

Train the Trainers: Do Researcher and Professional Collaborations with Teachers Increase Student Career Interest? – A Mixed Methods Study

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ABSTRACT: An impending workforce shortage in the water sector necessitates educational outreach to engage students across demographics and viewpoints to train the next-generation STEM workforce. Train the Trainers, a program based on collaboration among university researchers, career professionals, and K-12 educators, is designed to stimulate student interest in environmental engineering. The program includes workshop training for teachers on water science, researcher designed video content on water science and careers, teacher developed lesson plans, and guest lectures by research professionals. Four middle school classrooms and two high school classrooms (133 students) participated in the program. Surveys (107 pre- and 68 post-program) explored consenting students' preconceptions of environmental engineering and changes in their beliefs after the program. Data analyses included Wilcoxon Rank-Sign tests, non-parametric ANOVA, and correlative analysis with additional context from lesson plan content analysis and student behavioral assessment. Overall, the program effectively improved students' perceptions of environmental engineering to provide a platform for future interest in related careers and activities. Ethnicity, race, and gender did not significantly impact student evaluation metrics. T-STEM survey results indicated high teacher confidence in teaching and expected positive impact on student performance. Content analysis showed four out of five teachers engaged students with multiple levels of Bloom's Taxonomy.

INTRODUCTION

Current workforce needs within environmental engineering, the water field, and STEM professions at large require a proactive approach to enhance student interest in STEM fields and prepare students to excel in these areas. According to the American Water Works Association (AWWA) State of the Water Industry for 2023, the loss of much of the workforce to retirement was ranked sixth of the most pressing issues facing the water industry, as nearly 30% of the AWWA survey respondents in water careers with or without college degree requirements are expected to retire in the next decade and over 50% in the next two decades (American Water Works Association, 2023).

Transferring the expertise of retiring water professionals to the next generation is crucial to successful turnover in water utilities. Fulfillment through service to the communi-

ty, stimulating work environments, and the need for water professionals are great draws for attracting new talent to the water sector, but educational outreach and workforce development are necessary to give the next generation proper exposure to the field (DeNileon & Stubbart, 2005). STEM outreach is the preferred method for addressing the needs of the water workforce, as it cultivates the mindset, skills, and drive necessary for future STEM professionals (Fernández-César et al., 2020).

Target Audience. Outreach to demographics historically underrepresented in STEM fields is a particularly promising strategy to increase the influx of future professionals. Female professionals comprise 34% of the STEM workforce, a figure that drops to nearly 25% when considering

only STEM workers without a bachelor's degree (National Science Foundation, 2021). Meanwhile, Blacks or African Americans, Hispanics or Latino/as, and American Indians or Alaska Natives represent 30% of the employed U.S. population and just 23% of the STEM workforce due to underrepresentation among STEM workers with a bachelor's degree or higher (National Science Foundation, 2021).

Several challenges have historically hindered underrepresented students from entering STEM careers. One roadblock to female engagement in STEM fields is that these students are less likely to view themselves as being able to achieve in STEM fields, otherwise termed low self-efficacy (Ayuso et al., 2021; Kinkopf & Dack, 2023). Student surveys from low-income neighborhoods found African American females to be particularly prone to a low sense of identification with STEM (Kang et al., 2019). The disconnect between sense of self and student perceptions of a successful professional in a given field lead to decreased interest in that field according to role congruity theory (Diekmann & Eagly, 2008). Meanwhile, continued systemic segregation in K-12 schools has led to the separation of African American and Hispanic students into poorly funded districts and lower-achieving courses in secondary education (Hirschl & Smith, 2023; U.S. Government Accountability Office, 2022). The effects of these inequalities manifest in disproportionately low percentages of underrepresented minorities (URMs) attaining bachelor's degrees or higher-level degrees in STEM fields. In addition, eighth grade math assessment scores show widening margins between Asian and White students and URMs in STEM, indicating that this issue exists not just at the university level, but also in K-12 (National Science Foundation, 2024). Therefore, education that can equally engage students regardless of race, ethnicity, or gender is needed to advance education equity.

The critical age for STEM outreach is at the middle school grade levels. While studies indicate a high interest in STEM for students throughout much of primary school, this interest quickly drops during middle school (Blotnick et al., 2018; Murphy & Beggs, 2005; Tai et al., 2006). In addition, science and mathematics performance on National Assessment for Educational Progress (NAEP) tests indicates a decrease in scores during middle school or shortly thereafter (National Center for Education Statistics et al., 2015). A study of sixth and seventh-year students in the UK, found career aspirations as a primary motivation for practical science decreased significantly, from 25% among sixth-year students to 1% among seventh-year students (Braund & Driver, 2005). Evidently, a shift occurs in the transition from primary to secondary schools in which students are less likely to see a career as the endpoint for their studies in science. Even so, STEM outreach shows promise for changing this trend. A meta-analysis of 56 quantitative research studies indicated STEM education improved students' over-

all academic performance, with particular effectiveness in science courses (Kazu & Kurtoglu Yalcin, 2021). Given this evidence, STEM outreach programs can be most impactful by focusing efforts on middle school students, especially females and URMs.

Advantages of a Hybrid Approach. A meta-analysis of 21 studies on science programs for grades 6-12 highlighted particularly noticeable improvements in student performance in six studies that used a technology-based approach, combining computer and video resources with traditional teaching methods (Cheung et al., 2017). Other prominent models encouraging problem-solving and discussion within a real-world context have proven academic advantages (Capraro & Jones, 2013; Freeman et al., 2014; Linton et al., 2014; Lombardi & Shipley, 2021; McKenna et al., 2018; Stearns et al., 2012), but the success of contextualization is often accompanied by challenges of time and material constraints (Jain et al., 2022; Kertil & Gurel, 2016; McKenna et al., 2018). Thus, content based on familiar (local) and engaging contexts has great potential to benefit students when paired with online modules that minimize time and resource-intensive in-class activities.

Context is Key. Identifying common experiences among target student populations is key to maximizing the benefits of a contextualized approach. For example, citing the high percentage of U.S. families who own a pet, one study used animal-based lessons to promote interest in STEM careers. The study found that student interest in engineering significantly improved after participation in weekly and daily animal-based education programs ($p < .01$ and $p < .05$, respectively), yet interest in science did not show a significant increase (Mueller et al., 2018). These findings indicate educational context should relate to the subject taught (i.e. STEM) in addition to student experiences. Water science satisfies both these criteria. With connections to all four fields of STEM, water science is inherently interdisciplinary. Environmental engineering is particularly attractive because it has an almost equal representation of male and female college majors and the highest percentage of women among engineering professions, making it a welcoming gateway to STEM for an otherwise underrepresented demographic (Roy, 2019; U.S. Census Bureau, 2022). In Alabama, the location of this program, water resources are abundant and rich in biodiversity. Water problems, such as lack of sewerage and failing septic systems, are prevalent as well (Maxcy-Brown et al., 2021). Meanwhile, sewer overflows, distrust of tap water, and leaks in indoor plumbing, are common experiences shared by students nationwide. Given this daily exposure to water challenges, water science and environmental engineering provide an ideal context for engaging students while maintaining strong connections to STEM.

The majority (70%) of current K-12 national standards related to water literacy address the cognitive domain of education while only 20% of these standards address the affective domain, which encompasses student interest and attitudes in the social and emotional spheres (Mostacedo-Marasovic et al., 2022). This imbalance indicates that students are currently engaged in water science primarily with academic performance in mind, not their interest in related careers and their role in society. Previous research suggests the implementation of water science in middle and high school curricula is useful for improving content knowledge, critical thinking, student science self-concept, and interest in STEM careers (Alsultan et al., 2021; Riskowski et al., 2009). However, analysis of student science self-concept and STEM careers was limited to qualitative analysis of student exit interviews, warranting further investigation of these effects (Alsultan et al., 2021).

Many STEM programs are rooted in electrical, chemical, or aerospace engineering, which are associated with exciting inventions, robots, rockets, and “mad scientists” (Akin et al., 2022; Fan et al., 2022; Jain et al., 2022). However, a more relatable context may be more effective for recruitment of URM students. Civil engineering and water science may not seem as flashy as other STEM fields, but using environmental contexts in education can be especially powerful for engaging URM students, many of whom live in communities disproportionately affected by environmental justice issues (Roller et al., 2019). According to Gottfredson’s (1981) circumscription and compromise theory, as students connect the subject matter to their daily life they establish alignment between personal goals and career objectives and feel a sense of occupational knowledge, all of which are necessary for forming career interests. Furthermore, environmental engineering and water literacy are associated with municipal fields and global issues, promoting the sense of local and global citizenship, critical thinking, and problem-solving skills that are essential for young professionals (Ontario Public Service, 2015). In addition, exposing students to a wide array of field experts and career professionals in environmental engineering may provide relatable role models for students, which has been suggested to increase student interest in these careers (Akin et al., 2022; Davis & McIntosh Allen, 2020; Dickens et al., 2021; Hernandez et al., 2017). As students begin to identify with career professionals, they strengthen a social identity congruent with the career (Akin et al., 2022). Therefore, content and outreach activities should incorporate role models displaying not only demographic diversity but also a range of perspectives to ensure relatability (Hernandez et al., 2017).

