Integration of a Local Wicked Problem into the Environmental Engineering Laboratory Curriculum

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Daniel Delgado spent six years in the Navy as a nuclear plant operator onboard a submarine. Those experiences created an interest in engineering that became a desire to pursue a degree in environmental engineering. He enrolled in community college soon after completing his Navy contract and eventually transferred to San Diego State University (SDSU), San Diego. Needing some hands on learning he applied for a research position at SDSU where he was accepted as a research assistant helping with algal biomass research. In this lab he discovered a love for resource recovery from waste and wastewater treatment when he was given a project to analyze algal feedstock cultivation in wastewater. Upon completing his bachelors, he was accepted to University of South Florida (USF), Tampa, for a Ph. D. program where he researches onsite wastewater treatment for removal of nitrogen species. His research interests revolve around food, water, energy nexus specifically in wastewater treatment, resource recovery from waste, and bioremediation.

Integration of a Local ‘Wicked’ Problem into the Environmental Engineering Laboratory Curriculum

INTRODUCTION

The Accreditation Board for Engineering and Technology Inc. (ABET) works to ensure confidence in programs and ensure graduates are prepared for the workforce. One outcome of specific importance is ABET outcome j, which is for students to ‘gain a knowledge of contemporary issues’ or outcome 4 which comes into effect in 2019 and states that students must have “an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts [1].” For students to be prepared for the workforce they must be aware of current topics impacting their field and their everyday life. Also, future ABET outcome 2 challenges educational institutions to contribute solutions to current challenges that meet the needs of the program’s constituents [1]. These topics are not just being addressed in ABET, but also within organizations such as the National Science Foundation where two of their 10 Big Ideas, “Convergence Research” and “Broadening Participation”, aim to merge ideas, techniques, and fields in order to formulate solutions [2]. ‘Wicked’ problems allow the incorporation of these concepts into educational settings.

Wicked problems are social or cultural problems with responses rather than solutions, multiple stakeholders, and no conclusive formulation. The problems are topics such as sustainability, poverty, and equality, amongst others that impact multiple individuals [3, 4]. One way in which wicked problems are currently being addressed within engineering is through the National Academy of Engineering’s (NAE’s) 14 Grand Challenges for Engineering in the 21st Century [5]. For this environmental engineering laboratory, students were asked to address lead in the city’s drinking water. This class topic directly links to two NAE grand challenges: 1. Restore and improve urban infrastructure and 2. Provide access to clean water [5].

The class topic was a local issue brought to light on August 9th, 2018, when the Tampa Bay Times released a story, “The Hillsborough School District found lead in its water. It didn’t tell parents for a year [6].” The authors of that article linked it to a newspaper database presenting the results from the school district’s tests to date. Main concerns highlighted in that article were 1) the district did not inform parents about the tests or the results for 17 months, 2) parents were concerned about the impact of lead on their kids’ development, 3) levels of lead were of concern in some schools, 4) the district had only tested 53 schools to date and 2022 was the expected data for completion of testing of their 270 facilities, and 5) the target concentration of lead in drinking water is unclear as different entities recommend different levels.

Soon after that article was released, the Hillsborough County Public Schools (HCPS) published information on lead on its own website, including the raw data based on the schools that had been tested. According to the district's Water Testing Information for Families & Community website, *"Results of the schools and sites tested so far are available online and we will add future results as we receive them. In addition, if a school has a fixture that tests above our district's guidelines, we will notify that school's parents and staff by email and text message. Please know that when we find any issue, we are committed to addressing it and fixing the problem.*

This testing is not required by any law; it is an additional step we are taking to improve safety for our students and staff, and we hope other school districts in Florida will join us in this effort. Please note that charter and private schools are independently managed and therefore are not part of this testing program [7]."

By September 8th, 2018, the number of schools tested by HCPS had increased to 114 schools and by September 21st that number was 156. The district was now on track to completing tests by the end of 2018 if not before for the schools serving its 206,841 students. As the HCPS post on their website states, school districts in Florida are not required to test for lead in schools. HCPS joined a list of other districts in the state that are testing for lead. In Leon County School District, home to 34,000 students, tests began in 2016 through a collaboration initiated by researchers at one of the local universities. Their lead testing plan and results were shared via that district's water quality website. Across the Tampa bay, the Pinellas School District, responsible for 150 schools, started a lead testing program in 2016.

