https://doi.org/10.53656/nat2023-3-4.04

Interdisciplinary

INTEGRATING PRIMARY SOURCE ANALYSIS IN REMOTE TEACHING OF EARTH AND ENVIRONMENTAL SCIENCE DURING THE COVID-19 PANDEMIC

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Abstract. The COVID-19 pandemic disrupted learning, and obstructed social connections and spatial awareness. To rectify, an interdisciplinary curriculum integrated remote teaching of earth and environmental science with primary source analysis. Two professional development workshops trained 20 teachers and librarians who designed 17 cross-curricular activities for 540 students. In semi-structured interviews, the participants reflected that primary source analysis engages students in active learning and inquiry, develops critical thinking, provides multiple perspectives, and advances spatial skills by investigating real-world situations. Teachers concluded that teaching with primary sources enhances instruction and saves their time because activities can be adapted for any mode of instruction.

Keywords: primary sources, remote education, professional development, cross-curricular activities

This work was supported by the Teaching with Primary Sources Western Region Consortium Member at Metropolitan State University of Denver [grant of November 2020-June 2022]

Introduction

The COVID-19 pandemic forced education to transition to distance teaching and learning. Suddenly, an online community of earth and environmental science learners has expanded to include students from all walks of life at various levels of knowledge. Teachers had to modify curriculum for distance education very quickly and some assignments were abandoned because of technical difficulty or logistics. Educators were challenged to provide a full educational experience in an exclusively virtual setting in which students sometimes felt disconnected from their peers, teachers, and society in gen-

eral. This abrupt transition hindered the development of critical thinking and spatial awareness in the learning community.

To overcome these barriers, the University of Colorado Colorado Springs (UCCS) and Douglas County School District (DCSD) in the state of Colorado developed curriculum integrating primary source analysis in remote teaching of Earth and Environmental Science and provided professional development opportunities for educators. The Library of Congress (LOC) Teaching with Primary Sources Western Region Consortium Member[1] supported the project. **The participants learned how primary source analysis enhances critical thinking activities, which are pertinent to and can be modified between different modes of instruction.** The project team used the LOC digitized collection[2)] and which contains millions of artifacts in a variety of formats, including, but not limited to, texts, maps, data tables, images, audio recordings, and video clips. These primary sources document significant environmental phenomena and historical moments in American society and there are many benefits to integrating primary sources into the STEM classroom.

1. Benefits of Integrating Inquiry Process and Primary Source Analysis in Remote Science Instruction

Integrating primary source analysis provides opportunities for students to investigate the first-hand record. Students reach conclusions and make decisions based on evidence and reasoning. Through the process of inquiry, students are engaged in asking questions, filtering information, and solving problems, which develops critical thinking (Facione, 2011; Hilsdon, 2010). Inquiry-based learning becomes especially important during times like the COVID-19 pandemic, when students receive knowledge in their immediate residence and their interaction with content, peers, and teachers happens virtually. This online environment can limit learning by focusing on content comprehension and application unless the instructor designs learner-centered activities to promote higher-order thinking skills. Author (2018) demonstrates that learner-centered design in online geography courses increases student engagement and satisfaction, while critical thinking and group activities advance student knowledge to higher levels. The diagram (Figure 1) below outlines how designing inquiry-based activities with primary source analysis contribute to critical thinking enhancement by facilitating both independent research and scientific collaboration, while synchronous and asynchronous discussions enable interpersonal communication and multiple perspectives by connecting past and present experiences.

