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NSF TUES: Development of Water Distribution System Lab Modules and Kits for Undergraduate Student Education

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Development of Water Distribution System Lab Modules and Kits for Undergraduate Student Education

Introduction

Water distribution systems are very complex systems where biological and chemical reactions occur within a network of pipes, pumps, and tanks that deliver water whose use exhibits a spatial and temporal variation. However, academia has largely ignored the need to fully educate students in understanding the complex behavior of these systems.

Currently, in spite of present dynamics and complexities in water distribution systems, fluid mechanics and hydraulic courses are taught to engineering students focusing only on the physical properties and dynamics of fluids. There is a significant need for engineering students to understand physical, chemical and biological dynamics, and their interrelations, in water distribution systems to meet the demand for both a trained work force and the maintenance of an aged water infrastructure [1-7]. This project aims to address the current lack of integrated water distribution system education by providing laboratory modules and kits coupled with a computational modeling tool for hydraulics and water quality simulation in water distribution systems.

The main objective of this project is to develop and test "Water Distribution System Analysis Lab (WDSAL)" modules and kits, which allow undergraduate and graduate engineering students to understand the physical, chemical and biological dynamics in water distribution systems via practical hands-on lab experiments. A public domain mathematical simulation model, EPANET developed by the USEPA, is used in this endeavor.

Detail objectives of this project are:

- To increase students' understanding of water distribution networks by providing systematic information and concepts associated with biological, chemical, and hydraulic dynamics in water distribution systems as well as their interaction.
- To introduce students to real world problems by adapting and implementing problem based learning modules with real-life context.
- To apply computational techniques for hydraulics and water quality simulations to develop and evaluate complex dynamics in water distribution systems.
- To help instructors/faculties develop expertise in water distribution systems requiring a multi-disciplinary approach.
- To disseminate lab modules and kits to a broad audience (other institutions, water engineering professionals).
- To improve the current civil engineering curriculum by developing and providing hands on lab based modules and kits related to fluid mechanics, hydraulics, water chemistry and microbiology for integrated student understanding.

Laboratory Module and Kit Development

During the first project year, user adaptable four basic lab modules covering three major areas of interests in water distribution system analysis were developed. The basic modules and kits include disinfection kinetics of bacteria [both Gram positive (spore form) and Gram negative], decay/ reaction kinetics of disinfectants, contaminant mixing and basic hydraulic labs (friction and energy losses). Using the basic modules, three integrated modules coupled with mathematical modeling using the EPANET were developed to help students understand the combined role of biological, chemical and hydraulic dynamics on water quality changes in the distribution system.

Implementation

The implementation plan is composed of phase 1 (the first and second years) and phase 2 (the third year) projects. During the first year of the project, developed laboratory modules and kits were tested and evaluated at two institutions. Participating students had the opportunity to conduct lab experiments with the modules and kits using detailed manuals and model codes with the EPANET. Students also had opportunities to apply computational simulation to hydraulics and water quality in water distribution systems. By comparing laboratory data and mathematical model simulation results, students were asked to synthesize and interpret multiple information sources for model building and calibration.

During the second phase of the project, both basic and integrated laboratory modules and kits at the leading universities, WDSAL labs and kits will be disseminated to other participating universities. Faculty members from three institutions have shown their interest in this project and are committed to this project. They will review and evaluate developed modules and kits for their classes. The WDSAL will also be introduced to water resources engineers at a local engineering firm to educate junior engineers.

Evaluation

Both basic and integrated modules were tested in identified classes. Lab modules and kits were evaluated with TAs' feedback, instructors' feedback and the course evaluation forms of the college of engineering at participating institutions. These provided general feedback as to the effectiveness and academic value of the modules and kits. A detailed analysis and specific evaluation of each component in the modules and kits will be completed via detailed student surveys as well as instructor's assessments.

Outreach activities

The modules and kits were employed during various outreach activities for local high school students from northern Ohio and Michigan. PI has been engaged in these activities and successfully introduced developed lab modules and kits to local high school students and their parents to increase their awareness of the dynamics and importance of maintaining water quality for the water distribution system. The PI has also directly interacted with inner city Latino students via the Latino Youth Submit program in support of the Ohio Migrant Education Program introducing the developed contaminant transport and mixing lab.

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