Water and Wastewater Technician Education

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Introduction

The water and wastewater industries in both the public and private sectors are facing critical workforce shortfalls in the coming years as existing operators retire and gaps in tacit knowledge are created. The origins of this looming crisis predate the original American Water Works Association (AWWA) State of the Industry Report from 2004, where it was noted that most survey respondents, a group comprised of industry professionals, were over 45 years of age and had over 20 years of experience. Further, certified operators who comprise a subset of this group were found to have an average age of 50 and planned to retire or leave the industry within 10 years[1]. Subsequent releases of this annual AWWA report have promulgated and accelerated concerns addressing succession planning and implementation throughout the trade[23456789]. This concern has persisted and gained recognition throughout the nine years of data collection, even in the midst of troubling economic conditions, making the exodus of incumbent water and wastewater operators one of the top five concerns facing the future of the industry[10].

Moreover, according to the Bureau of Labor Statistics' 2012 Occupational Outlook Handbook, job prospects in the field of water and wastewater operations are expected to be excellent for the next decade. This is due to an increasing population and more stringent environmental and safety regulations[11]. However, as detailed by a survey conducted by Franione & Good there is a lack of new prospective employees to meet this elevated demand. In fact, 75-76% of respondents (composed of private water and wastewater operations) to the Franione & Good study indicate that they have had difficulty recruiting certified operators. According to 79% of respondents this was due to a shrinking applicant pool, while 82% of respondents cite "other" issues, including high turnover rates, and poor reading and math skills[12]. Additionally, the AWWA Research Foundation and the U.S. Environmental Protection Agency (USEPA) document that as much as 41% of operator positions are unfilled.[13] Further, a 2008 interview with Teresa M. Boepple-Swider, a professional certification chief for the New York State Department of Health, eluded that a lack of professional recognition by the general public and a continued stigma as a profession of last resort have hampered recruitment and retention efforts for water and wastewater operators[14].

Currently, as dictated by federal regulation, the minimum training that most states require is completion of secondary education and a state-certified examination[15]. However, the AWWA and the Water Environment Research Foundation (WERF) have documented that the current pool of available, non-degree workers lack the skills of prior generations and that future employees will need a greater level of technical skills than those currently employed in the industry, as plant automation and technological advancements have made the treatment and transmission of water a much more technical occupation[16]. Further, while many utilities offer compensatory training beyond state certification, there are few operators that take advantage of such resources.[17] This indicates that the operator profession is currently in transition from an unskilled occupation to a more knowledge-based profession. This transition, however, has been met with little to no participation among current employees.

With this in mind, an associate degree in Water Resource Management has been established at Western Kentucky University (WKU) through funding from the National Science Foundation's Advanced Technological Education (ATE) program to address these workforce needs. It is believed that this program provides the necessary technical competency that the future of the trade dictates and also helps to remove the moniker that reasons it as a dead-end career path. Furthermore, the degree program was created on a distance-learning platform, in order to: reach the greatest number of students; provide education to incumbents who work full-time and lack the temporal resources necessary to participate in physical classroom meetings; and connect with a diverse geographical audience. Participation in the program has been enhanced by using an open courseware policy in the classes and by linking the content with state continuing education unit (CEU) programs, required to maintain licensure as a water or wastewater operator.

Degree Program

The degree program consists of 60 hours of academic credit, including general education, core science requirements (mathematics, chemistry, biology, etc.) and concentration-specific courses. Currently there are three potential concentrations for students: water operations, wastewater operations, and utility management.

The general education requirements are those that university policy dictates as mandatory for the student to receive an associate degree from the institution and compose 15 of the 60 required academic credit hours. Analogous to most professionalized degree programs, the science requirements are comprised of academic disciplines that have been deemed to be supplemental to the concentration-specific requirements and consist of natural sciences, physical sciences, and mathematics. They make up 21 of the 60 required academic credit hours. The final 24 required academic credit hours are comprised of each concentration-specific course load which function to familiarize the student with water and wastewater operations and seek to apply much of the knowledge conveyed in the science requirements portion of the degree program. Furthermore, each concentration requires that the student complete an internship at a water or wastewater plant to complete the degree program. To facilitate this experience, students are paired with a utility in their local geographic area to gain hands-on experiences required for operator licensure. Table 1, Table 2, and Table 3 describe the core requirements under each track.

This degree program was developed and refined by a Steering Committee comprised of industry representatives including trade associations and utility partners, as well as government regulatory agencies and other educational entities. These linkages ensure the degree program remains relevant to industry needs.