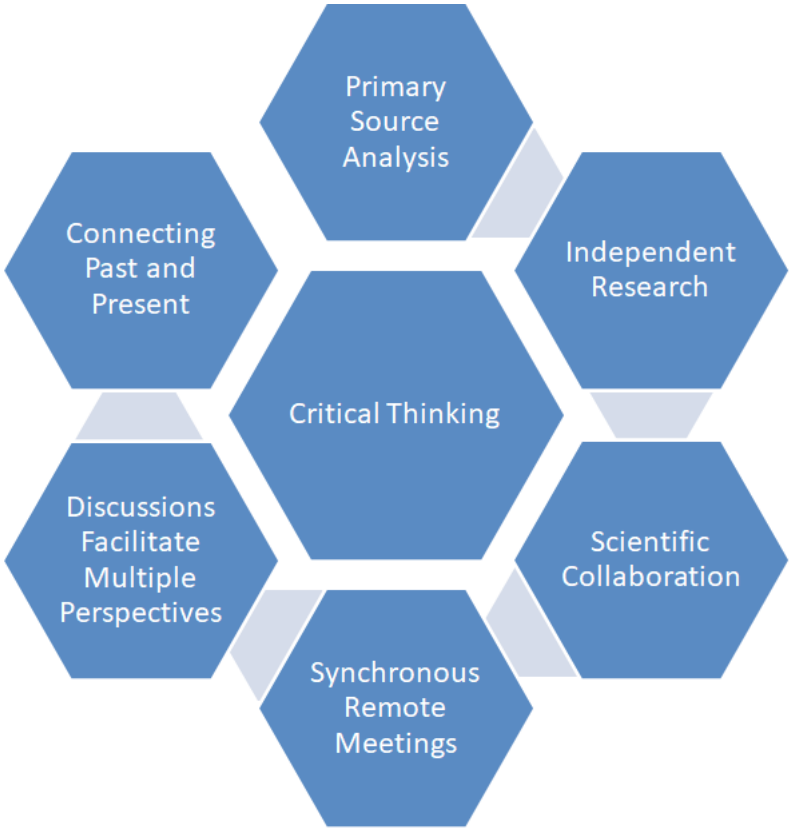

Figure 1. Best Practices in Remote Teaching During the COVID-19 Pandemic

Specifically, synchronous remote meetings conducted over *Zoom, Google Meet, MS Teams* or similar computer applications connect learners in real time and facilitate inquiry (*Fig. 1 Best Practices in Remote Teaching During the COVID-19 Pandemic*). "Synchronous class time" is best for discussing data and sources, problem solving, Q&A, and study sessions. The class is brought together to work on assignments and to create experiences. Collaboratively the class can work through a practice problem, clarify a complex theory/policy/idea, or just ask and answer questions. The following meeting structure is advised:

- Begin with greetings and an attention grabber
- Tell stories, comfortably use appropriate humor, and discuss academic/career values.

- Outline expectations and remind occasionally how everyone's participation leads to success
- Ask students about their experiences
- Encourage students to talk about their dreams. For example, "Here's why I want to be [fill in the blank]."
- Invite students to ask questions via microphone or by typing in the chat
- Instruct on sharing the screen, using video and audio, as well as utilizing Paint, Snipping, Excel, and other basic technical tools
- Work together on ways to complete the most challenging problems in the assignment/s
- Demonstrate solutions of sample problems by writing in the shared document or on online whiteboard, and by creating and editing images (maps, etc.), tables, and graphs
- Check student progress by randomly calling on them and asking to type their estimates in the chat or to show their map by sharing their video or screen
- Analyze primary and secondary sources in different formats such as pictures, videos, historical accounts, articles, etc. to take student imagination to the broader world
- Facilitate student reflection on the content and assignments to develop critical thinking and to relate to real-world issues
- Facilitate multiple perspectives in live discussions
    - ✓ Break up students into smaller groups and assign them different questions
    - ✓ Ask each student to find a different source to answer the question
    - ✓ Schedule group time for finding a consensus/solution within the group
    - ✓ Eventually bring them back from their breakout room to the main meeting to share their findings
    - ✓ Invite students to pose questions to and/or summarize presentations of their peers
- Discuss long-term projects and their stages to facilitate independent research
- Review upcoming assignments and tasks
- Take attendance and grade class participation by their contribution

A clear structure and timing are crucially important for a remote synchronous meeting, which should last approximately half of the period, but less than 1.5 hours. For a satisfying experience, teachers should plan lessons in advance and communicate expectations via email or another tool before and during the semes-

ter. An online Learning Management System should be used by the teacher to support learning by including the following: announcements, contact information and office hours, course overview, technical tips, syllabus with course schedule, accessibility information, online gradebook, online quizzes to check understanding of the content, online individual assignments to develop skills, asynchronous online discussions to initiate discussing the content. By adding fun conversations and visual aid, synchronous online (remote) meetings create the community of inquiry with a lively and personable atmosphere for active learning.