Based on personal communication with Florida State University faculty leading testing in Leon County, there will be calls for installation of water filters on kitchen faucets and water fountains in all Florida schools.

This local wicked problem resonated with students as many attended the schools in the district and some had young children who attend or are about to attend, schools in the district and surrounding districts. After presenting the wicked problem, the class was challenged with developing research questions, investigating, and sharing the data-based conclusions found.

This paper presents an overview of the course, results from the class project deliverables, how the integration of a wicked problem helped to develop student understanding of contemporary problems, and how the research context integrates with engineering approaches.

COURSE DESCRIPTION

The Environmental Engineering Laboratory class is a one credit course required by all Civil and Environmental Engineering undergraduates. One credit hour includes no less than 12.5 hours of direct faculty instruction over 15 weeks during the semester and a minimum of two hours of out-of-class student work each week. Usually the course is taken by upper level students, it introduces experimental design, procedures, and analysis through material related to environmental engineering. Complexity is highlighted through exposure to human impacts on water quality and the impact of water quality on human health from local and global contexts. In addition to set laboratory-based experiments, students worked on group projects that were connected to a larger class project, usually one that aims to solve a timely wicked problem. The group project topic depends on the instructor; previous projects focused on emergency response water treatment after Hurricanes Irma and Maria in Fall 2017. In Fall 2018, 47 students completed the course with the group project accounting for 37% of the overall grade. For this, students were asked to imagine the entire class as a consulting firm with the Professor as the Principal, the TAs as directors, and each person's interests and skillset critical to the success of the project.

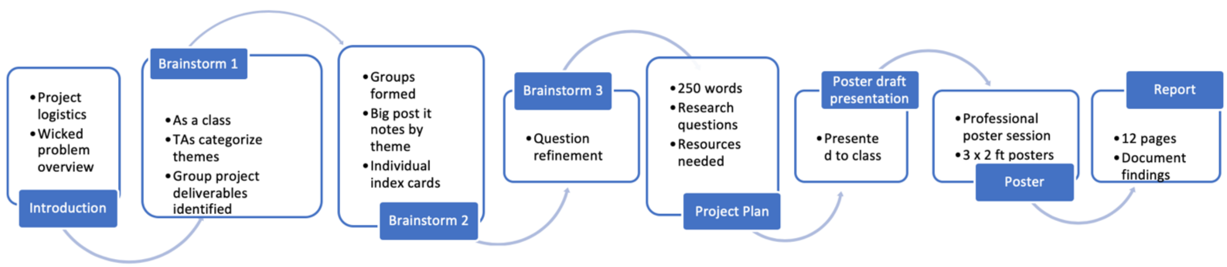

Figure 1. Main components and deliverables of an Environmental Engineering Laboratory group project focused on a wicked problem.

Figure 1 visually presents the main components associated with the class project. After introducing the wicked problem on the first day of class, three brainstorming sessions followed to get students to take ownership of their projects and to guide their research. These were held during three different weeks and lasted ~2.5 hours each. During the first brainstorm session, students were allowed to discuss with each other topics within the local wicked problem that interested them. A follow up discussion was facilitated by the teaching assistants and general research topics were then established by the TAs based on student interests. Students also identified deliverables they would like to see for this project, and these were then incorporated into the syllabus.

At the second brainstorming session students completed personalized index cards stating their research interests with the class project and then worked for the first time with peers on their selected group project. In groups of 3 to 8, they shared ideas with each other on the topics summarized by the TAs and wrote these on large posters around the room. During the third brainstorming session students drew pieces of paper with questions pertaining to the class project from a box (refer to Table 1 for questions). The questions were created by the professor based on the topic areas summarized by the TAs after the first and second brainstorming session. Students read their questions aloud and were encouraged to trade with someone else until they had at least one question that they thought properly aligned with their specific group project and their personal interest. They were to use these questions as a bases for exploring a deeper understanding of their specific topic within the overarching wicked problem.

Table 1: List of questions presented to class during Brainstorm Session 3.