Professional Development for Teachers. Providing professional development opportunities for teachers is a key factor in enhancing student success. A survey of 328 teach-

ers in Spain indicated that teaching engineering concepts in the classroom is a challenging task for most teachers, who do not feel adequately trained. Notably, 70% of the teachers reported low to fair levels of self-efficacy in this area. Additionally, 80% of the teachers had never attended a professional development course on engineering implementation in the classroom, and almost 90% rarely or never considered incorporating engineering practices into their classroom (García-Carmona & Toma, 2024). On the other hand, teachers who are well-versed and confident in teaching the subject matter experience higher levels of student performance and engagement in their classes, with effective professional development for teachers catalyzing this outcome (Emiru & Gedifew, 2024; Jerrim et al., 2023; Nadelson et al., 2013). Thus, educational programs should facilitate interactions between teachers and STEM experts to enhance content knowledge and boost teacher confidence.

METHODS

The Outreach Program - Train the Trainers. Based on the direct suggestions and implications of the reviewed literature, a clear framework for a STEM outreach program emerged, utilizing cross-collaboration between environmental engineering researchers, water-science professionals, and K-12 teachers. Researchers and professionals trained teachers in environmental engineering concepts, who in turn trained students in the areas of environmental engineering and water science. This educational program, hereafter referred to as Train the Trainers (TtT), began with researchers creating age-appropriate, research-based video content for students to view in class or at home. This approach provided real-world exposure and contextualization while minimizing classroom time and resource constraints. Recognizing the importance of relatable context, the videos focused on environmental issues and careers that regularly impact students’ communities. The videos highlighted environmental careers and professionals, featured multimedia presentations with animations, included tours of public works facilities, explained high-level environmental engineering concepts, and introduced environmental justice issues. Environmental engineering includes a wealth of professions that do not require a college degree (e.g., water treatment plant operator, landfill manager, conservation officer, recycling plant operator, remediation technician, etc.). Middle-skill career opportunities within environmental engineering were highlighted in a video series titled *A Day in the Life of an Operator*, designed to reach students considering direct entry into the workforce or vocational training. Other topics included saltwater intrusion, persistent chemical contaminants, water plant tours, mathematical units of measure, mass balances, wastewater management, environmental justice, well-drilling, levee breaches, and much more. Video scripts emphasizing career

opportunities were reviewed by the workplaces featured in the videos.

Each year, secondary-level teachers in Alabama were recruited to collaborate with university researchers in creating lesson plans and supplementary materials centered around the videos. Teachers were recruited based on university partnerships with organizations such as the Scientific Research and Education Network (SciREN) and Southern Research as well as through in-person interactions, such as preliminary school visits, and through fliers that advertised the program to local schools via principal emails. All teachers participating in this study had seven or more years of experience and taught STEM subjects in different Alabama secondary schools. Due to budgetary limitations, 5-7 teachers were able to participate in the program each year. Program recruiting largely focused on middle school classrooms given the importance of this age range for career interest (Blotnick et al., 2018; Murphy & Beggs, 2005; Tai et al., 2006). Teacher retention in the program was preferred to promote program sustainability; thus many teachers participated in the program for multiple years.

While teachers were given the creative freedom to design lesson plans tailored to their classroom needs, they were asked to ensure the lesson plans were adaptable for other classrooms of equivalent grade level and subject matter. University researchers provided feedback on the lesson plans in the spirit of fostering mutual professional development and collaboration for the teachers and researchers. All educational materials were made publicly available through the TtT website (<https://trainingthetrainers.weebly.com/>) and YouTube channel (Train the Trainers, 2021). Each year of the program, partnering teachers were required to implement at least one lesson plan created through TtT.

In addition, university researchers with backgrounds in water quality, groundwater resources, water distribution modeling, and contaminant fate and transport actively participated with teachers during the professional development and in their classrooms. University researchers in the field of environmental engineering served as guest lecturers, visiting each participating classroom at least once to educate students about the history, impact, and career opportunities in civil and environmental engineering. The presentations included topics such as the basics of environmental engineering, pollution sources, federal cleanup programs, environmental activism, examples of current real-world problems, methods and tools used by environmental engineers and related professionals, and career opportunities, with an emphasis on non-college career pathways. If time permitted, a lengthy question-and-answer session was included at the end of the presentation. Each guest lecture included a presentation by two research professionals, representing both male and female engineering role models. The researchers each presented half of the presentation with the other taking

observation notes. This dual approach facilitated classroom observation triangulation in that multiple observers were able to compare notes on the classroom (Seale, 1999).

To further enhance professional development for educators, all participating teachers attended an academic workshop each summer. This 3-day workshop was organized under an Integrated Groundwater Management NSF grant and began with an overview of TtT program updates and a review of the latest TtT content. Each day was largely filled with research presentations that enabled teachers to learn the latest water science, with a focus on water quality, water quantity, and sustainability practices. During mealtimes and poster presentations, teachers shared their experiences with lesson plan implementation, reflected on the previous year with peers, and participated in presentations and poster sessions related to research activities aligned with the educational video topics. The first evening, each teacher presented their plans for the coming year and successes in the TtT program from the previous year, while researchers offered feedback. The teachers were further exposed to water science research during onboarding meetings in which partnering university researchers discussed their research and its impact on local communities. The teachers were encouraged to interface with university research professionals and educators through the SciREN program framework which trains researchers in transforming their research into educational materials and connects researchers with local K-12 educators. Finally, the participating vocational school teacher worked in the university water science labs and conducted field work collecting environmental samples with university researchers. These professional development strategies were implemented to familiarize participating teachers with the current state of the water science field and aid them in applying this knowledge to their lesson plans with researcher-provided feedback. Following participation, teachers documented classroom demographics, provided program feedback, highlighted successes, and indicated their decision to continue participating in the upcoming academic year. The majority elected to renew their participation annually, demonstrating their commitment to the program.

Study Hypotheses. For the TtT outreach program to be considered a success, we needed to collect evidence showing that the program's goals (promoting student interest in environmental engineering and developing teacher confidence and ability to engage students in environmental engineering) were met. Therefore, the program evaluation centered on the following hypotheses: (1) the Train the Trainers program will significantly increase student interest in environmental engineering and related careers, (2) after program participation, teachers will exhibit high confidence in their ability to teach environmental engineering and positively impact student learning, and (3) as a result of professional

development, teachers will design lesson plans that engage students with environmental engineering at multiple orders of Bloom's Taxonomy.

Data Collection and Analysis. A mixed-method approach was employed to assess program outcomes. This approach combined a qualitative content analysis of teacher-developed artifacts with quantitative data from both students and teachers.

Student Surveys. Student engagement levels were measured before and after program activities using a survey framework developed by Masters & Barth (2022) for use with middle school students; questions were adapted to focus on environmental engineering and related careers. This survey was selected because it was developed specifically to evaluate middle-skill career (no college degree required) interest amongst adolescents. While environmental engineering includes career pathways requiring college degrees, the focus of the TtT outreach program was primarily municipal environmental engineering professions that do not require a college degree. The survey was ideal for the middle school age demographic because the questions were positively coded and simply worded to avoid misunderstanding. Questions were based on Gottfredson's circumscription and compromise theory and role congruity theory which collectively emphasize gender, goal alignment, and knowledge of the occupation in shaping students' career interests (Diekmann & Eagly, 2008; Gottfredson, 1981). These constructs are particularly useful in middle and high school contexts in light of emerging awareness of gender differences and the capacity for long-range goal formation predictive of future profession (Ceci & Williams, 2010; Salmela-Aro, 2009; Tang et al., 2020). The survey also measures the three components of career-related social identity formation as set forth in Akin et al. (2022): belief in career aptitude, personal relevance of the career, and career accessibility to the student.

Survey questions are included in the Appendix. Three questions were designed to assess knowledge of environmental engineering occupations. Two open-ended questions were included to evaluate students' understanding of the purpose and impact of environmental engineering. The questions were worded to encourage specificity in responses and maintain positive coding since negative specificity could be statistically conflated with knowledge of environmental engineering. Career knowledge, interest, and goal-alignment questions were coded from 0-5, with 0 representing low interest, knowledge, etc. and 5 representing high interest, knowledge, etc. The question on perceptions of gender inclusivity in environmental engineering, "Who mainly works in environmental engineering?" was coded to a 0-4 scale based on the ordinal distance from the central response, "Equal Men and Women." Auxiliary questions

were included to facilitate analysis of the relationships between students' career perceptions and demographic factors, values, and academic progress. Gender was recorded on a scale aligned with STEM representation (1=other, 2=female, 3=male). Three categories were coded as binary: ethnicity (2=Hispanic or Latino/a students, 1=non-Hispanic or Latino/a), race (2=URMs, 1=non-URMs), and students' best subjects (1=non-STEM subjects, 2=STEM subjects). Pre- and post-surveys were identical. Surveys were offered to all students in the participating classrooms, and students had the option to consent to complete the survey voluntarily. Pre- and post-surveys were completed within one month before and after the guest lecture and teacher lesson plan implementation, respectively. Post-surveys were administered a minimum of one week after guest lectures.