Active learning and dialogue improve cognitive skills and the community of inquiry becomes integral to education in digital age (Anderson 2017). Integrating primary source analysis promotes inquiry-based learning and spatial thinking. *Figure 2* illustrates that primary source analysis involves students in conducting research with real-world evidence and establishing connections of social issues with natural phenomena at various times and in different locations.

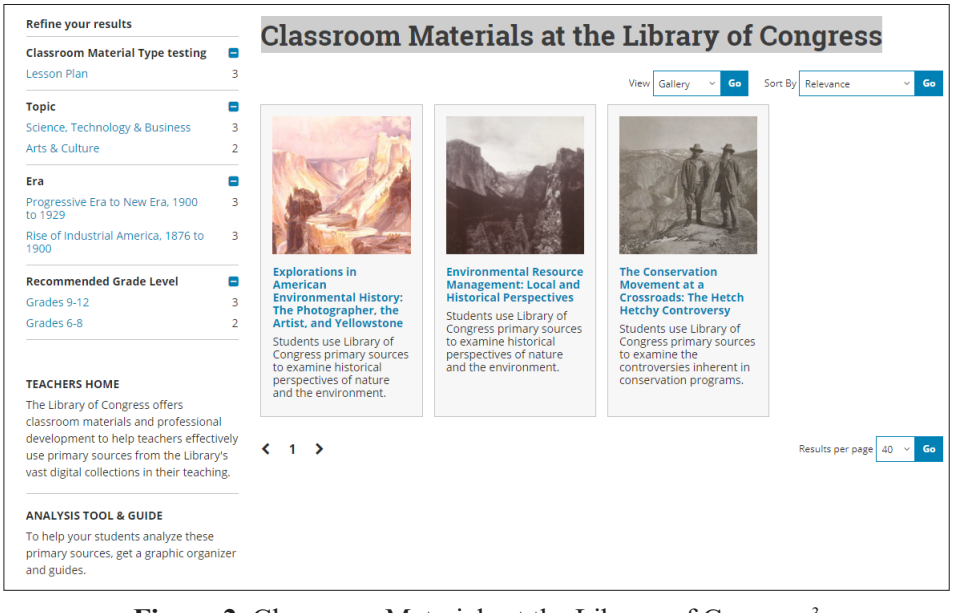

Figure 2. Classroom Materials at the Library of Congress[3]

Stripling (2009) confirms that comprehension achieved by primary-source investigation can be much deeper and longer lasting than knowledge acquired through someone else's perspective, for example reading a textbook. Designing and utilizing critical thinking activities with historical primary sources creates a comprehensive learning experience, which benefits STEM education.

2. Methodology: Creating Professional Development Opportunities for Teaching Science with Primary Sources

The expansive size and wide social spectrum of the LOC collections complicate identifying primary sources applicable for science instruction. Professional development (PD) programs are needed for teachers to learn how to locate resources and create primary source-based instructional activities. The DCSD recognized the need and collaborated with Author, UCCS, who designed the teaching with primary sources (TPS) content for a stand-alone professional development course. The DCSD Office of Sustainability and Curriculum, Instruction and Professional Development department delivered the course via the Canvas platform[4)], while *Zoom* or *Google Meet* was used for remote live meetings. The content laid the foundation for two PD workshops conducted with the help of DCSD Learning Specialist, Ms. Berry, in the spring and summer of 2021. Each workshop and its deliverables took approximately 20 hours to complete, where live meetings comprised half of that time. The time commitment and content met the requirements of teacher re-licensure and certification in DCSD.