1. What is lead? 2. Where is lead found? 3. How is lead produced? 4. What is lead used for? 5. Why is lead a human health problem? 6. How are humans exposed to lead? 7. Which populations are most at risk to lead exposure? 8. How is lead produced in drinking water systems? 9. What forms of lead could potentially come through the tap? 10. How does the human body process different forms of lead? 11. What are the current regulations for lead in tap water? 12. What are current regulations for lead in schools? 13. How is lead tested in residential tap water? 14. How is lead tested in schools? 15. What analytical techniques are used to test for lead in drinking water?	16. What do utilities do to reduce lead in drinking water? 17. What do utilities in Tampa do to reduce the risk of lead in tap water? 18. What ways exist to reduce the intake of lead from drinking water? 19. How much does it cost a homeowner to remove lead from drinking water? 20. How much does it cost a school to remove lead from drinking water? 21. What is Hillsborough County Public Schools doing to reduce lead in drinking water? 22. How can you identify whether you have lead in your piping system? 23. What Apps exist to identify whether lead pipes exist for a residence? 24. What proposed regulations are there for lead in drinking water? 25. Which bottled water companies post lead data on their bottles or website and what does that data show?

The project deliverables agreed upon by the class included a 1) ***Group Project Plan*** that identifies the specific question being addressed by the group, steps to better understand the issue, including resources needed, and who is the target audience for communicating results; 2) ***Group Project Report*** that presents the research and results from the group project and that can be integrated into an overall class report on the wicked problem; and 3) ***Group Project Poster*** that visually summarizes the research and findings and is used during a poster session where groups give a 2-3 minute presentation. A grading rubric for each component that addressed format, content, and organization was shared with the students. Students also presented their posters in class prior to the poster session, and obtained feedback from the faculty, teaching assistants, and class. They were also asked to keep an activity log on their project participation.

METHODS

The body of work produced by students in class and as a project deliverable were reviewed by the authors for this paper. That included outputs from the 3 brainstorm sessions, project plan, poster presentation, and project report. A survey was administered to the students during the last week of the class to understand their perspectives on the course structure and content. Five questions relevant to the wicked project were: (1) How did the course get you involved with local issues? (2) Imagine someone close to you asks you for the main takeaway message from our overall class project on lead. What would your answer be in 3 or less sentences? (3) How have your expectations of this class changed from the beginning of the semester to now? (4) On a scale of 1 to 5, with 1 being not at all and 5 being very enhanced, rate how this class has changed your ability to formulate a research question. (5) On a scale of 1 to 5, with 1 being not at all and 5 being very enhanced, rate how this class changed your ability to communicate engineering research. Responses to questions 1-3 were grouped, coded by the authors, and quantified. Student comments were used to qualitatively describe their experience. Reflections from the professor and three teaching assistants, all authors of this paper, were shared during a post class meeting and those meeting notes were reviewed for this paper. The paper's authors have worked on group projects and community-based projects through research, coursework, or participation in student groups like Engineers Without Borders. The professor has taught this course for 14 years, with use of various types of group projects, however, this was the first time integrating a locally controversial project in real time in this class.

RESULTS

Student Work. The following topics were iteratively defined by the students in the course through the brainstorming sessions and after review of project plans: (1) human health and regulations for lead in drinking water, (2) lead contamination in cities' water supplies around the US, (3) analysis of the water infrastructure and supply in the city of study, (4) sampling drinking water stations in local parks, (5) bottled water sold locally and lead levels, (6) laboratory analysis for lead levels in water samples from parks bottled water, (7) personal solutions for reducing lead exposure, (8) residential solutions for reducing lead exposure, (9) toxicology risk assessment of lead in schools, (10) economic assessment of filters on water fountains and taps at schools in the local school district, and (11) mapping of socioeconomic and demographic data coupled with water infrastructure age and lead levels in schools. Initially, some groups were as large as eight persons based on their interest in the identified area of research. These groups were split up to improve teamwork efficiency and allow students to focus more on specific issues. For example, the solutions group was split into three smaller groups with foci ranging from personal to residential to school district scale.

Students were asked to formulate a project plan as one of their deliverables for the group project. Each group was asked to state the challenge for their topic, what research questions they would ask, and how they will answer their research questions. Students were also asked to provide potential tools and sources they would use as well as present any preliminary data they have acquired at this point in the semester. To answer their research questions, most groups used peer reviewed sources and the university's database as a source of information. Several groups identified communication between the groups as a valuable and necessary asset to their part of the study. Others also suggested connecting with and/or interviewing district leaders (i.e. the city's Parks and Recreation Department, engineers in charge of water treatment and distribution, director of the city's water department) would be necessary to gain certain information that otherwise may not be readily available online.