Teacher Perspectives and Classroom Environments. Educational settings, instructional practices, and teacher experiences were recorded using a multi-faceted approach. Teachers' self-efficacy and beliefs in their ability to impact students with their teaching was assessed using the Teacher Efficacy and Beliefs toward STEM (T-STEM; Unfried et al., 2022) survey which was chosen for its clarity, positive coding approach, focus on growth rather than achievement, and methodological rigor. Survey results were assessed by the structural equation model outlined by Unfried et al. (2022). The model consists of two components: personal science teaching efficacy beliefs (PSTEB) and science teaching outcome expectancy beliefs (STOEB), which describe teachers' confidence in their ability to teach on the subject of interest and teachers' perceptions of their influence over student success in the classroom. The STOEB component is split into two subscales representing expectancy beliefs for high-achieving and low-achieving students (STOEB Above and Below).

The effectiveness of guest lectures was evaluated based on student engagement, following a modified version of the Behavioral Engagement Related to Instruction (BERI) observation protocol (Lane & Harris, 2015). This protocol evaluates student engagement by the number of students displaying behaviors associated with "paying attention" (e.g., looking at the screen, staying on topic, interacting with others) at specified time points during the observation. The BERI also assesses the level of disengagement (e.g., appearing distracted, not staying on topic, looking at cellphone). Language that might unfairly record neurodivergent students as being disengaged (e.g., lack of eye contact, fidgeting) was removed. Quantitative analysis of student engagement was adapted to report and analyze the various categories of BERI engagement separately, yet within a cohesive framework (Lane & Harris, 2015). Thus, behaviors were tallied separately and used to interpret one another. For example, a student who is interacting with others (engaged) but in

a manner which is distracting to the lesson (disengaged) would be counted as disengaged. The number of engaged and disengaged students was normalized to the total number of students in the class. The number of questions and discussion points made by the class as a whole were tallied and divided by the total number of students to determine the level of discussion in the class. Teacher-developed lesson plans and supplementary materials were collected as artifacts for content analysis using Bloom's Taxonomy (Bloom, 1956). The qualitative content analysis data complemented the quantitative data from the T-STEM surveys and behavioral engagement records, providing a comprehensive perspective of student outcomes in each classroom.

Quantitative Data Analysis. Wilcoxon signed-rank tests were used to analyze student outcomes since the data were not normally distributed. Similarly, Kendall's Tau was used to explore correlations between student demographics and survey responses, given the presence of ordinal data with non-normal distributions. Non-parametric ANOVA was applied to student survey responses separated by class and demographic factors to identify any differences between student groups. All statistical analyses were performed using Origin (OriginLab Corporation, 2023).

Qualitative Data Analysis. A content analysis was conducted of the lesson plans and supplementary materials submitted by each participating teacher. The teacher served as the unit of analysis; all materials submitted by a given teacher were reviewed as a single case. There was no standardization for the lesson plans or supplementary materials, thus it was necessary to create a process to evaluate the lessons in a way that aligned with the project goals. Bloom's Taxonomy was chosen for its flexible framework for describing the level of thinking required to perform specific tasks (Forehand, 2010) with descriptive words aligning with each of the levels. The purpose of this analysis was to understand how participating teachers implemented the provided lesson content and inform future design of STEM outreach materials in environmental engineering contexts. It is important to note that the analysis was limited to what teachers submitted. Additional instructional strategies or classroom activities may have been implemented but were not documented, which may affect the comprehensiveness of the findings. Future iterations of this work will provide clearer expectations for how teachers submit lesson materials, with the goal of gaining a more complete understanding of how teachers implement instructional materials available to them from training programs.

Bloom's Taxonomy includes six levels of thinking, coded numerically from lowest to highest: (1) Knowledge (Remembering), (2) Comprehension (Understanding), (3) Applying, (4) Analyzing, (5) Evaluating, and (6) Creating.

Activities that allow students to use higher-order thinking are associated with increased student learning (Cutucache et al., 2018; Dogan & Kahraman, 2021). Thus, the materials were analyzed for activities that engage students in divergent thinking or applying the content in new or different ways.

The Remembering level included tasks that required students to recall vocabulary terms or factual information from a video, reading, or class discussion. The Understanding level involved students explaining ideas or expressing their point of view to others, demonstrating comprehension beyond simple recall. At the Applying level, teachers described asking students to use their knowledge in a new but related context. At the Analyzing level, teachers expected students to interpret data or compare different solutions. The Evaluating level involved asking students to make judgments or justify decisions. The Creating level included tasks where students generated new ideas or products.

Evidence of more than one level of Bloom's taxonomy is important because the primary benefits of environmental engineering as a context for STEM outreach lie beyond memorization of facts. Rather, the benefits lie in understanding the importance of the material, synthesis with STEM concepts, applying knowledge to real-world scenarios, and evaluating and creating meaningful solutions. These methods of engagement are crucial to contextualization.

The lesson plans and supplementary materials were also analyzed to assess engagement of students' prior knowledge, a key factor in how learners process new information and develop higher-order thinking skills (Brod, 2021). Because there was no standardized format for materials submission, the entirety of each document was reviewed for both direct and indirect references to students' prior knowledge. This analysis followed the same limitation as Bloom's Taxonomy coding: the submitted materials may not fully reflect what occurred during instruction. Direct references to prior knowledge included explicit instructions or activities designed to activate what students had previously learned.

Finally, although the program videos described the work that engineers and engineering-adjacent professionals do, the technology used, and the procedures employed to solve societal issues, the videos did not necessarily explain why engineers and related professionals choose their field. Students tend to view engineering professionals as "laborers" or "fixers," as opposed to creative thinkers (Karatas et al., 2011; Newley et al., 2017). Because a central aim of this study was to examine how the lessons influenced students' perceptions of engineering and the work of related professionals, submitted materials were analyzed for three key elements: (1) whether the work of engineers and related professionals was described, (2) whether the societal role of engineering was addressed, and (3) how well the teacher connected TtT content to students' lives. Each document was reviewed in its entirety for references to these aspects. Although some of

Table 1. School descriptors, and demographics for participating students; not all totals sum to 100%. *Teacher Cancellation Low Income is a federal status for schools that have >30% low-income students.

Class	A	B	C	D	E	F
Rural (R) or Suburban/Small City (S)	S	R	S	R	R	R
Teacher Cancellation Low Income*	☑	No Data	☑	☑	☑	☑
≥2/3 Student Eligibility for Free or Reduced Lunch		No Data	☑	☑	☑	☑
# Total Students	21	9	43	13	33	21
# Participating Students	17	9	22	5	33	21
Black	29%	56%	50%	60%	58%	57%
White	18%	22%	23%	0%	3%	14%
Hispanic	6%	0%	5%	0%	0%	10%
Asian	12%	0%	9%	0%	0%	0%
American Indian/Alaska Native	0%	0%	0%	0%	9%	0%
Pacific Islander/Native Hawaiian	0%	0%	0%	0%	0%	0%
Multiple Races	18%	11%	9%	20%	21%	19%
Other Race	12%	0%	5%	0%	0%	0%
Non-reported Race	12%	11%	5%	20%	9%	9%
Male	59%	56%	36%	20%	60%	62%
Female	29%	22%	59%	60%	33%	38%
Other Gender	12%	11%	5%	0%	3%	0%
Non-reported Gender	0%	11%	0%	20%	3%	0%

these ideas may have been presented through TtT videos or supplementary materials, they were only coded as present if the teacher explicitly included them in the lesson plan.

Study Participants. All seven actively participating teachers were invited to take part in the program evaluation study; five teachers consented, each teaching at a different school. Each teacher and their corresponding classroom were identified by unique letters. University guest-lecture presenters visited almost all of the classrooms during the study period, with classroom A also receiving a guest lecture during the semester prior to the study period. The standard procedure was for both the lesson plan and guest lecture to take place between the pre- and post-surveys; however, there were some variations. One teacher taught both Classes D and F. Class D received a guest lecture and the teacher used a TtT lesson plan, while Class F only received the lesson plan. Class E received a guest lecture before the pre-survey and only the lesson plan between the pre- and post-surveys. Classes E and F were analyzed separately to assess variations within the program. These classes were included in the pre-survey analysis, but not in the analysis of pre- and post-survey data. Additional information on each class is provided in Table 1 (National Center for Education Statistics et al., 2023; U.S. Department of Education, 2023). No data was available on Classroom B regarding Teacher Cancellation Low Income status of the

school or free or reduced lunch status of the students.