Six modules comprise the workshop content, which includes synchronous and asynchronous activities. Each module provides links to resources, assignments to check understanding, and discussion forums to reflect on and present information. The introductory, fully asynchronous, self-paced module focuses on best practices for remote instruction and a teacher's reflection on what practices can be utilized in their classroom. The first TPS module focuses on learning about primary sources and the LOC collections. During the second module, participants discuss and utilize the primary source analysis tools. The third module introduces to the *Primary Source Activity Plan and Template* and participants start planning their TPS lesson or activity. The participants review the peers' primary source activity drafts and discuss their implementation strategies during the fourth module. The workshop concludes with publication and presentation of the final activity/lesson plans during the fifth module. Each TPS module begins with a two-hour remote live meeting, which consists of a small introduction/lecture, followed by group work and discussions, and concludes with large group discussions and homework for the following week. Remote live meetings build a learning community and demonstrate how the process of inquiry flourishes where multiple perspectives are present during live discussions, while the follow-up asynchronous assignments complete individual development of critical thinking. The details of each live meeting are outlined below.

During the first remote live TPS session participants meet each other and their instructors as well as start learning about the LOC primary sources collections and resources for teachers located[5]. Live introduction can include an attention grabber such as the prompt to share a vacation plan if unlimited resources were provided and

what sources could help create such a plan. A discussion on the difference between primary and secondary sources follows. The session concludes with conducting the 60-minute activity on *Analyzing Maps*, which utilizes the LOC investigative process "Observe-Reflect-Question"[6]. Afterwards in the asynchronous discussion forum, the participants reflect on what they learned. The following questions can guide the discussion: "*What has been difficult for you this week at the workshop? What was easy? What have you learned about primary sources? What strategies will you use to succeed in the workshop and beyond? How does this apply to your professional development?"*

The second remote live session begins with a short quiz/survey to review the LOC analysis tool and teacher's guides. Participants then form groups to work in break out rooms and to search for classroom materials associated with Earth Day or other earth science projects in the LOC collections, including exploring resources[7]. To share their findings, groups come together in the virtual community meeting room and discuss the following: *"What did you like, and why? Can you use it in your classroom, and how? What modifications would you propose?"* Finally, participants brainstorm topics for a TPS activity that they will develop and integrate into their teaching. To advance learning, the participants are assigned to search for three primary sources of various formats (e.g., text, video, or image), which can support the development of the proposed lesson plan/activity.

The third live session begins with a fun discussion on *Leaving Evidence of Our Lives,* where the participants share the historical "footprint" they created over the past 24 hours and how such primary sources may be interpreted in the future. Next, the participants are introduced to the *Primary Source Activity Plan and Template* to guide the lesson development. The *Primary Source Activity Template* was recommended by the TPS Western Region Consortium Member and modified for teaching earth and environmental science. After discussing expectations, teachers participate in the *Living with Volcanoes* activity designed by Author and which integrates teaching earth science with primary sources. The activity focuses on Mt. St. Helens and its impact on the environment and society, and the activity is described later in the *Cross-Curricular Activities* section of this article. For homework, participants are assigned to draft the primary source activity plan and to post their drafts in the asynchronous discussion forum in Canvas, as well as to share it with the instructors to receive feedback on resources and revisions (*Figure 3*). The asynchronous discussion focuses on activity goals, and prompts can include but are not limited to: "*What big idea do you want students to explore through this activity? What will come before and after this activity? Will it be used as an introductory activity, a summary activity, or an activity within a unit of study? What content and critical thinking skills do you want students to gain as a result of this activity? How will you measure student mastery of the objectives? Which Colorado Academic Standards does the activity address?"*