Due to time constraints and challenges with running the analytical instrument, not all groups were able to complete their proposed plan in its entirety. Recommendations for future work, however, were discussed in their reports and in their presentations. Students' knowledge on the subject and how it related to one another's topic was evident in the in-class presentations and poster presentation. Several groups were able to complete their proposed plan and reached out to members in the water sector in the city of study. For example, the "analysis of the water infrastructure and supply in the city of Tampa" group proposed the following research questions and approach in their project plan: What are the primary sources of drinking water for the city of Tampa? What is the acidity and alkalinity of the water? What is the temperature of the water? What are the pipes that distribute the water made of? How old are the pipes? How long does the water stay in the pipes? Does the city perform testing on end user's water? Are there coatings in the pipes? What is the treatment process for drinking water in Tampa? How does lead make it into the drinking water? What are steps taken to prevent lead from getting into the drinking water supply and/or homes? Are inhibitors used by treatment plants to target lead? Once the level of lead is detected to be above the acceptable level, what actions are taken?

This group proposed using the university's online databases and peer reviewed literature to help answer these questions. To gain a deeper perspective, this group also arranged a meeting to interview the employees tasked with the treatment and distribution of water in the city. In their report, the team included the interviews they had with the City of Tampa's Water Quality Assurance Officer and Water Director. While the Director was listed as a potential interviewee by other groups, he was not originally one of the persons identified in this group's project plan. One of the team members in this group was actually completing an internship with the city's water department at the time and spearheaded these interviews. The student included the professor in emails to his supervisors and vetted questions prior to the interviews. After the first two interviews, additional staff were permitted to share information with him, including results from the city's testing of its own buildings throughout the city, including those at public spaces. Some of the specific questions asked during the interviews were: 1) Does piping or water storage at the water treatment facility leach lead into treated/partially treated potable water? 2) Does the city test residential water for lead? 3) How does this specific water treatment facility test for lead as well as other elements?

Based on the interviews, this group reported that no leaching of lead was expected at the treatment plant. They also introduced the class to the Aggressive Index, a tool used at the facility to monitor the "aggressiveness" or corrosiveness of the water. The students also shed light into what the city does to combat high risk for potential lead contamination in certain residential areas and were able to take a tour of the equipment used for lead analysis. Their report exemplifies some of the outcomes that came from the integration of this local wicked problem into the curriculum. Another group interviewed grocery store employees to identify the most popular brands of bottled water in the area prior to selecting bottles to analyze for lead. Many of these are actually produced in Florida with limited lead water quality data available online. While a visit to one of the source springs and facilities was recommended by the professor after the project plan phase, this never materialized. Another group sampled drinking water stations in city of Tampa parks early in the morning of a weekday, collecting pictures of the state of the fountain. Their interactions with community members was minimal.

The poster presentations were used to evaluate the students' knowledge on their selected topic and communication of engineering ideas to the public. Figure 2 depicts a poster that investigated the efficiency of personal use filters. The experimental set-up for this topic allowed the entire class to become engaged by making it one of the general laboratory experiments in the course where each student group (usually a group of 3 persons and different from the wicked problem class project) tested one of the filters with a given lead contaminated tap water sample. The samples from these experiments were then given to the wicked problem group focused on analysis. The professor worked with that analytical group on the instrument available, a Varian DUO AA240Z Atomic Absorption Spectrometer. Actual running of the instrument was done by the professor and TAs. Hence, the group project looking at personal filters connected to other group's lead projects and to the traditional laboratory exercise.