Students were considered participants if they completed the pre-survey. There was a balanced distribution of demographics across the classes, with a significant percentage of URM students in all classes. Classes C and D had low response rates, whereas Classes B, E, and F had 100% response rates. While most classes had similar demographic profiles, class A had a lower percentage of African American students responding to the pre-survey. Additionally, Classes C and D had higher percentages of female respondents, although Class D's percentages were affected by its small sample size.

RESULTS AND DISCUSSION

Trends in Students' Preconceptions of Environmental Engineering. Of the approximately 133 students in the participating classrooms, 107 students consented and completed the pre-survey. Of these, 68 students completed both the pre- and post-surveys. 32 of these students (Classes A, B, C, and D) experienced all components of the TtT program in between administration of the two surveys; these students' survey responses were analyzed for pre/post comparisons.

To better determine if demographics are correlated with student preconceptions of environmental engineering, Kendall correlations were calculated for each pair of variables on the pre-survey. The resulting correlations were tested for significance with a False Discovery Rate (FDR) of 0.05 according to the Benjamini-Hochberg procedure as a correction for multiple comparisons and at a significance level of 0.05 without correction for multiple comparisons (see Figure 1) since any subset of correlations may be analyzed separately in order to avoid inflation of Type 1 error as an alternative to post-hoc correction.

Questions within the same section (i.e. career knowledge questions, goal-alignment questions, interest questions) showed significant positive relationships with each other, as expected, due to their shared indication of a positive outlook on environmental engineering. Consistent with reviewed literature, higher desire for/interest in a job in environmental engineering was significantly and positively correlated with knowledge of the career and goal alignment, specifically with goals of free time for family and feelings of uniqueness (Gottfredson, 1981; Masters & Barth, 2022). However, in contrast with circumscription and compromise theory and role congruity theory, no significant correlation was found between career interest and either gender or goal alignment. Interestingly, no significant correlations were found between race or ethnicity and initial survey question responses. The lack of significant difference between URM and non-URM students may possibly be because one of the sources of STEM career disparities between these groups is funding

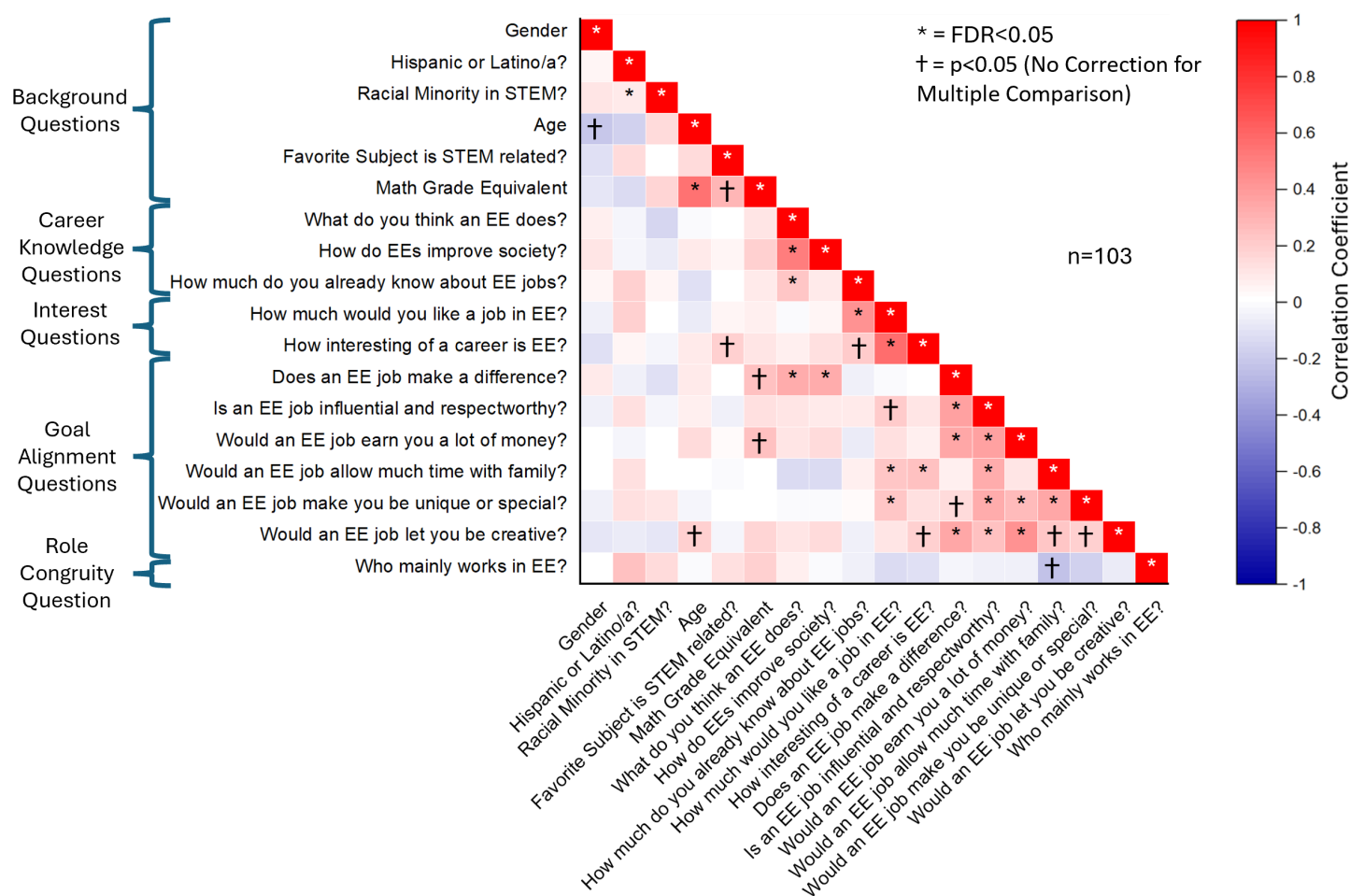


Figure 1. The correlation matrix of student demographics, academic factors, and survey responses. Strong negative correlations between intersecting labels are indicated by deeply blue-colored boxes, while strong positive correlations are represented by deeply red-colored boxes. Statistically significant correlations are marked with an asterisk for significance with correction for multiple comparisons (false discovery rate < 0.05) and a cross for significance without the correction ($p < 0.05$). EE = Environmental engineering.

discrepancies between schools with and without significant URM populations (U.S. Government Accountability Office, 2022). Thus, differences in initial perceptions of environmental engineering may exist primarily between schools rather than within schools. Alternatively, the discrepancies may disappear altogether if students appear to be afforded equal opportunity regardless of URM status (Hirschl & Smith, 2023). Subsequent Kendall correlation analysis did not reveal any significant correlations between the school of the student and environmental engineering preconceptions, supporting the latter explanation.

Hypothesis 1 - Changes in Student Career Interest Post-Intervention. Hypothesis 1 of this study (The Train the Trainers program will significantly increase student interest in environmental engineering and related careers) was tested according to changes in survey responses of the 32 students who completed both the pre and post-surveys. Data from Classes E and F were excluded. Pre/post comparisons were made using the Wilcoxon signed-rank test. The FDR cutoff

was set to 0.05 as a correction for multiple comparisons. Results are summarized in Figure 2.

Students' self-assessed knowledge of environmental engineering increased significantly, indicating a potential increase in self-efficacy. After implementing the guest lecture and TtT lesson plan, students showed significantly increased beliefs in four of the six aspects of goal-alignment, specifically that environmental engineering makes a difference, is a respectable profession, makes a person unique, and allows time for family ($FDR < 0.05$). There was not a significant increase in students believing that both men and women equally work in environmental engineering. While the increase in student interest in environmental engineering and related careers was not significant at the 0.05 level, this may be due to the short inter-survey period which may not completely reflect long-range impacts such as teacher professional development. We compared the effect size of the current program to similar intervention programs to further elucidate the practical significance of the short-term impacts of TtT on students' career interest (see Table 2).