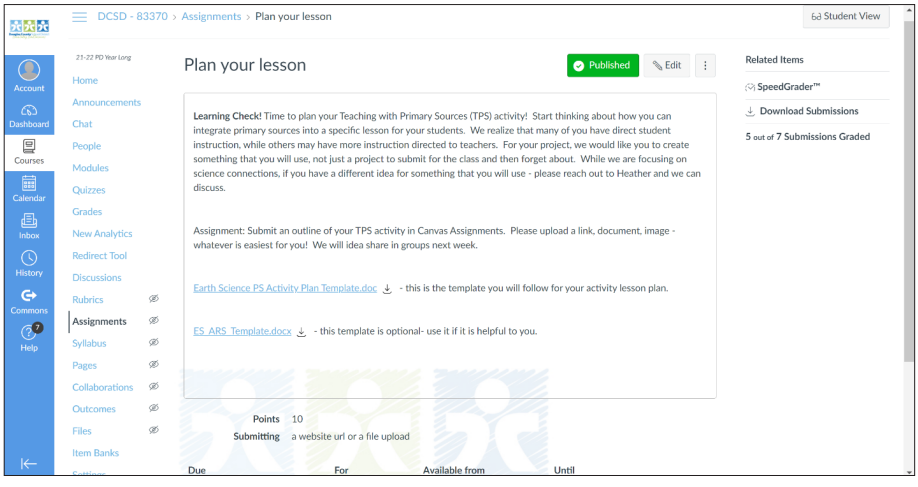

Figure 3. The DCSD Canvas page of the TPS workshop

The fourth live session begins with a demonstration of *Fun Science Facts* from the Library of Congress[8]. and a discussion on which *Everyday Mysteries* may be useful for their classroom. Then the participants work in groups to share and discuss a working draft of their lesson plans. The following questions guide the discussion: "*What role does primary source analysis play in the activity? How does the use of sources in multiple formats assist in identifying multiple perspectives in the study? How do primary sources support a teaching strategy, including but not limited to literacy, inquiry-based learning, historical thinking, etc. in teaching earth/environmental science? What workshop strategies or activities will you use?"* Following the small group discussion, everyone then comes together to review lesson submissions from previous workshops[9]. The examples demonstrate how other teachers integrated LOC primary sources in their earth and environmental science curriculum and provide ideas for activity design. After the live session, the participants are asked to revise their drafts, share it with the instructors as an individual assignment, as well as to post and discuss the final version in the respective asynchronous discussion forum. The discussion following the module focuses on implementation and the prompts include: "*How will you collaborate with others in your implementation? What do you still need to do before implementing your activity plan? For example, do you need to revisit the PSA Teacher Guides, meet with a teaching partner, or create additional materials?"*

The final live session focuses on the presentation and discussion of the final version of primary source activities. Then teachers are instructed to publish their lesson or activity plan at the *TPS Teachers Network* in the *TPS Commons* group (the widest audience), or in the focused *Geography and Maps* group or another group[10].

All deliverables described above are necessary for the participants to receive the DCSD professional development units for relicensing/certification and the TPS stipend.

The TPS professional development workshop was conducted twice in 2021 to test the content and to analyze the participants' responses. The project reached 30 educators, 20 of whom completed the program, and received continuing education hours as well as earned the LOC stipend and swag. Semi-structured interviews were conducted throughout the workshops. The data was collected via anonymous surveys, as well as teachers informally reflected on their experience and new knowledge during synchronous remote Zoom/GoogleMeet sessions and in the Canvas asynchronous discussion board. At end of each workshop, the participants filled out a formal anonymous survey and the data was processed by the *TPS Western Region Member*. The workshops received positive feedback from both the teachers and librarians in this course and it was beneficial to have feedback from each group as they have different perspectives. All participants noted how they will purposefully utilize primary sources in their classes, and a few have mentioned presenting the materials in other professional development classes. The participants said they enjoyed using the LOC search together, going through a sample lesson plan (Mt. St. Helens) and taking time to explore the LOC primary source collection as well as brainstorming its applications. The environment of collaboration facilitated content delivery and engaged the participants in creating new educational products.

3. Cross-Curricular Activities Facilitate Critical Thinking

Most participants of the TPS workshop designed activities which engage students in research and inquiry and connect scientific and social issues. Some teachers paired with another teacher or librarian to design an activity suitable for their curriculum. Overall, 17 new activities/lessons were created to use in both F2F and remote instruction. The participants designed various activities from students researching, applying and presenting the LOC resources on their own, to group experiments and entire class discussions. Including historical primary source analysis in a scientific inquiry promotes cross-curricular relationships as well as it promotes the development of higher-order thinking skills following Blooms taxonomy (Bloom 1956, p. 200).