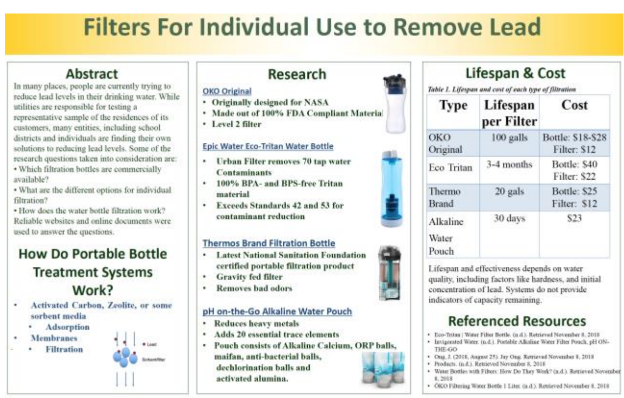

Figure 2. Filters for Individual Use to Remove Lead student poster as a deliverable for the Fall 2018 Environmental Engineering Lab. Experiments were run on these technologies, however that data was not presented.

Surveys. Forty-five students completed the online exit surveys during the final week of classes. Responses to the first two questions of the exit survey were categorized and coded by the authors and converted to bar graphs displaying frequency of responses (Figures 3 and 4). Sixty percent of students only gave the generic response, “the project made me aware of the lead issue,” when responding to the first question regarding the project, “How did this class get you involved with a local issue?” This is shown as, “Aware of Lead Issue (ALI)” below. The more specific the student’s response, the more specific the category. Often the students did not answer in a specific manner to their type of engagement, but rather described the project. The second and third highest response to question 1 were, “Research Local Issues (RLI)” and “Awareness of Local Wicked Problem and Difficulties of Resolutions (AWPD)”, respectively.

The student response categorized as the project did not (DN) get them involved in local issues specifically responded, “Since I was part of the experimental group we simply interpreted the results and generated a report. I feel I did not really get involved in this specific local 'issue'.” In research, data interpretation is an important step, but this was not translated to this student in this group. Challenges with sample analysis arose due to instrument servicing, methodology, and scheduling and this resulted in delayed data provision to the analytical student group. Additionally, the student was in a group of six students total and it is possible that the size of the group and the responsibilities could be altered to improve engagement opportunities. Given the length of time required to analyze samples, this activity was scheduled outside of the main class times and not all group members could participate.

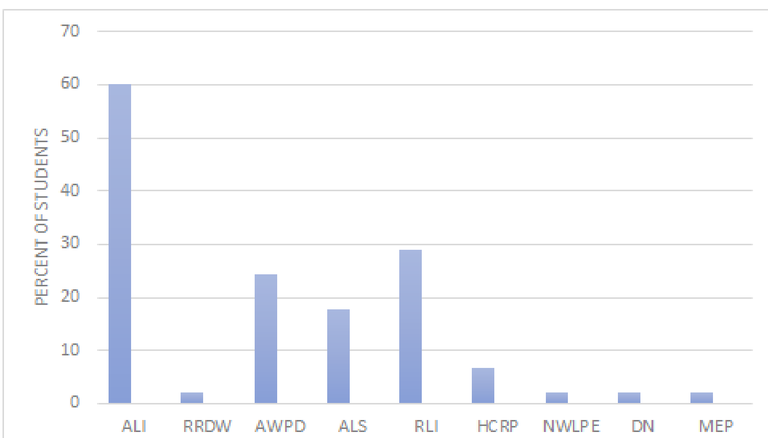

Figure 3. Percentage distribution of student (n=45) answers to “How did this class get you involved with a local issue?”[Awareness of Local Issue (ALI), Research Regulations for Drinking Water, (RRDW), Awareness of Local Wicked Problem and Difficulties of Resolutions (AWPD), Analyze Local Samples (ALS), Research Local Issues (RLI), How to Communicate Research to Public (HCRP), Network With Local Professional Engineers (NWLPE), Did Not(DN), Mapping Extent of Problem (MEP)].

One student visited the David Tippin Water Treatment Facility and asked the experts there about water quality issues. According to that student, that experience “Helped me visualize potable water treatment and distribution networks to a greater degree. The project allowed me to network with these professionals and help me understand the responsibilities and challenges that these engineers face. This knowledge will aid in my own personal delineation of the responsibilities and actions required of me when I become a graduate engineer." The fact that the student that had the most engagement with local professionals got more out of the project is expected. This type of engagement needs to be encouraged more, perhaps with extra credit. It also highlights the benefit of a student internship and being able to link classroom projects with that internship experience as the student would not have otherwise met some of those professionals.

Figure 4 shows a percentage distribution of the coded responses given to survey question 2, "Imagine someone close to you asks you for the main takeaway message from our overall class project on lead. What would your answer be in 3 or less sentences?" The top two responses were classified as "Severity of Lead Issue (SLI)" and "Necessity to Educate Public (NEP)."