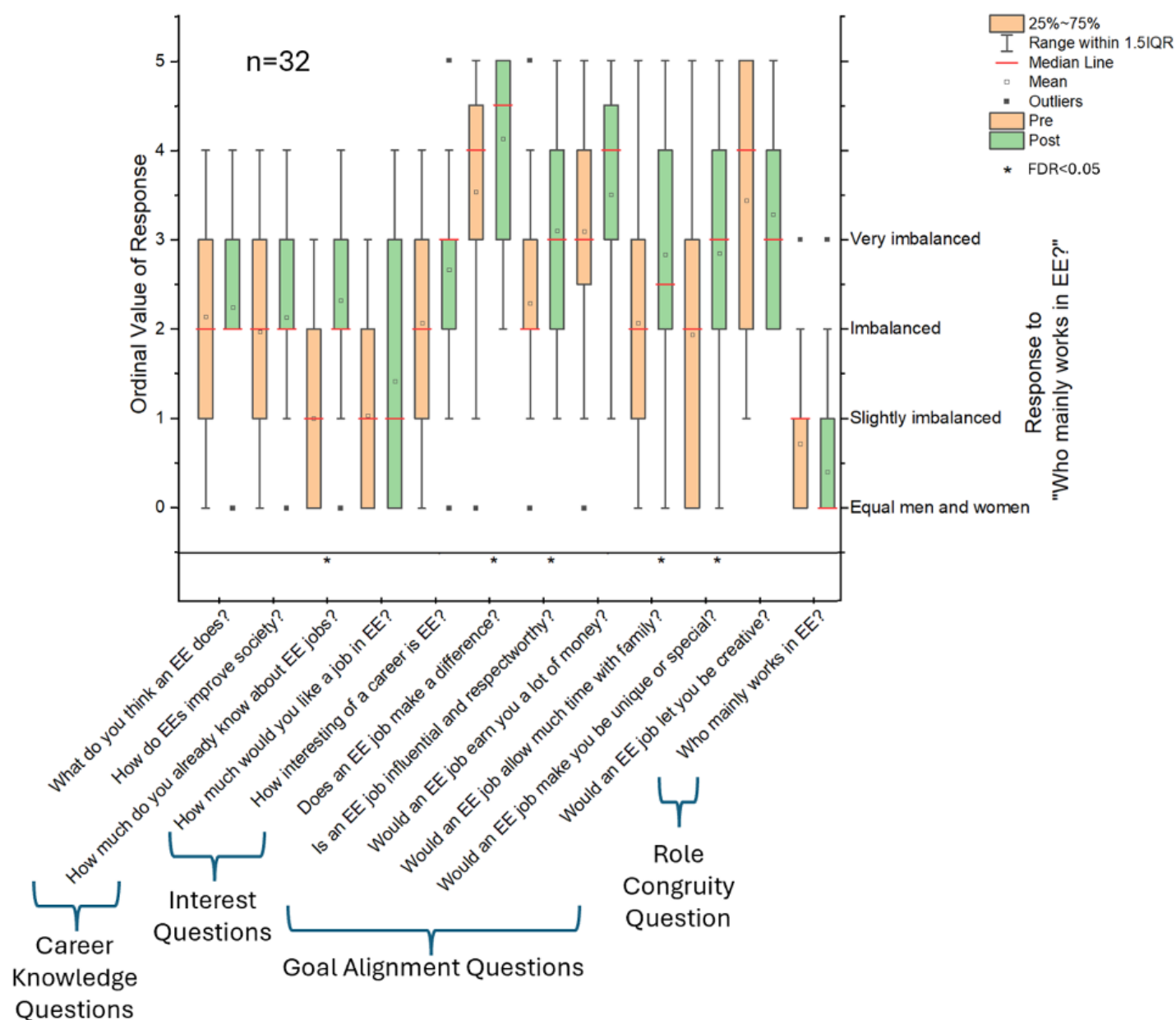


Figure 2. Box and whisker plots denote the medians, total ranges, and interquartile ranges of the pre- and post-survey responses for students who experienced both a guest lecture by university researchers and a Train the Trainers lesson plan between the surveys. Asterisks indicate significant differences between the pre- and post-survey medians (false discovery rate < 0.05). EE = Environmental engineering.

Vekiri et al. (2024), who approximated the current study's approach by using online resources to present STEM role models, found a very small effect size based on the Wilcoxon signed-rank test (rank-biserial $r = -0.04$), indicating little practical change in STEM-career interest. This could be due to the lack of teacher training, meaningful context, or physical presence of STEM role models as in the guest lectures of the present study. Loya et al. (2023) implemented a relatable context by having students participate in athletic activities and had an effect size slightly lower than the current study (rank-biserial $r = 0.19$). The Baucum and Capraro

study (2021) compared the impact of in-person and virtual STEM camps on students' career interests. Despite the 1-week exposure, the online program had a small effect size (rank-biserial $r = -0.15$) while the more resource-intensive in-person program has a large effect size (rank-biserial $r = -0.43$). Frehm et al. (2019) reported a medium-large effect size (rank-biserial $r = -0.35$) slightly higher than that of the current study. This study had a similar environmental focus to that of the current study combined with an engaging snorkeling activity. However, the contextual approach, while still centered on the environment, may not have had

Table 2. Effect sizes (rank-biserial correlation, r) for pre- and post-survey STEM career interest for the Train the Trainers (TtT) program and comparable intervention programs. EE = Environmental engineering. *The Z statistic was back calculated from the reported p -value. **paired t statistic rather than Z

Study	Grade	Summary of Methods	Context & Program Length	Z	Sample Size	Effect Size, r
TtT program (How much would you like a job in EE?)	Middle/ high school	Researcher guest presentation, teacher/ researcher collaboration on lesson plan creation, teacher workshop and ongoing professional development activities	Water science/ environmental engineering and related careers; 2 class sessions	-1.37	31	-0.25
TtT program (How interesting of a career is EE?)				-1.68	30	-0.31
Vekiri et al., 2024	Grades 7-9	Online resources (video game) featuring relatable STEM role models	Digital game-based learning; 1-2 weeks of class time	-0.37	69	-0.04
Loya et al., 2023	High school athletes	Use of premade DIY athletic measurement devices and discussion on using results for training applications	Biomechanics in sports; 4-hour session	1.72	80	0.19*
Baucum & Capraro, 2021	Grades 9-12	Online problem-based engineering and coding classes, chemistry and physics shows, test prep, and career panels	General STEM; 1-week camp	-0.74	26	-0.15
		On-campus stay with problem-based engineering and coding classes, chemistry and physics shows, test prep, and career panels		-2.17	26	-0.43
Frehm et al., 2019	Ages 11-17	Training in fish identification, snorkeling trip in Florida and recording of catalogued fish	Ecological surveying; 1-week camp	-2.20 **	36	-0.35

the same universal relevance as topics used in the current study such as wastewater or recycling. Resource limitations are also likely given the limited accessibility of snorkeling activities for most schools. Relatable context combined with the physical presence of researchers in the classroom and teacher professional development makes the current study distinctive. Further research isolating the variable of program context from other program components is recommended given the potential for a higher effect size than many similar intervention-based outreach programs while at the same time not requiring significant time and resources.

Despite the lack of a statistically significant increase in students' career interest, the medium effect size of this increase points to the value of the program in planting a seed of interest that may develop in future years, indicating a partial acceptance of Hypothesis 1 (The TtT program will significantly increase student interest in environmental engineering and related careers). Meanwhile, the statistically significant increases between the pre- and post-surveys for four of the six goal-alignment questions suggests that students have more positive views post-program about environmental engineering and its relevance to their life. Thus, the TtT program accessibly and effectively paves the way for future student participation in environmental engineering related activities, further bolstering their career interest in this field. We note that development of career interest often takes repeated exposure over time. As such, it is advisable to supplement one-time experiences with follow-up opportunities for career exposure. During the TtT program, the participating teachers displayed great initiative in providing these opportunities, including designing in-class projects on water treatment, volunteering as a class for work with a local riverkeepers association, inviting additional career professionals for guest lectures, and organizing week-long career exploration

events with a focus on water science. We hypothesize that this was due to teachers' high confidence in their ability to teach about environmental engineering and impact student performance following program participation. This was investigated in Hypothesis 2, using the T-STEM framework.

Impact of Demographics and Classroom Environment on Survey Response Changes. To determine if certain subsets of students were more positively impacted by the program than others, a Kendall's correlation analysis was conducted on student demographics and changes in responses on the post-survey (see Figure 3).

This analysis did not show any significant correlations between the changes in survey responses and student demographics when tested according to an FDR of 0.05. Therefore, it appears the findings from our pre-post survey analysis can be generalized to the student population participating in this study without regard to demographic factors. Non-parametric ANOVA analysis on the student responses categorized by class identified no significant inter-classroom differences between the classes for an FDR of 0.05. This indicates pre-post survey analysis is generalizable to all participating students irrespective of class. In other words, the program's impact was apparent irrespective of race, gender, ethnicity, or school.

