The WeatherX Project: Understanding Weather Extremes with Big Data and Inspiring Rural Youth in Data Science

Project background

Early on a February morning in 2015, an experienced mountain climber set out to hike the Presidential Range in New Hampshire. She was caught in an extreme weather event and perished on a trail, short of her goal: the summit of Mount Washington, often called "Home of the World's Worst Weather."

The WeatherX project will develop prototype classroom materials that help grade 8 students explore this weather event through hands-on opportunities to analyze and model publicly available weather data collected by the Mount Washington Observatory (MWO), the National Weather Service, and the National Center for Environmental Information. The curriculum will be an inquiry-based science exploration of weather and climate aligned with the Next Generation Science Standards. It will integrate two student-friendly online tools: Common Online Data Analysis Platform (CODAP) for analyzing data, and SageModeler for modeling systems dynamics.

This National Science Foundation-funded project is a collaboration between Education Development Center (EDC) and MWO, and includes project partners from the University of Maine, the University of Washington, and The Concord Consortium.

Research questions

WeatherX will address the following research questions:

- RQ1. What is the feasibility of using WeatherX units in participating classrooms?
- RQ2. How do teachers enact WeatherX units?
- RQ3. What are the mechanisms by which WeatherX units and their enacted components may have an impact on student learning and interests?
- RQ4. To what extent do students who work through WeatherX units show improved understandings of, abilities in, and interest in scientific data analysis, modeling, and earth or data science careers?

Project setting and participants

The project team will collaborate with 5 rural grade-8 science teachers and their students from rural towns in New Hampshire and Maine to develop and test the WeatherX materials. We anticipate that approximately 200 grade-8 students will participate during each testing cycle.

Program description

Through iterative design and testing, the WeatherX project will develop three 2-week units. The first unit will have students investigate the conditions that led to the hiker's death, exploring the unique conditions and terrain of Mt. Washington and how, through data analysis, various attributes such as wind speed, temperature, and visibility interrelate. The second unit will seek predictive trends and deepen students' understanding of the complexity of the weather system. The third unit will provide open exploration of local weather events, using an online data portal to access local data.

Students will also have opportunities to interact with weather scientists at MWO through live video, virtual chat, and other online channels. Through these interactions, MWO scientists will support students' data investigations, and students will learn about what it is like to live and work as a scientist. The project will use these experiences to generate a model format for facilitating virtual interactions between weather scientists and rural students to enhance and deepen students' data investigation experiences.

Theory of change

The project hypothesizes that a multidimensional set of learning strategies can promote positive learning outcomes in scientific data analysis and interest in data science careers among rural middle-school students. A summary of key strategies and envisioned student outcomes is shown below. To strengthen the relevance of WeatherX learning experiences for students in underserved rural areas, the project will develop tools and protocols that can help students build on the local knowledge within their communities as they engage with WeatherX materials.

WeatherX Curriculum Units

Key strategies:

- **Active data investigations**: Students engage in hands-on investigations with authentic large-scale weather data to examine extreme weather events on Mt. Washington and in their local area
- **Use of CODAP**: Students focus on analyzing weather data patterns visually with CODAP
- **Use of Sage Modeler**: Students construct, test, discuss, and assess models with SageModeler to explain and predict extreme weather events
- **Chat with a Scientist**: Students watch prerecorded videos and attend virtual live presentations by MWO scientists about their work; students pose questions and receive input from MWO scientists on their weather data investigations

Format:

- Three sets of 2-week units organized into two series, each 2-week unit containing 8–10 45-minute lessons; the two series focus on describing and modeling extreme weather events on MW or in students' local areas, respectively

Primary audience:

- Middle school students (grade 8) in rural NH and ME districts

Student Outcomes

1. **Improved abilities** to analyze and interpret data, particularly with graphs and tables
2. **Improved understanding** of the nature and uses of scientific models
3. **Stronger interest** in the practices of and careers in the earth or data sciences

Data collection and analysis

Table 1 summarizes the timeline of project activities, including the data collection activities.

Qualitative data analyses. Qualitative data sources will be analyzed using both *a priori* codes and an open coding process to capture emergent themes (Strauss & Corbin, 1998) relating to feasibility of unit implementation, manners of unit enactment, and student experiences, and will map onto the core design components, learning processes, and sub-processes assumed within the conjectures underlying the project's theory of change (Cobb, Jackson, & Sharpe, 2017; Sandoval, 2004). Analytic memos will identify unit implementation successes, challenges, and suggested implications for unit improvements or refinements; and will explore how unit design features may be associated with student learning and interest outcomes.

Quantitative and combined data analyses. To address RQ4, the project team will analyze pre- and post-data collected from a Graph Understanding Test (Lai et al., 2016), a statistical understanding assessment (Jacobbe, Case, Whitaker, & Foti, 2014), a set of academic interest scales (Linnenbrink-Garcia et al, 2010), and the STEM-CIS science subscale (Kier, Blanchard, Osborne, & Albert, 2014) during the beta testing cycles. Matched-pair dependent-sample *t*-tests will examine whether student scores on each measure are higher after students complete each unit. OLS regression models will examine whether post-test scores on each measure are associated with levels of unit implementation, controlling for pre-test scores. Concurrent collection of quantitative and qualitative data will provide the study with a mixed methods, convergent parallel design (Creswell & Plano Clark, 2011).

Tables

Table 1. Iterative testing phases, participants, and activities, by cycle

<table>
<tr><th>Testing phase</th><th>Participants</th><th>PD and unit development</th><th>RQs</th><th>Research data collection</th></tr>
<tr><td>2019, Fall: Early feedback</td><td>5 teachers</td><td>Initial development, 3 units*
2 afterschool teacher feedback sessions
Unit revisions</td><td>RQ1</td><td>Teacher surveys and focus-group interviews</td></tr>
<tr><td>2020, Spring: Units 1 and 2, alpha</td><td rowspan="4">Each cycle:
5 teachers, 200 students</td><td rowspan="4">Each cycle:
1.5 days teacher PD to prepare for unit testing
Series testing (2 units, 4 weeks)
2 after-school teacher feedback sessions
Unit revisions</td><td rowspan="2">Alpha phase:
RQ1
RQ2
RQ3</td><td rowspan="2">Alpha phase:
Teacher surveys, implementation log data, focus groups, individual interviews, observations
Student surveys, focus groups, observations, screencasts, work samples</td></tr>
<tr><td>2020, Fall:
Unit 3, alpha</td></tr>
<tr><td>2021, Spring: Units 1 and 2, beta</td><td rowspan="2">Beta phase:
RQ2
RQ3
RQ4</td><td rowspan="2">Beta phase:
Same as in alpha, plus quantitative measures of improvement in student learning and interest in data analysis, modeling, and scientific careers</td></tr>
<tr><td>2021, Fall: Unit 3, beta</td></tr>
<tr><td colspan="5">2022, Spring: Data analysis, reporting, and dissemination</td></tr>
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References

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