Toxic Crusaders: A Youth STEM Outreach Program

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Introduction

DTSC-ECL seeks to increase student exposure to a variety of environmental science careers and the application of science to real-world environmental problems. The Toxic Crusaders Program was a two-day outreach event for juniors and seniors from a local high school consisting of hands-on activities that simulated the sampling, analysis, and reporting of hazardous chemicals found at a hypothetical contaminated site and communicating these results to the public. The aims of this program were to promote scientific engagement, critical thinking skills, and interest in STEM careers in the participating high school students.

Methods

- An interactive workbook was developed to give students detailed information on site investigation to deepen their understanding of environmental contaminants and facilitate their learning experience.
- The program consisted of two on-site visits and four online lectures. The initial visit aimed to familiarize students with background information needed for the second visit, which consisted of hands-on sampling and analysis.
- For each onsite visit, 5 groups of 6-8 students rotated between different stations following the schedule in Table 1.
- Four online lectures were provided between the two visits to reinforce and promote retention of concepts related to environmental analysis.
- Effectiveness of the program was measured with surveys administered before and after the second visit, followed by an unpaired t-test to compare survey averages.

November 30 & December 1: On-site
Safety Rules; Toxic Crusaders Case Scenario
Station 1: Health and Safety Fact Sheets; HARP Pre-Site Visit Form
Station 2: Sampling Requirements for Test Methods; HARP: Sampling Plan
Station 3: Calibration, Quality Control (QC) and Instrument Check Requirements
Station 4: Pipetting Techniques and Exercise
Station 5: Public Meeting and Community Engagement Preparation
Jan. 12 – Feb 16: Virtual Lectures
Chrome Plating; MSDS-Fumetrol 140 Mist Suppressant
Per- and Polyfluoroalkyl Substances (PFAS)
Metal-Containing Jewelry Law
Title 22, California Code of Regulations (CCR)– Characteristics of Toxicity
February 22 & 23: On-site
Station 1: Site Inspection and Sampling
Station 2: Calibration of Per- and Polyfluoroalkyl Substances (PFAS)
Station 3: Sample Preparation and Analysis of PFAS by LC-MS/MS
Station 4A: Sample Preparation of Lead (Pb) and Cadmium (Cd) in Jewelry Station 4B: Sample Preparation of Hexavalent Chromium, Cr(VI), in Wastewater
Station 5A: Analysis of Lead (Pb) and Cadmium (Cd) by ICP-OES Station 5B: Analysis of Hexavalent Chromium by HPLC-ICP-MS

Table 1. The Toxic Crusaders Program schedule.

EPA Methods & Instrumentation
Analyte/Matrix: PFAS in wastewater • LC-MS-MS • EPA Method 3500C - Organic Extraction and Sample Preparation • EPA Method 8000C - Determinative Chromatographic Separations
Analyte & Matrix: Hexavalent chromium in wastewater • HPLC-ICP-MS • EPA Method 6020B – Metals Analysis by Inductively Coupled Plasma – Triple Quadrupole Mass Spectrometry • Title 22 California Code of Regulations Appendix II - Waste Extraction Test
Analyte & Matrix: Lead and cadmium in jewelry • ICP-OES • EPA Method 3050B - Acid Digestion of Sediments, Sludges, and Soils • EPA Method 6010D – Metals Analysis by Inductively Coupled Plasma – Optical Emission Spectroscopy

Table 2. EPA methods and instrumentation used in the analyses performed by students on the day two on-site visit.

Results

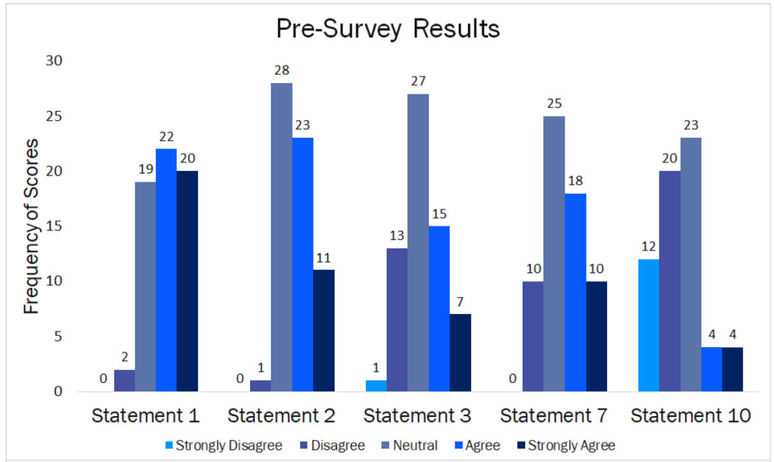

Figure 1. Distribution of scores on survey statements that were found to have statistically significant differences between pre-survey and post-survey means.

Discussion

- A significant difference was found in the averages between pre- and post- surveys in statements 1, 2, 3, 7, & 10 (highlighted in Figure 2).
- A highlighted difference in means indicates the program was successful in increasing scientific engagement, and students retained some concepts related to environmental analysis.
- Students seemed to have gained a broader understanding of what laboratory practices are and how samples are tested.
- The Toxic Crusaders program exposed students to a variety of environmental science careers, and sought to increase critical thinking, scientific engagement, and interest in STEM through a series of hands-on activities.
- Potential reasons for similar means in certain questions were due to lack of emphasis on how the government is addressing pollution and lack of incentives for STEM interest/careers.
- Additional student feedback in short answer responses included on the post survey suggested too much information provided in one day.
- Some students felt rushed through stations and were not able to gain an in-depth understanding of the analyses presented due to lack of time or too many new concepts introduced at once.

Statement No.	Survey Statement	Pre-Survey Average	Post-Survey Average	Difference
1	I feel comfortable with some laboratory techniques and scientific terms like pipetting and PFAS.	3.95	4.33	0.38
2	I know some basic concepts of laboratory testing.	3.70	4.05	0.35
3	I can explain how a scientist may quantify how contaminated a sample might be.	3.22	3.74	0.52
4	I like learning about science.	3.62	3.84	0.23
5	I know about some of the potential pollution in my community.	3.65	3.59	-0.06
6	I know how the government addresses the pollution problem in my community.	3.13	3.12	-0.01
7	I'm familiar with the different professions in DTSC.	3.44	3.90	0.45
8	I can see myself in a career in STEM.	3.03	3.29	0.26
9	I am thinking about majoring in STEM during college.	2.70	2.86	0.16
10	Being a scientist sounds like a boring job.	2.49	2.03	-0.46
11	I am open to a career at The Department of Toxic Substances Control.	2.76	3.05	0.29

Table 3. Survey statements rated from 1 (strongly disagree) to 5 (strongly agree) by students before and after the day two event. The highlighted statements have a p-value of <0.05.

Conclusion

The Toxic Crusaders Program made a difference in some outcomes relating to self-reported interest in science and STEM careers in general. However, effectiveness of the program could be increased by decreasing the number of stations and analytes focused on. In the future, longer stations following the entire process from sample prep to analysis would provide a more coherent and complete learning experience for the students. Additionally, smaller groups would allow for more interactions between the students and DTSC scientists, providing a personalized learning experience. Sampling method could be improved by providing students with a unique, yet anonymous identifier so a paired t-test could be used. With future Toxic Crusaders events, we hope to continue working closely with local schools and establish a lasting relationship that will enable us to help strengthen their science curriculum and increase student interest in STEM careers.

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