Hypothesis 2 - Post-Program Teacher Self-Efficacy and Expectancy Beliefs. To test Hypothesis 2 (After program participation, teachers will exhibit high confidence in their ability to teach environmental engineering and positively impact student learning), we conducted a quantitative analysis of teacher attitudes toward teaching environmental engineering topics (see Figure 4). The data only reflect post-participation attitudes because multi-year participation by

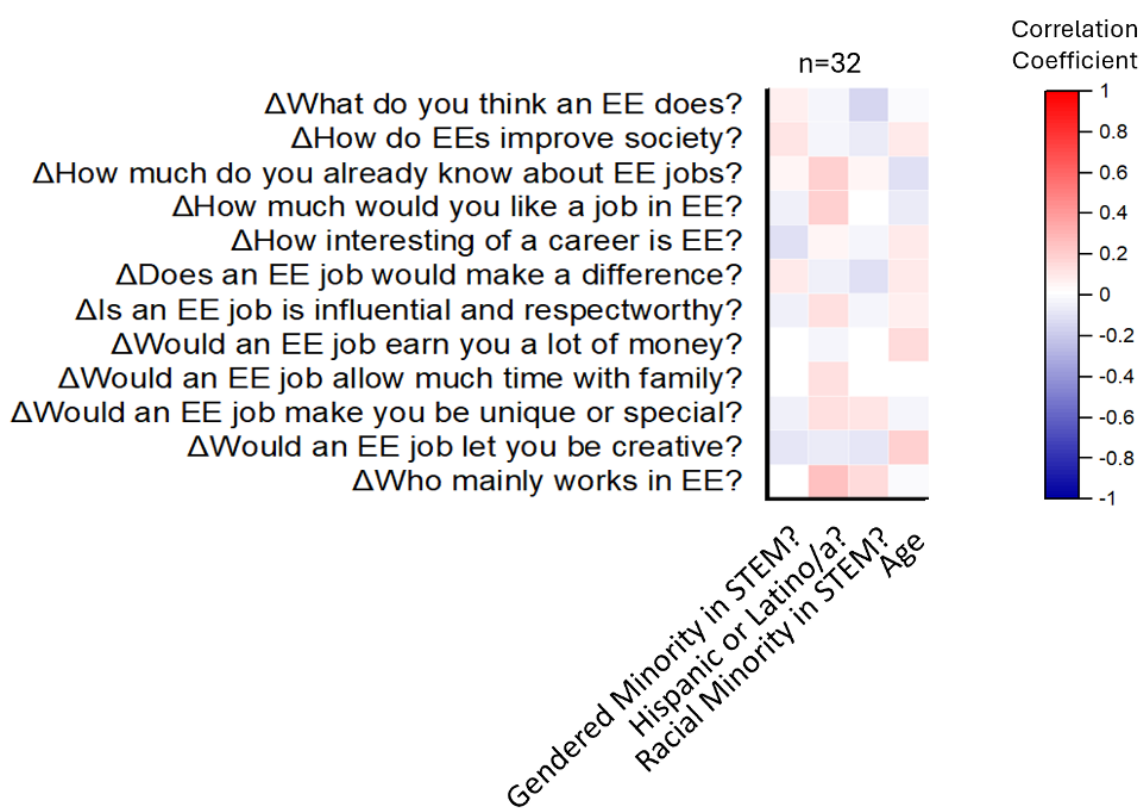


Figure 3. The correlation matrix for illustrating changes in pre- to post-survey responses compared to demographics, highlighting negatively correlated variables in blue and positively correlated variables in red for students who responded both before and after the Train the Trainers program implementation. EE = Environmental engineering.

teachers prior to this study rendered pre-surveys unviable.

All teacher survey responses indicated PSTEB and STOEB Above and Below scores between three and five, demonstrating that each teacher expressed confidence in their ability to teach environmental science (PSTEB) and believed in the impact of their teaching practices on high-achieving and under-achieving students alike (STOEB Above and Below). Except for teacher A, all teachers had similar PSTEB scores, suggesting a comparable level of confidence in their ability to teach environmental engineering effectively; teacher A's responses indicated a somewhat higher level of confidence. Despite Teacher A's relatively short participation in the program, subsequent analysis revealed low correlations of duration in the program with PSTEB scores ($r = -0.05$) and STOEB responses ($r = -0.74$). From these results, Hypothesis 2 is accepted for all participating teachers in the program. This finding points to the TtT professional development methods as a model for outreach programs seeking to ensure participating teachers feel equipped to continue teaching on the subject material even after the intervention period of the program.

Hypothesis 3 - Lesson Plan Content Analysis. To test Hypothesis 3 (As a result of professional development, teachers will design lesson plans that engage students with environmental engineering at multiple orders of Bloom's Taxonomy), each teacher's instruction and evaluation methods, as reported in their submitted lesson plans, were analyzed according to Bloom's Taxonomy. The content analysis highlighted each teacher's goals and approaches in their classrooms. It also provided insight into the applicability of the TtT program methodology and resources to various educational settings.

Teacher A implemented a lesson plan focused on introducing environmental engineering, supplemented by resources related to recycling center operations, including the TtT video tour of a recycling center. The lesson plan used the 5E learning cycle and included two activities. The first activity required students to demonstrate their understanding of recycling through a presentation (the Engage, Explore, and Explain elements of 5E). The second activity tasked them with applying their knowledge by analyzing remediation efforts at Superfund sites (Elaborate). The two activities collectively aligned with the knowledge, comprehension, and application levels of Bloom's Taxonomy (Forehand, 2010). The teacher planned to assess knowledge through tasks such as defining key terms, recalling key facts, or discussing what they learned from the video or guiding worksheet. The lesson plan included evaluation of Comprehension by asking students to present and explain the recycling process at the facility they researched. The lesson plan also demonstrated Application by including instructions for students to relate

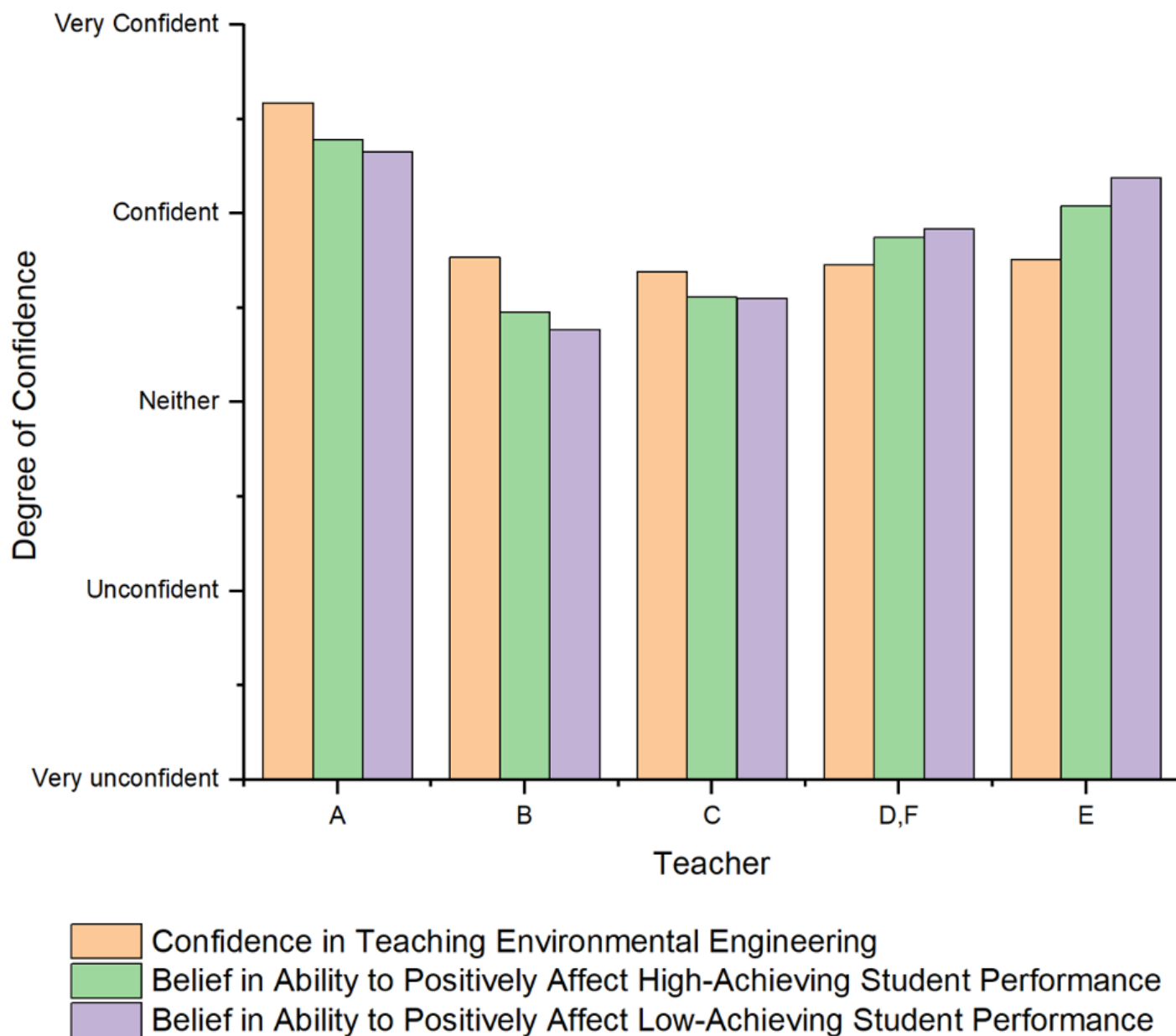


Figure 4. Estimates of teacher personal science teaching efficacy beliefs (PSTEB) and science teaching outcome expectancy beliefs for above-average performing students (STOEB Above) and average/below-average performing students (STOEB Below) were calculated. PSTEB and STOEB values were rescaled from the structural equation model's arbitrary scale back to the original 0–5 (very unconfident - very confident) scale of teacher survey responses for clarity.

their knowledge of recycling centers to a new context, clean-up efforts at a Superfund site.