The *Living with Volcanoes* activity, designed by Author, scaffolds learning from a basic level of understanding physical processes to applying this knowledge to the environment and human activities and to finally, creating an evacuation plan for towns in the volcano proximity. To begin the activity, the workshop participants form teams, and each team member is asked to collect their own piece of information on volcanoes, their hazards, and safety guidelines. A variety of topics facilitate independent research and allow multiple perspectives. Everyone is to take notes about their research and to create or choose one illustration such as an image, table,

graph, or a map to visualize data. This is a good time to discuss what is a primary source and how it differs from a secondary source. The assigned research topics may include, but are not limited to the following:

1. Learn about volcanism and volcano types. How did the Cascade volcanoes form? Why are there so many active volcanoes in Washington State? What kind of eruption would they produce: explosive or effusive, and why?
2. Learn about geologic hazards and the environment in Washington State. Which hazards are associated with volcano eruption? Which hazards can happen independent of volcano eruption?
3. Study information about volcanoes in Washington State and analyze the volcanoes proximity to people and their settlements.
4. Watch a video showing the disastrous eruptions of Mount St. Helens in 1980 and reflect on it.
5. Review pictures associated with the 1980 eruptions found in the LOC digital collections. Apply the *Primary Source Analysis Tool* (Observe | Reflect | Question). What do you see? Why? What can we do?
6. Analyze the extent of Mount St. Helens hazards and decide which towns are most at risk and why? Compare the volcanic hazard situation of cities close to and farther away from Mount St. Helens. Which hazard is most likely to occur in Cougar? Which hazard is most likely to occur in Kalama (or Longview)? Which hazard is most likely to occur in Tacoma (or Seattle) or in the US in general?
7. Search for and review an evacuation plan for a volcanic eruption. Given the types of volcanic hazards, what problem/s do you see with the evacuation plan? What would you modify?
8. Review the Mount St. Helens monitoring map. How many earthquakes happened this (or last) month? What was the magnitude of the strongest earthquake? How are earthquakes associated with volcanic eruptions? Can we predict an eruption by observing earthquakes?
9. Collect demographic information about the town, which you will evacuate. Include details about elderly, minors, disabled, hospitals, schools, etc.
10. Study the map of your town to evacuate, the layout of its roads, the presence of rivers, and its proximity to Mount St. Helens.

Later in class, the teams share their research by providing specific information about the environmental setting and volcanic hazards. They should then brainstorm an evacuation plan for their selected town including the timeline and routes. Finally, teams present their evacuation plan to the entire class. The activity incorporates primary and secondary sources at various stages, and it is

crucial to point out how the use of primary sources leads to making independent observations and decisions.

Earth Science instruction always involves analyzing historical information to predict future events, such as earthquakes and their impacts. The LOC collections can be an immense help in illustrating earthquakes and the work of plate tectonics. David Ward and Catherine Wheeler created new lesson plans by incorporating primary sources for teaching high school students about the *1906 San Francisco Earthquake.* Each teacher created a unique lesson because primary sources can beautifully reflect multiple perspectives. Ward's lesson directs students to analyze the earthquake damage in order to propose solutions for rebuilding the city to minimize fatalities from future earthquakes. Wheeler's lesson focuses on the history of seismology and maps analysis to evaluate the damage spatially, and how human development impacts the severity of an earthquake. Both activities develop student skills, from analyzing primary sources, to gathering and synthesizing data on seismology and human development, and creating a plan of action for people in the area. Assessment is based on the evaluation of student participation and contribution to their teams as well as presentation of the developed safety plans. The rubric evaluates: 1) the use of primary sources to document earthquake hazards with sources cited; 2) accuracy of hazard assessment; 3) suitability of proposed solutions, and 4) level of detail of proposed solutions. Ward incorporates LOC films and newspaper articles with first-hand accounts and images of people and San Francisco's streets before and after the fire caused by the 1906 earthquake. Historical information inspires natural curiosity about people and life in the early 20th century, provides the students with perspective on what the downtown area looked like four days before the earthquake, and describes the types of damage sustained. Wheeler begins the lesson with the analysis of maps of San Francisco Bay in 1838, 1848, and 1908. After the discussion on spatial changes in the bay, students read a digital copy of the letter from Andrew Jackson to Mary Caffery written in 1812. The letter expresses concern for the people in the New Madrid area on the west side of the Mississippi because of the 1812 earthquake shocks. The sources lead to investigating what people experienced during and after the San Francisco and Madrid earthquakes, and assessing the damage and impact in each area.