Looking beyond the associate degree requirements, several articulation options are available to students who wish to continue their education beyond a 2-year degree. Two options currently available are a bachelor degree in either Technology Management or Interdisciplinary Studies. These options allow the student to transfer the academic credit received under the associate degree program and complete additional academic credit hours to receive the more advanced degree.

Table 1 Required Core Curriculum for the Drinking Water Operations Track

Course Name	Description
Water Supply & Wastewater Control	Students completing this course will have: • A conceptual understanding of the fundamentals of hydrology and hydraulics, to the extent that they impact the operations of water supply and wastewater control operations. • An understanding of the common constituents of water that impact its quality, to the extent that they impact the operations of water supply and wastewater control operations. • An operational understanding of drinking water treatment and distribution, and wastewater treatment and collection.
Water Distribution & Wastewater Collection	Students completing this course will have: • An understanding of the basic concepts governing the layout and operation of water distribution systems and their component parts. • An understanding of the basic concepts governing the layout and operation of wastewater collection systems and their component parts. • Knowledge of the needs and expectations of distribution/collection system maintenance, repair and emergency response.
Water & Wastewater Instrumentation & Control	To familiarize students with instrumentation used in water & wastewater industry, including: • A conceptual understanding of the principles of operation of the instrumentation most frequently in use in the water and wastewater industry • An ability to read, calibrate and maintain mechanical, electrical, hydraulic, and pneumatic sensing equipment; and indicating, recording, and control equipment
Water Chemistry	To expose students to the basic chemical concepts and principles as they relate to water and wastewater treatment
Introduction to Water Treatment Processes	This course is designed to provide operators with the knowledge needed to safely and effectively operate and maintain drinking water treatment plants, including:

	• A conceptual understanding of the unit operations involved in the drinking water treatment • An understanding of the core processes typically utilized in the treatment of water from surface and groundwater sources • An operational understanding of the technologies integrated to process water from source to finish and the related maintenance activities necessary for smooth operation
Calculations and Hydraulics for Water	To provide the student with an understanding of the mathematical principles and practical hydraulic design related to water supply, including: • A conceptual understanding of the behavior of water, as a fluid, under static and steady flow conditions, and its measurement • An operational understanding of the basic mathematical relationships that describe the behavior of water • An operational understanding of the technologies used in water supply to distribute and store water
Advanced Water Treatment Processes	This course is a continuation of Introduction to Water Treatment Processes, and is designed to train operators to safely and effectively operate and maintain drinking water treatment plants with advanced treatment processes.
Internship in Utility Operations	Internship in water/wastewater operations.

Table 2 Required Core Curriculum for the Wastewater Operations Track

Course Name	Description
Water Supply & Wastewater Control	Students completing this course will have: • A conceptual understanding of the fundamentals of hydrology and hydraulics, to the extent that they impact the operations of water supply and wastewater control operations. • An understanding of the common constituents of water that impact its quality, to the extent that they impact the operations of water supply and wastewater control operations. • An operational understanding of drinking water treatment and distribution, and wastewater treatment and collection.

Water Distribution & Wastewater Collection	Students completing this course will have: • An understanding of the basic concepts governing the layout and operation of water distribution systems and their component parts. • An understanding of the basic concepts governing the layout and operation of wastewater collection systems and their component parts. • Knowledge of the needs and expectations of distribution/collection system maintenance, repair and emergency response.
Water & Wastewater Instrumentation & Control	To familiarize students with instrumentation used in water & wastewater industry, including: • A conceptual understanding of the principles of operation of the instrumentation most frequently in use in the water and wastewater industry • An ability to read, calibrate and maintain mechanical, electrical, hydraulic, and pneumatic sensing equipment; and indicating, recording, and control equipment
Water Chemistry	To expose students to the basic chemical concepts and principles as they relate to water and wastewater treatment
Introduction to Wastewater Treatment Processes	This course is designed to train operators to safely and effectively operate and maintain wastewater treatment plants, including: • A conceptual understanding of the unit operations involved in the wastewater treatment • An understanding of the core processes typically utilized in the treatment of domestic and light industrial wastewater • An operational understanding of the technologies integrated to process wastewater from raw to secondary treatment levels, and the related maintenance activities necessary for smooth operation
Calculations & Hydraulics for Wastewater & Stormwater	To provide the student with an understanding of the mathematical principles and practical hydraulic design related to wastewater and stormwater control, including: • A conceptual understanding of the behavior of wastewater, as a fluid, under static and steady flow conditions, and its measurement

	• An operational understanding of the basic mathematical relationships that describe the behavior of wastewater and stormwater • An operational understanding of the technologies used to collect and transmit wastewater and stormwater
Advanced Wastewater Treatment Processes	To train operators in the practical aspects of operating and maintaining wastewater treatment plants using advanced treatment processes, emphasizing safe practices and procedures.
Internship in Utility Operations	Internship in water/wastewater operations.