Teacher B employed a lesson plan focused on explaining wastewater treatment accompanied by a video illustrating the daily work life of a wastewater treatment plant operator. The activity included a wastewater simulation where students used guided worksheets aligned with the video and the simulation. The questions primarily aimed at recalling information. Students had the opportunity to review the video and simulation if they needed clarification on the concepts.

Teacher C's lesson plan encouraged students to reflect on

prior learning, collaborate to design a conversion problem, and interact with the work of their peers. According to the lesson plan, students were expected to Apply their understanding of conversions by creating their own conversion problems. The lesson included strategies for assessing student learning and utilized a video featuring real-life example conversion problems, with the teacher serving as a facilitator. Real-world conversion problems were also incorporated into the lesson, with the video serving as a demonstration of the concept being taught. A plan to assess Knowledge was included based on the students' ability to recall the pro-

cess for solving problems. Comprehension was to be evaluated by their capability to extend their understanding of unit conversions to teacher-designed problems and explain their problem-solving methods. Additionally, students were to demonstrate their ability to apply the content by solving problems using unit conversions and by designing, solving, and explaining their own conversion problems.

Teacher E implemented the same lesson plan as Teacher A but without the Superfund site application activity. The lesson plan included instructions to answer recall questions, reflect on their learning, research a recycling center, and present it to the class with a rubric for assessment included (Understand/Report). Plans to assess Knowledge comprised of tasks that required students to define key terms, recall or record key facts, or demonstrate their understanding of recycling during discussion and assessment questions. Comprehension was to be assessed by prompting students to explain the process of plastic recycling at the recycling facility they researched.

Class F's lesson plan focused on ratios similar to that of Class C but within the context of saltwater intrusion, an environmental engineering issue. Knowledge was assessed by tasks such as having students define key terms and recall or record key facts from the video. Comprehension was evaluated through questions that prompted students to explain how ratios could be utilized to compare two quantities using information from the video. Questions in the lesson plan allowed for responses based on recall (Remember) and understanding (Understand). The video illustrated a real-world example of ratios and maintained a connection, albeit somewhat tenuous, to environmental engineering.

A summary of the content analysis is shown in Table 3. Class D was not included since a TtT lesson plan was not implemented in that classroom during the study period. Four teachers (A, B, E, and F) utilized the TtT lessons to teach concepts related to environmental science and engineering (e.g., wastewater treatment, recycling). However, it should be noted that Teacher F's questions about the video asked the students to focus on the concept of ratios and not saltwater intrusion. One teacher (C) used the TtT content to teach mathematical concepts (e.g., ratios, conversions) without linking them to environmental science and engineering. All teachers assessed low-level thinking skills, such as defining terms and recalling facts. Lessons plans focused on recalling facts from videos and defining content-specific terms. For example, lesson plans from math teachers (C and F) asked students to define a ratio or conversion while the lesson plans from teachers A, B, and E asked students to define environmental terms related to the video they watched (e.g., watershed). Four of five teachers (A, C, E, and F) made plans to evaluate student comprehension of the content. The plans of the two math teachers (C and F) assessed comprehension by requiring students to explain how to solve problems using ratios or conversions. Two other teachers (A and E) planned to assess comprehension by having students research and give a talk explaining the process of recycling plastic. Two of five teachers (A and C) wrote instructions to assess their students' abilities to apply the taught content. Teacher A included instructions for students to apply what they learned about recycling centers by investigating how Superfund sites are remediated. Teacher C included an assessment of students' abilities to create and explain how to solve a con-

Table 3. Content analysis summary of Train the Trainers (TtT) lesson plans that teachers implemented as part of the current study.*The teacher may have implemented other relevant lesson plans as part of the current study that were not submitted to the TtT program.**The teacher described the motivations and creative thinking approaches of engineering professionals beyond simple descriptions of work activities.

Class	Teacher Gender	Grade of Students	Subject (s) of Classroom	Lesson Plan Name	Lesson Plan Bloom's Taxonomy Level	Video Title	Encourages divergent thinking	Prior knowledge considered*	Describes the work of engineers**	Describes the role of engineering in society	Connects importance of the environment to students' lives
A	F	8	Physical Science	Environmental Engineering	1-3	Recycling Center Tour	Yes	Yes	Yes	Yes	Yes
B	F	10,11	STEM	Waste Water Treatment	1	A Day in the Life of a WW Operator	No	No	No	No	No
C	M	8	Math	Unit Conversions	1-3	Unit Conversion Problems	Yes	Yes	No	No	No
E	M	11,12	Physical Science, Biology	Recycle Center Tour	1-2	Recycling Center Tour	No	Yes	No	No	Yes
F	F	8	Math Intervention	Saltwater Intrusion Ratios	1-2	Saltwater Intrusion	No	No	No	No	No

version problem. Two teachers (A and E) endeavored to help students understand the relevance of environmental science to their lives by planning to ask them to research and give an oral report on a recycling center. Teacher A attempted to help students understand the work of engineers and related professionals by including instructions for students to investigate how society and engineering professionals approach remediating a Superfund site. The remaining lesson plans that focused on environmental science (B and E) or math (C and F) focused on technology and factual knowledge, without mentioning the motivation of the career professionals using the technology. Since evidence of higher order engagement with environmental engineering was present for a subset of participating teachers, Hypothesis 3 is partially accepted, with the disclaimer that this conclusion is not consistent for all teachers. This conclusion is also limited to artifact analysis and does not reflect the actual teaching practices of each teacher, indicating that future research should include observations of lesson plan implementation. Student interest and engagement with lessons also must be investigated to determine if students are responding well to environmental engineering programming.

Guest Lecture Engagement and Discussion. To assess student reception of environmental engineering lessons and the impact of guest lectures by university researchers on student outcomes, student engagement and discussion during the guest lecture were recorded for each class using the BERI protocol (see Figure 5). Classes C and D completed a survey immediately before the guest lecture, but this did not appear to negatively impact engagement, as all classes displayed relatively high engagement during the introduction slides. Overall, the eighth-grade students in Class A showed lower engagement with the guest lecture than students in Classes B-D. However, Class A received a similar presentation seven months prior, and the lecture took place during the last class period of the day. Student engagement peaked during the discussion of Superfund sites and the Q&A section. Although the teacher was observed interacting with the students throughout the guest lecture, student engagement was highest during the lecture sections corresponding to the lesson plan that Teacher A had previously implemented (i.e., history, Superfund sites). While the class's level of discussion was fairly low during most of the lecture, discussion spiked significantly during the question-and-answer portion.

Class B was situated in a vocational school aimed at career development equivalent to a high school. The class had a high level of engagement throughout the guest lecture and during the question-and-answer portion. This class was the first of the day, and half of the students typically attend this class during the second period of the school day. The high engagement could be attributed to the small class size ($n = 9$) and frequent teacher interactions that encouraged students to

listen and ask questions, with emphasis on the presentation's relevance to the students' lives. High school students may have a greater general interest in college and career pathways than younger students, thus the class may have been more invested in dialogue with the university research scientists.

Class C was a middle school math class that received the guest lecture during the second and third periods of the school day. Class C's level of engagement declined after the slide presenting the history of environmental engineering as a profession and picked up again during the discussion of "Tools We Use" and "Career Opportunities." Discussion was high during the introduction slides and dropped to zero for the "Tools We Use" and "Career Opportunities" slides, concurrent with the cessation of teacher interactions.

Class D was a middle school class that received the guest lecture during the second-to-last period of the school day and was 40 minutes shorter than other classes. This class displayed relatively high levels of engagement during the lecture, despite the time constraints of a 20-minute session. This shorter duration may have maintained student attention due to the fast pace of the presentation. An increase in Class D's engagement was seen during the discussion of "Tools We Use" and "Career Opportunities." However, the question-and-answer section was not held due to time limitations.

Class E was a high school class which attended the guest lecture during the second and third periods of the school day. Students in Class E exhibited low engagement overall, although there were occasional spikes in discussion and engagement (i.e., Pollution, Tools We Use). The teacher was frequently outside the classroom during the lecture, limiting interaction with the students and presenters. However, teacher interactions along with student engagement increased during "Tools We Use". Student discussion spiked during the "Current Challenges" section which describes applications of environmental engineering.