Students in the engineering and sampling group were far more likely to have a positive outlook and renewed confidence in our lead situation with responses like: "By and large (barring some extreme cases), a municipality's water treatment and distribution system is extremely safe. The care and attention to detail that water professionals have towards public safety is paramount, and it is evident through speaking with them and observing their application of rigorous standards put forth by the government (local, state, national)." Students in groups where the focus was dealing with lead and health effects caused by exposure showed an accomplishment of ABET outcome 3 with responses like, "The main take away for me from this project was how complex it is to address public health. So many variables go into making decisions on public health that often the welfare of the public is compromised," and "The major takeaway for me was that as engineers we have somewhat of a responsibility to get involved in community issues."

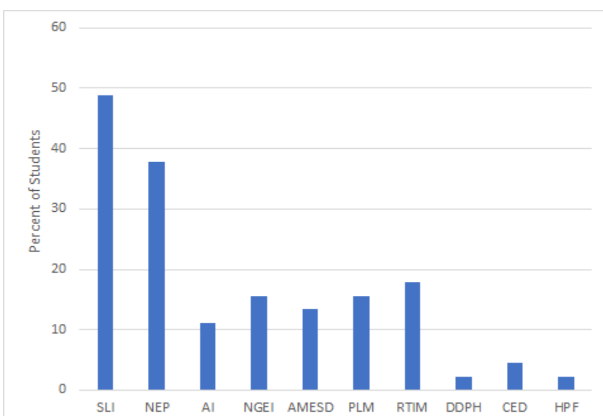

Figure 4. Percentage distribution of student (n=45) answers to "The main takeaway message from our overall class project on lead." [Severity of Lead Issue (SLI), Necessity to Educate Public (NEP), Aging Infrastructure (AI), Need for Government Engagement/Intervention (NGEI), Take Additional Measures to Ensure Safety of Personal Drinking Water (AMESD), Take Lead Monitoring Into Own Hands (PLM), Renewed Trust In Municipality (RTIM), Difficulties of Dealing with Public Health In Engineering (DDPH), How Cost Affects Decision Making (HCEDM), How to Present Findings to Public (HPF)].

Survey question 3, “How have your expectations of this class changed from the beginning of the semester to now?” did not specifically pertain to the class project; however, 40 percent of students mentioned that the class project improved their experiences or expectations of the course. The project was also mentioned for its faults in reaching expectations. One student wrote, "In practice, I feel that the work the class did was not necessarily as impactful as I had envisioned earlier. Also, we did not get the chance to engage with the community to present our findings.” This student’s index card from the second brainstorm session made it clear that this student was excited to conduct research on bottled water and share with the local community. Another student reflected on the pros and cons of the project with, “I was expecting just a standard lab class, where we perform experiments and write reports, but I was really glad to have hands-on experience on an environmental issue happening in our county. I thought the class project would be more structured, but turned out to be more loose than what I would have preferred.”

The outlier was clearly the student who engaged with the David Tippin Water Treatment Facility. That student talked about how the conversations for the project led to an interview for another internship. The added benefits of engaging with the community and professionals was clear. While the time constraints of the class limited the end results, one student mentioned that they would like to continue the investigation throughout their capstone design class.

Table 2 summarizes the results from two questions asked to numerically rate the class on how it impacted research formulation and communication of engineering research.

Table 2. Answers to exit survey questions asked to numerically rate the class on how it impacted research formulation and communication of engineering research (n=45). A scale of 1 to 5 was used with 1 being not at all and 5 being very enhanced.

Question	Avg.	Std. dev.
rate how this class has changed your ability to formulate a research question.	3.6	0.98
rate how this class changed your ability to communicate engineering research	3.7	0.95

Instructor Reflections. The professor and 3 TAs noted multiple things that worked and that could be improved during an end of semester reflection exercise. Starting, there was a great deal of initial enthusiasm about the project when pitched. The local newspaper had released an unsettling article on lead a few weeks prior to the start of class, and given the number of students who attended school in the same district, students were motivated to revisit their old schools and grab water samples as the district’s target date to complete sampling was 2022 at the time. Confronted with challenges to formally engage with the school district on the project, and after some brainstorming, the class decided to sample local public parks. A student with a young child proposed this as she was concerned with what they were drinking when they visited local parks.