The Water Cycle and *Water Conservation* are taught in Earth and Environmental Science as part of a natural resources unit in 9th grade in DCSD. Rebecca Roberts and Shannon Rademacher designed an activity to explore how the steps of the water cycle are interconnected and how the environment around water sources can affect water quality. Students view different photos from the LOC collections such as photographs of various water reservoirs and glaciers, paintings of clouds, rain, and snow as well as related maps. For example, Figure 4 shows the *North Platte River Basin*. In groups of four, they discuss which part of the water cycle each picture could depict. Then students read a scientific text from the EPA (Environmental

Protection Agency) and the WHO (World Health Organization), analyze the associated data and graphs, and present their interpretation to the class. For assessment, students propose an explanation for how animal waste affects water quality and human health and make a poster showing the water cycle and where this waste can enter the cycle. Students can "tweet" their posters to other groups and a gallery walk will follow. Warren Berg's lesson incorporates the analysis of historical photos of Denver and the Platte River as well as war-time water conservation posters to brainstorm what is similar and different in modern practices compared to war time efforts. Pictures of Denver Water's Cheesman Reservoir help students understand where water comes from for residents and businesses of Denver/Highlands Ranch. Researching the Centennial Water District website gives ideas on how water can be conserved. Students synthesize new knowledge by creating a water conservation plan and a multimedia presentation or designing a new poster to encourage people to conserve water. These two different earth science lessons teach that sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources, including the development of technologies.

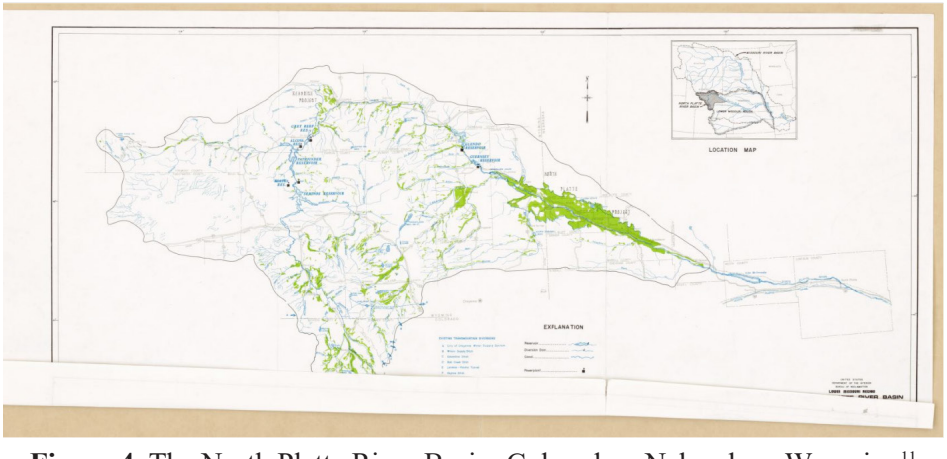

Figure 4. The North Platte River Basin: Colorado – Nebraska – Wyoming[11]

Autumn Rosengren designed the lesson *Let's Investigate Everyday Mysteries!* for teaching science in 11th and 12th grade. This activity includes accessing an article from The Library of Congress's *Everyday Mysteries* collection. In this lesson, students analyze an informational text that seeks to answer the question, "Why Do We Yawn?" Students will learn that while many claims regarding the functions of yawning have been presented, scientists have yet to reach a consensus about the answer to the question. This frequent challenge and re-examination of scientific claims helps to strengthen scientific knowledge. The students then choose an addi-

tional mystery to investigate and access at least one of the additional resources provided. Pairs of students then develop their own questions to submit to the science librarians using the online form provided by the Library of Congress. This lesson advances student research inquiry skills by asking them to find their own source in the LOC collections as well as introducing them to jobs done by professionals at LOC. Rosengren's lesson received recognition from the *TPS Teachers Network*, and was featured in the *Best of August 2021* newsletter.