Summary data of the BERI classroom observations along with T-STEM results and effect sizes are presented in Table 4 for ease of reference.

CONCLUSIONS AND IMPLICATIONS FOR FUTURE RESEARCH AND PRACTICE

Overall, the Train the Trainer program had a significant and positive impact. The extent of changes in student interest in environmental engineering and water science careers depends on the quantity and quality of interactions among teachers, students, and university researchers. TtT effectively addressed many key challenges to fostering interest in environmental engineering and related careers as summarized in social identity and circumscription and compromise theory constructs. Students reported significantly increased knowledge about environmental engineering and a greater

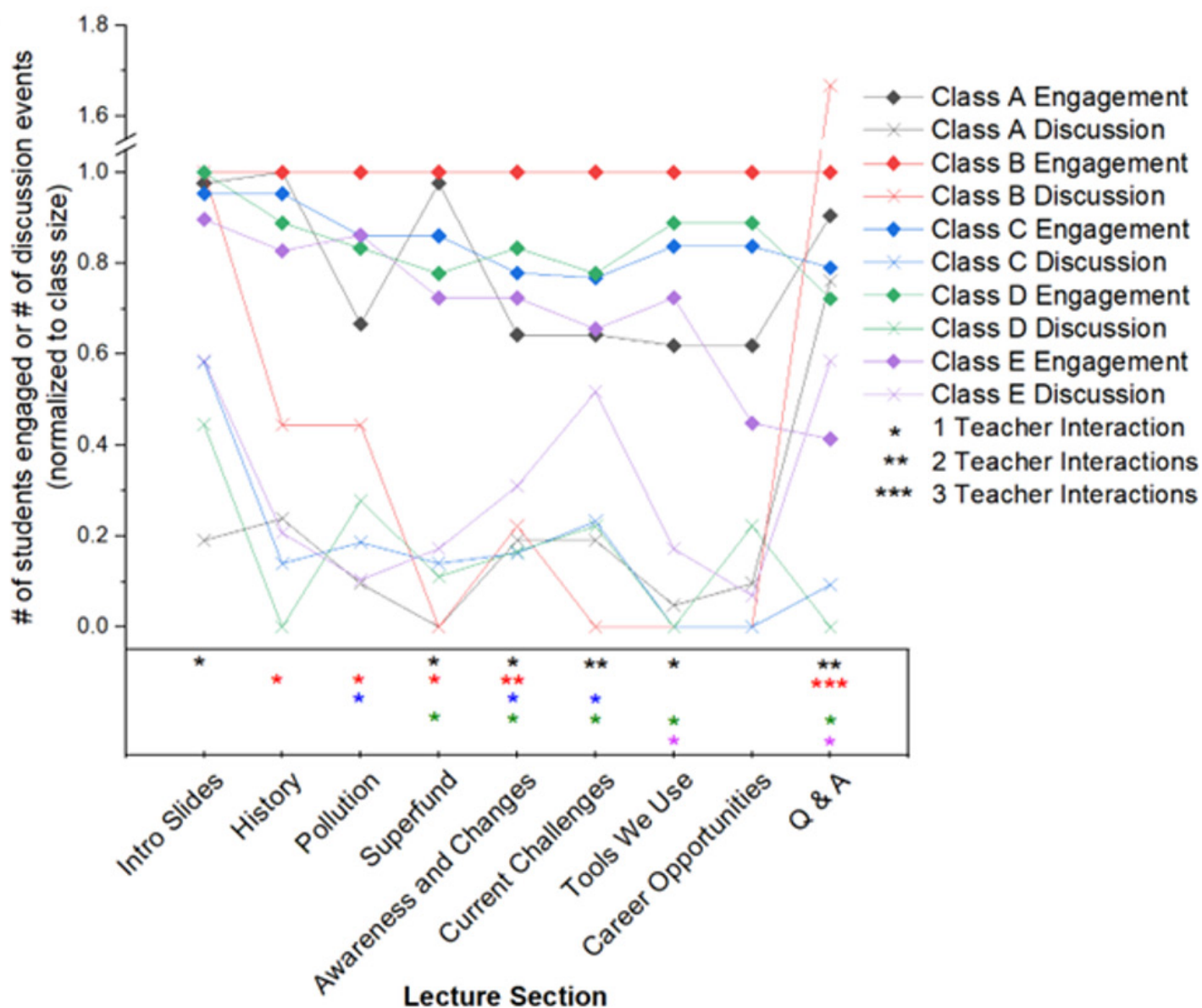


Figure 5. The timeline of student engagement and questions normalized to class size, alongside the number of teacher interactions during guest lectures, were analyzed to evaluate the effectiveness of guest lecturing in each class. The number of teacher interactions is denoted by asterisks color-coded to each classroom below the plot.

appreciation for how environmental engineering aligns with common life goals. Hypothesis 1 was accepted in part. The medium effect size on student interest in environmental engineering and related careers was noteworthy when compared to similar-scale programs; almost all comparable short-term outreach programs had either small or small-medium effect sizes. This holds implications for future outreach programs as exposure to STEM should be ongoing to achieve greater impact on student interest in STEM careers. Even so, the positive impact of the TtT program on student career interest cannot be ignored even in the short-term, given its medium effect size. Importantly, the program outcomes did not vary significantly by student ethnicity or gender. This highlights the potential of the program to attract URMs to STEM fields,

particularly environmental engineering, by connecting STEM concepts with local water and environmental issues that are associated with the socioeconomic backgrounds of URMs.

Comparisons to similar studies indicate that TtT is a valuable program for fostering student interest in STEM careers. Further investigation into each component of its multi-pronged approach would better identify the individual benefits of exposure to role-models through technology and in-person interactions, training for teachers, and contextual relevance to students. The last of these three components is a particularly notable advancement of the TtT program. While previous work has shown qualitative support for water literacy as a context for STEM outreach, the current study is the

Table 4. Summary of classroom results with the corresponding teacher results. Effect size results are also shown for each survey question for classrooms (A-D) that received both the guest lecture and the lesson plan between pre- and post-surveys (* = $FDR < 0.05$). EE = Environmental engineering.

Class	Years Teacher Was in the Program	Teacher PSTEB Score	Teacher STOEBAbove Score	Teacher STOEBAbove Score	Average Guest Lecture Engagement (% of Class Engaged)	Average Guest Lecture Discussion (% of Class Discussing)	What do you think an EE does?	How do EEs improve society?	How much do you already know about EE jobs?	How much would you like a job in EE?	How interesting of a career is EE?	Does an EE job make a difference?	Is an EE job influential?	Would an EE job earn you a lot of money?	Would an EE job allow much time with family?	Would an EE job make you unique or special?	Would an EE job let you be creative?	Who mainly works in EE?
A	1	4.59	4.39	4.33	78%	20%												
B	3	3.77	3.48	3.39	100%	42%												
C	2	3.69	3.56	3.55	85%	17%												
D	1	3.73	3.87	3.92	85%	16%												
E	2	3.76	4.04	4.19	70%	30%												
F	1	3.73	3.87	3.92														
A-D							-0.09	-0.12	-0.68*	-0.25	-0.31	-0.44*	-0.44*	-0.34	-0.55*	-0.56*	0.10	0.41

first to provide strong quantitative evidence to complement the qualitative evidence in support of the water science contextual approach.

Furthermore, participating teachers exhibited high confidence in their ability to teach environmental engineering effectively and positively influence students of all levels of achievement following the program, validating Hypothesis 2. Hypothesis 3 was partially confirmed, although not for all participating teachers, possibly due to the lack of observations of lesson plan implementation. However, the program was successfully implemented in a wide variety of educational contexts, ranging from math to science and from middle school to high school. We recommend future research to confirm these methods in other geographical regions and age ranges and with a larger sample size of teachers, particularly to verify water science as an appropriate context for STEM outreach in other educational settings. In conclusion, the TtT program serves as a valuable model for engaging diverse young students in environmental engineering, benefiting both students and educators.

ASSOCIATED CONTENT

Supplemental material mentioned in this manuscript can be found uploaded to the same webpage as this manuscript.

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Author Contributions

The manuscript was written through contributions of all authors. All authors have given approval to the final version of the manuscript.

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ABBREVIATIONS

AWWA: American Water Works Association; BERI: Behavioral Engagement Related to Instruction; EE: Environmental engineering; FDR: False Discovery Rate; NAEP: National Assessment for Educational Progress; PSTEB: Personal science teaching efficacy beliefs; SciREN: Scientific Research and Education Network; STOEB: Science teaching outcome expectancy beliefs; T-STEM: Teacher Efficacy and Beliefs toward STEM; TtT: Train the Trainers; URM: Underrepresented minorities

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