Some of the initial enthusiasm for the class waned throughout the semester and this was likely due to confusion over the mechanistic portions of the course. More contact with student groups on progress of projects would have likely reduced student confusion, and increased the quality of, and engagement with, the research project.

The open research question and requirement to develop their own methods to address the wicked problem, challenged the students. This challenge was then compounded by the difficulty of communicating their questions and findings amongst groups in different research components. One recommendation is to have a few groups give a three-minute update during each class with time allowed for an open discussion. This could lead to new ideas on how to proceed with their project, identify gaps existing in their research, and provide more opportunities to present research to a larger audience.

The professor expected students to take more initiative, and act on recommendations made on graded project plans and during class discussions. The professor and a local community member discussed having the student poster presentation at a church in a part of the city with older homes and higher percentages of persons below the poverty line. While this community was initially highlighted as a potential place to find partners for the group projects based on the professor's engagement there, no student groups did any substantial work there. One group sampled water fountains at public parks in the area, but that was done without any participation of neighbors. Prior to finalizing that community presentation plan, the class voted to hold the poster session on campus and the professor did not invite the public as was initially intended.

When reflecting on student development throughout the class, the professor and TAs realized that an initial baseline of student understanding and feelings towards wicked problems would have been helpful. This would provide a measurable outcome of the students' learning through the course.

CONCLUSIONS & RECOMMENDATIONS

Implementing a local wicked problem into the classroom is a great way to ignite class engagement. This was seen in the Fall 2018 Environmental Engineering Laboratory class, where 47 students participated in the course with the group project addressing a local wicked problem. Although the project accounted for 37% of the overall grade, the class itself was a single credit. This undoubtedly played a role in the amount of outside time the students were willing to invest. The students did a great job analyzing and reporting on the problem, but had limited engagement with local residents outside of their existing circle of friends, public officials and professionals in the industry. These types of interactions should be better organized or incentivized, especially since initial brainstorming sessions resulted in students identifying areas of interest for the class to study and those were locally used public spaces. Setting shorter deadlines that corresponded with different levels of project completion would improve the quality of the end product.

The group project helped meet ABET outcomes and led to students' recognition of the importance of their role as engineers. Given the recommendation that more ethics be included with environmental engineering curriculum [8], this problem presented multiple avenues for expansion on the topic, beginning with the school district's late notification to parents of their testing program.

The outputs and experiences from the Fall 2018 course were shared with the instructor for the Spring 2019 course. Given that the problem of lead in drinking water still exists, a guest lecturer from public health who is pushing for 0 ppb lead in school's drinking water presented to the new cohort. Given the background covered by the Fall 2018 course, the Spring 2019 student groups tested different drinking water samples, including those found in more area parks, restaurants, homes, the campus, and the schools. Some of the Fall 2018 students and the authors of this paper will serve as resource persons to help improve the student experience, and to share this material with the wider community during the end of semester poster session. To date, the local school district has supposedly completed testing of all of its facilities, and decision makers are now discussing filters be placed at all schools in the district. Many questions remain unanswered on this issue. While students in the Fall 2018 undergraduate class project did not get an opportunity to formally engage with a targeted community external to the class on the project or present to the public, the problem is one that affects all in the city, including the students in the class. The poster session can engage a wider community, and lead to new opportunities for partnering to test for lead in future classes. Daycare centers in older buildings would be a good future target, provided this is an identified need by the owners of such centers. Lead in drinking water has emerged as a contentious topic across the US and has spurred discussions on the role of engineering academics in engaging with communities to address complex challenges [9-13]. Given the pervasive nature of the problem in the city where the university is located, it makes sense to have students conduct research that raises their understanding of local infrastructure and contributes information that will hopefully lead to more informed decisions on how to best manage that infrastructure. While this work addresses two NAE Grand Challenges [5], it also links with United Nations Sustainable Development Goals (SDG) like SDG 6 targeting access to safe access to water, and SDG 16 targeting effective and accountable institutions [14]. Key competencies for meeting the SDGs like the "Integrated problem-solving competency" [15] were addressed by this class project and can be better integrated with ABET outcomes in the future to expose students to more global challenges.

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