The COVID-19 pandemic influenced educators and students in multiple ways and some environmental science teachers developed high school lessons associated with the disease. Gina Bernacchi assigns students to analyze a graph and article from the 1918 pandemic about the effects of mask-wearing on the spread of disease to learn why masks work and how they help stop the spread of disease. Using the *LOC Primary Source Analysis Tool,* students analyze and synthesize historical information on how masks helped save lives over 100 years ago and what steps health officials took to prevent the spread of the influenza virus. For assessment, students create an infographic or poster or other media informing others of what they learned to model human actions at present. A historical perspective on infectious diseases supports inquiry-based learning through asking questions to decide on mask-wearing. Focusing on scientific evidence, the activity presents an opportunity for students to formulate their objective point of view.

Another COVID-19 related activity, designed by Jody Lanterna-Lewis and Kim Cox for the 10th grade *Global Science* course, focuses on positive effects of the COVID-19 pandemic on the environment. The activity is part of a *Climate Change and Future Planet* unit, and students have some prior knowledge of climate change and the impact of human activities on pollution. Students analyze and evaluate evidence to determine what, if any, positive impact the COVID-19 pandemic has had on the environment and society.

The sources include, but are not limited to, cartoon drawings and children's books about the pandemic and hygiene[12)], articles on air pollution and federal air pollution policy (e.g., LOC blog on teaching civic ideals using primary sources), as well as before-and-after photos which show the dramatic effect lockdowns had on pollution around the world in 2020. Students discuss the changes in human behavior due to the pandemic and quarantines and their impacts on the environment. They research environmental legislation contributing to air quality around the world. Students observe the dramatic impact on air pollution brought about by human behavior change during COVID-19. Then, they draft an essay with their recommendations for local and federal officials to positively impact pollution amounts and climate change for the better. The lesson plan integrates the following content: Pandemic, Climate, Environment, Air Pollution, Human Behavior and Impact, Government Regulation, Water Pollution, and American Government.

Conclusion

The integration of historical primary sources into STEM curriculum benefits both teachers and students. Students engage in active learning and inquiry, connect scientific problems with social issues, and develop critical thinking and spatial skills by investigating real-world situations. A variety of sources and formats accommodates various learning styles and provides multiple perspectives. Both team and individual research thrive when students analyze evidence, form opinions and construct statements, for example, while examining primary sources of COVID impact on the environment. Cross-curricular connections flourish when science and social studies students are paired to investigate climate change or water pollution and respective legislation. "Live" remote meetings and asynchronous discussions build an engaging learning community with productive social connections.

The TPS workshops grow expertise and increase the confidence of science teachers. Teachers received guidance in the exploration of the LOC TPS site, which has sample lesson plans, linked resources and amazing teaching tools, including a blog. The participants learned to think beyond the resources they usually use such as databases, books, etc. The workshop participants stated that they plan to seek and use primary sources more intently than before because they are fun, new, historic, and exciting. The original documents illustrate the state of society and its culture as well as the biases and values that individual characters had at the time. By using primary sources, the participants developed engaging lessons, which include research and facilitate student critical thinking with questions such as, "What do you notice?" and "What do you think about that?" Teachers save time by designing inquiry-based activities which can be easily modified for any mode of instruction with modern learning technology tools. Integrating primary source analysis in science instruction is rewarding because it persuades research, relates to social issues, establishes cross-curricular connections, and advances knowledge development to new levels, an overarching goal of teaching.

NOTES

1. https://sites.msudenver.edu/tpswesternregion/
2. https://www.loc.gov/collections/
3. https://www.loc.gov/classroom-materials/?q=geology
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5. https://www.loc.gov/teachers
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