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Engineering and Data Science for Environmental Justice (Resource Exchange)

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Jennifer Taylor is an Assistant Director with the Integrated Teaching and Learning (ITL) Program of the College of Engineering and Applied Science at the University of Colorado (CU) Boulder. She directs the ITL Pre-College Engineering Education Program whose mission aims to broaden participation and build interest in engineering through hands-on learning experiences for K-12 students, especially underrepresented and underserved youth. Jennifer develops engineering education curricula that focus on integrating the engineering design process and design thinking into STEM education and works with K-12 educators to increase teacher capacity in classroom engineering education. She also teaches a first-year Engineering Projects course at CU. Prior to pursuing a career in higher education, Jennifer taught middle school science for 15 years and she received a Teacher of the Year community award and guided her students to numerous state and national sustainable project awards, including the Siemens We Can Change the World Challenge. After transitioning from the classroom, she joined the CU Cooperative Institute for Environmental Sciences (CIRES) Education & Outreach Program as a Curriculum Development and Program Manager where she created K-12 climate science and environmental education curricula and programs and was a team member that received a CO-LABS Governor's Award for High Impact Research in Atmospheric Science. Jennifer is a first-generation college student and holds a BSc in Biological Sciences from the University of Illinois-Chicago and an MSc in Environmental Biology from the University of Liverpool. In her downtime, Jennifer enjoys spending time with her family in neighboring Rocky Mountain National Park and the challenge of running ultra-marathons.

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Engineering and Data Science for Environmental Justice (Resource Exchange)

Description:
Engineers use their knowledge and skill to protect and improve the safety, health, and welfare of people and the environment and are guided by the ideals of sustainable development [1]. Similarly, one of the Environmental Justice (EJ) Principles [2] "mandates the right to ethical, balanced, and responsible uses of land and renewable resources in the interest of a sustainable planet for humans and other living things." Engineering ethics intersect with the right to environmental justice for all. However, communities of color have historically been and continue to be affected by environmental injustices, such as the location of toxic waste sites and interstate highways in their neighborhoods thus causing disproportionate health effects to residents [3].

Environmental justice is a core component of the Creative Engineering Design (CED) introductory-level high school course that is currently being developed and piloted in support of the NSF ASPIRE Engineering Research Center's engineering workforce development pre-college efforts. CED is a project-based engineering course that engages students, especially those from underrepresented and underserved communities, in exploring ASPIRE's goal of widespread and accessible vehicle electrification as a solution to transportation-related air quality and climate change concerns. The course weaves strong threads of the engineering design process, engineering skills development, and environmental justice throughout.

Using spatial data is an important tool in engineering education as it helps students to seek answers to the questions "What's there?", "Why is it there?" and "Why do we care?" as they view engineering from the perspective of the people and communities engineers serve. To explore timely real-world spatial environmental justice data in the CED course, a series of EJ-focused interactive spatial learning resources are created using ArcGIS StoryMap technology. The ArcGIS StoryMaps authentically engage students in building their knowledge about the intersections of particulate matter (PM) air pollution, air quality, health impacts, and environmental injustice in communities that experience increased exposure to PM 2.5 pollution, respiratory health risks, and traffic proximity.

Grade Level: High School

Time: 4 class periods (~50 min./pd.)

Materials:
- ArcGIS Environmental Justice StoryMaps: Air Quality, Transportation & Engineering Connections StoryMap [4]
- StoryMap Worksheet [5]
- Computer, tablet, or smartphone and internet service

Learning Goals:
Through using the ArcGIS EJ StoryMap tool, students will be able to:

- Understand PM air pollution types and their sources
- Recognize the relationship between PM air pollution and public health impacts
- Interpret the Air Quality Index and how PM pollution impacts air quality
- Analyze the basic relationship between weather (wind speed) and air quality through real-world EJ datasets
- Evaluate real-world GIS EJ data of the location of communities that are at risk of experiencing environmental injustice in relation to locations that are impacted by PM air pollution, high respiratory risks, and traffic proximity
- Explore ways engineers use datasets to understand the problem of transportation-related air quality and public health issues, and how environmental justice data can inform engineering-based and equitable, and sustainable transportation solutions for all.

Procedure:
The self-directed ArcGIS EJ StoryMap empowers students to explore the following scope and sequence at their own pace either independently or in pairs. The EJ StoryMap incorporates a variety of media and learning modalities including text, images, videos, infographics, webpages, interactives, and the EPA's EJScreen spatial data at its heart. The learning progression of the EJ StoryMap content consists of the following topics:

1. Introduction: The Burden of Air Pollution
    a. Define pollutant, air pollution, air quality
    b. Sources of transportation-related pollutants and air pollution facts (EPA graphs)
2. Particulate Matter (PM) Air Pollution:
    a. What is PM?
    b. Where does PM come from?
    c. What are the health effects of PM?
3. Air Quality:
    a. How is air quality measured?
    b. Air Quality Index
    c. AirNow.gov real-time air quality dashboard
4. Environmental Justice & Air Quality
    a. Impacts of air pollution on vulnerable populations
5. Spatial Data Analysis Comparisons:
    a. PM pollution levels and wind speed (Fig. 1)
    b. Demographics and location of communities experiencing environmental justice issues and location of PM pollution, high respiratory risk, and traffic proximity (Fig. 2)
6. Further Exploration & Discussion
    a. Potential for electric vehicles to be more accessible and improve air quality in areas experiencing environmental inequities

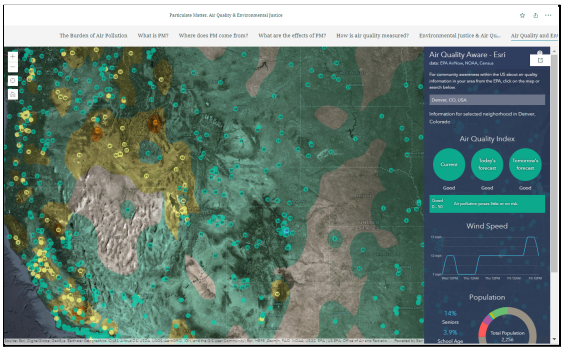

Figure 1. Screenshot of Air Quality and Wind Speed Spatial Data

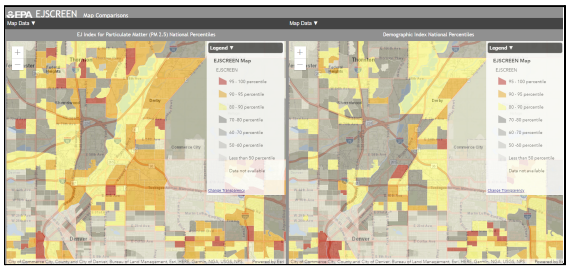
Figure 2. Screenshot of PM 2.5 and Demographics Spatial Data

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