teams and learned not only setting up experiments but also data collection and analyses. Data analyses included unit conversions, use of scientific equations and plotting of data to determine trends and values of coefficients. An image from the workshop activities is presented in Figure 4. A project website is also available to obtain relevant information about the grant and its activities for potential users [19].

Figure 4: High school senior workshop showcasing activities from WaterMOBILE

Project Assessment: An external evaluator from our College of Education is assigned to conduct online surveys and focus groups meetings with participants to gauge the impact of the project.

High School Participants: The high school students were asked to fill out a pre- and post-survey to allow us to learn if our activities allowed them to learn about careers in the water wastewater utilities. The questions asked were as follows:

1) Do you know how a water treatment plant works?
2) Do you know how wastewater is treated?
3) Are you aware of career in water and wastewater utilities?
4) Select which jobs apply to water/wastewater utilities?

The results are presented in Figure 5. It is important to note that for question 4, most students did not identify the professional jobs in select fields before the workshop.

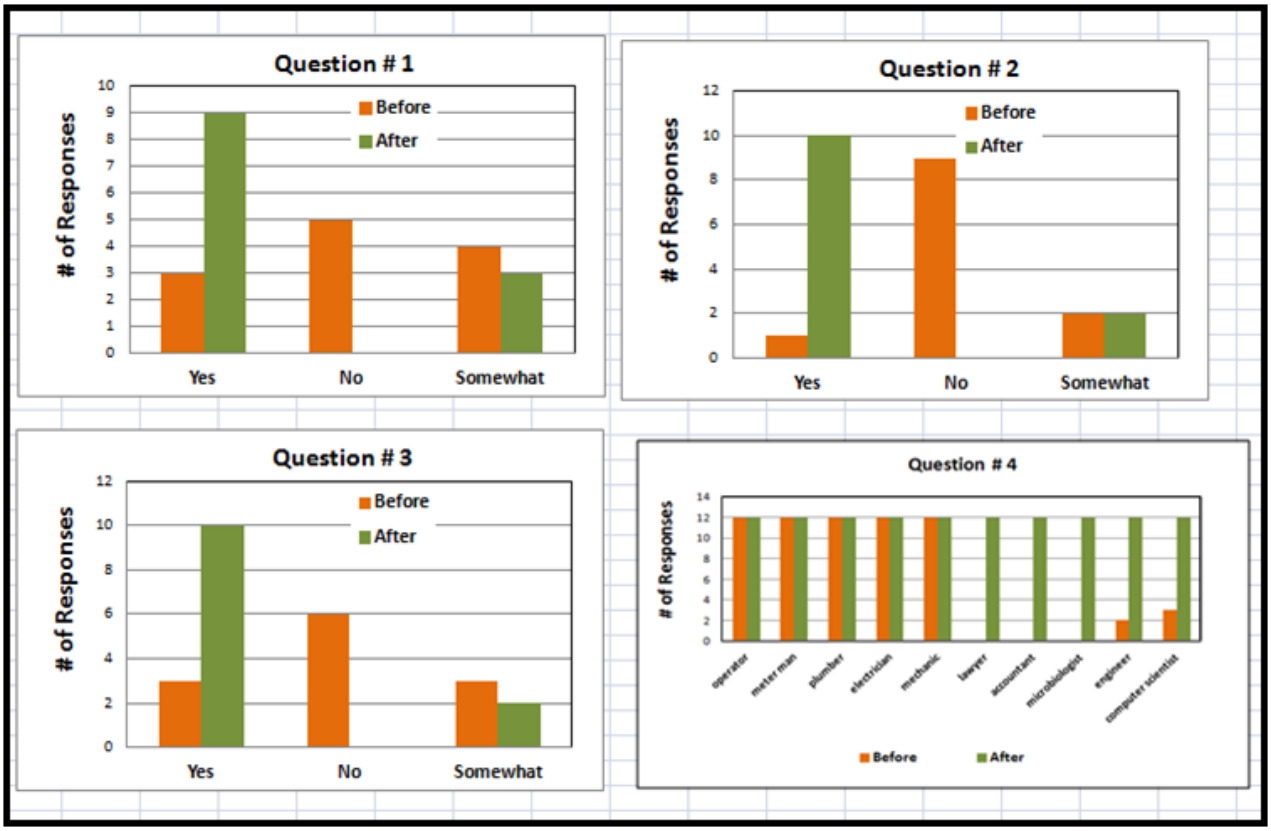

Figure 5: Preliminary results from workshop survey

A more in-depth evaluation process was also carried out. The evaluation addressed the following questions in relation to the WaterWorks modules through student participant surveys and a student participant focus group.

1. Implementation

a. What key program features characterize the program(s)?

b. What factors facilitated or hindered the implementation of this program?
c. How many students participated?
d. What was the implementation process?
e. To what extent was the program implemented?

2. Stakeholder perceptions
a. What were the experiences of the participants?
b. Would the participants recommend the program to others?
c. What changes would the participants recommend?

3. Program outcomes
a. What outcomes are observed among participants?
b. Were stated program outcomes met?
c. What unintended outcomes emerged?

A focus group meeting was also held with the participants with an additional survey. The focus meeting with the participants allowed them to discuss the workshop and their experiences. The Focus Group with WaterWorks modules participants consisted of the following questions:

1. How did you hear about the program?
2. In your own words, what was the purpose of the program you were attending?
3. What was your experience with the WaterWorks modules?
4.What stuck out for you? What would you change?
5. Has participation in the modules changed your interests in engineering?

The findings from the focus group meeting indicated the following:

- Majority of the participants did not have any knowledge about engineering careers in the water industry prior to participating in the modules, however after completing the modules reported more knowledgably of education, skills, and abilities.

- Majority of the participants appreciated the hands-on experiences of the water modules as opposed to fully online possibilities.

- Regarding career trajectories, a percentage of participants shifted thinking about their career interests in environmental engineering as opposed to other disciplines [biomedical, mechanical, etc.]

- Majority of the participants did not have any knowledge of how water treatment plants worked nor how to treat water, and 100% of the participants increased their knowledge because of participation in the WaterWorks modules.

Assessments are also in progress for all engineering students who worked on this project. The results will be collected at the end of the semester. Participating students involved in the development of various modules will be questions that focus on their roles in the WaterWorks

project, their knowledge gains regarding careers in water/wastewater utilities, understanding the role of mentoring K-12 students, and the impact of the project on their career goals.

Conclusions: Efforts such as our WaterWorks project are much needed to develop a much needed workforce as the water/wastewater utilities in the USA face worker shortages. We continue to develop some contemporary tools to excite the new generation and preliminary results indicate that our activities are exposing STEM and other careers to K-12 students and educators. Initial response from our pilot highschool workshop are positive.

Future Work: Currently site visits to the City of Camden schools are being planned along with a teachers workshop to be held in the Summer of 2023. Our partners at American Water and CCMUA will assist with these activities. An internship program has been established with the ACUA and we will be assessing the impact of the internship program this summer. The SJLWT has also been trained to adopt our activities and implement in their outreach program this summer. Activities for the WaterCave and WaterTalk modules will be ready by the end of the summer of 2023. We will initiate school visits and adaptation of the developed modules this Fall.

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