Table 3 Required Core Curriculum for the Utility Management Track

Course Name	Description
Water Supply & Wastewater Control	Students completing this course will have: • A conceptual understanding of the fundamentals of hydrology and hydraulics, to the extent that they impact the operations of water supply and wastewater control operations. • An understanding of the common constituents of water that impact its quality, to the extent that they impact the operations of water supply and wastewater control operations. • An operational understanding of drinking water treatment and distribution, and wastewater treatment and collection.
Water Utilities Management	Intended to provide the learner with an overview of the management aspects of water and wastewater utilities. A learner in this course will gain industry-based insight into the special operations and management functions of a water or wastewater utility.
Water Utility Organization, Regulation, & Law	Intended to provide the learner with an overview of the organization, structure, and legal aspects of water and wastewater utilities. A learner in this course will gain industry-based insight into the ways water and wastewater utilities are formed and organized with emphasis on their legal and structural frameworks.
Water Utility Finance and Administration	Intended to provide the learner with an overview of the financial and administrative aspects of water and wastewater utilities. A

	learner in this course will gain industry-based insight into the ways water and wastewater utilities are financed and how they apply collective resources with emphasis on administrative practices that demonstrate technical, financial, and management capacity.
Human Resource Management for Water Utilities	Intended to provide the learner with an overview of the staffing, compensation, and human resource utilization aspects of water and wastewater utilities. A learner in this course will gain industry-based insight into the ways water or wastewater utilities are staffed and how they apply collective human resources with emphasis on personnel practices that reflect functional capacity.
Water Utility Management and Human Relations	Intended to provide the learner with an overview of the management and human relations aspects of water and wastewater utilities. A learner in this course will gain industry-based insight into the special operations and management functions of a water or wastewater utility with emphasis on the human relations activity.
Modern Technology & Water Utility Management	Intended to provide the learner with an overview of the essential functions of public drinking water and wastewater utilities. Content emphasis will be on the emerging technologies and evolving legislation that drive quality and quantity issues. A learner in this course will gain industry-based insight into the crucial considerations of water and wastewater utilities. These include: source protection; surface and ground water supplies; the need for treatment; methods for making water safe to drink; etc.
Internship in Utility Management	Internship in water/wastewater utility management.

Content Delivery

All of the aforementioned coursework can be completed online without the student stepping foot on the university's physical campus. This model of delivery has been utilized due to research conducted by Fattic (2011), which found that because enrollment would not be large enough using a classroom-based approach, the only sustainable methodology of content delivery would be via remote applications[18].

Therefore, an online content management system (CMS), Moodle, was employed to serve as the arena of interaction between students and their instructors and serves as the central repository of data acquisition and storage. The only hardware requirements of the student in this scenario are a computer and internet connection.

Due to the high level of geographical dispersion with water and wastewater treatment facilities, students typically complete the internship portion of the program at their local plant. The Degree Program Coordinator coordinates with these utilities and typically introduces the students to the treatment works. Those students who are currently employed in the industry complete this degree requirement through their current positions. At the conclusion of the internship the supervisor who monitors the intern is required to evaluate the student's performance.

Outcomes

As of the fall 2012 semester, six students have completed the associate degree requirements and one student has completed the bachelor's degree. Over its duration, enrollment in the suite of courses has risen from six students during the fall 2009 semester to 36 in fall 2012, with a high of 46 enrollees in spring 2012 (additional course offerings in spring semester). Further, majors in all concentrations have risen to 16 as of the fall 2012 semester. There have also been increases in the number of graduates with the initial graduates completing the degree in fall 2011 and four students following suit since this time. Figure 1 displays enrollment trends through the past seven semesters. These figures represent enrollment in all courses; therefore students enrolled in more than one concentration-specific course are counted more than once. These numbers do not include any students who have taken the courses outside of the university, for credit from other institutions.

Successes of the program include: graduates who are being hired by the utilities where they conducted their internships; students who are gaining a comprehensive knowledge of the treatment components, infrastructure and operations of water systems; and an infusion of both highly-skilled technicians who understand the theory and concepts behind water operations, as well as existing operators gaining advanced knowledge in their field. Of the six students who have completed the degree requirements, five were either employed immediately upon graduation or chose to continue their education beyond the associate degree. Two of these students were employed by utilities where they conducted their internships. Surveys completed by the supervisors of these interns indicate that the students have performed well in their respective assignments. For example, one supervisor noted that the intern was "dependable, exacting, able to solve problems".

Though initially envisioned as a workforce development initiative to bring new talent into the water industry, it was discovered that many individuals already working in this industry were also interested in enrolling for professional development and career advancement opportunities. Fifty percent of the students currently in the program represent this demographic and typically their utility provides tuition reimbursement programs. Therefore, many of the courses have been reviewed by state certification boards and granted CEU credit. Of the courses listed in Table 1, Table 2, and Table 3, four courses (Water Supply & Wastewater Control, Water Distribution & Wastewater Collections, Water & Wastewater Instrumentation & Control, and Introduction to

Water Treatment) have officially been recognized by at least one state as opportunities for CEU credit.

Further applications have demonstrated that the CMS can be utilized to deliver course content to students outside of WKU. The researchers did so by entering into a subcontract agreement with Mountwest Community & Technical College (MCTC) in West Virginia. The students at MCTC took courses alongside those at WKU and the credits received were registered under the students' home institution. Thus, this delivery platform has proven to be wholly translatable to students outside the researchers' primary service area. Please note that enrollment figures at the subcontract institution are not included in Figure 1 or within any of the previous discussion concerning enrollment.

The online delivery format has also allowed instructors in the program to provide open source instructional material that is free for the students to utilize. This content is primarily produced by governmental agencies such as the USEPA and state regulatory authorities. Students who were unable to afford the once-required texts facilitated the main motive for this movement to open courseware. Once this obstacle was removed, an increase in the number of students enrolling in the program's courses was observed. Further, this facilitates participation among those that are socioeconomically disadvantaged.

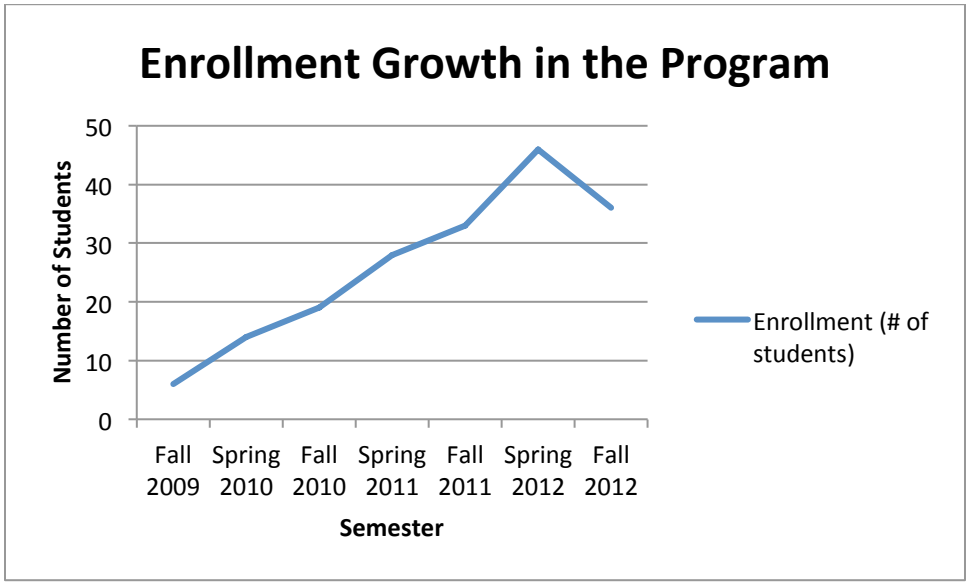

Figure 1 Enrollment Trends since the Program's Inception

Current & Pending Developments

The researchers are currently pursuing development of both a lab technician track and stormwater management track. This pursuit is the product of an interest garnered from both students and industry in these tracks. Further, an additional avenue through the Systems Management four-year degree program at WKU is also being pursued due to similar rationale. This endeavor is yet another exemplification of how a sustained relationship with those outside of the university and academic community can lead to productive outcomes.

Further developments include a proposal to include the program in a pilot study that will examine the use of a nontraditional approach to distance education. This methodology will deliver course content in a manner that is relevant to the students in the program, yet ties to other types of content utilized by other disciplines in the water and wastewater industry, such as engineering.

Conclusions

The water and wastewater operator associate degree program at WKU is in a constant state of evolution, as refinement of the curricula is matched with industry needs while striving to meet the needs of its students as well. As refinement has altered the initial concept of the program, enrollment and general interest have increased. Following this logic it can be assumed that future developments that continue to be aligned with the industry will contribute to this growth as well.

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