CSU-TIPS RESEARCH LESSON STUDY PROPOSAL

2025-6

Adapted from CANMEE Lesson Study Proposal

For the lesson on: History of Chemistry, How Chemistry is done, Who Does Chemistry
Place: CSUN, SSU, CSULB
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Course: First semester chemistry (General Chemistry, Intro Chemistry)

Title of Lesson: Chemistry Is Everywhere: Global Stories of Discovery and Innovation

Brief Description of Lesson: This first-day lesson introduces students to global, community-based chemistry practices and reframes chemistry as a human, collaborative endeavor practiced worldwide.

1. **Students' competencies and challenges**

   Evidence / assets-based descriptors include: why each focal student was chosen; their funds of knowledge (cognitive and affective), content and agency strengths; and a content and agency goal for each focal student Add rows as needed.>

To inform the design of this lesson, members of the lesson study team interviewed first-year and upper-division chemistry and engineering students across participating CSU campuses. Rather than identifying individual focal students, the team developed composite focal student profiles representing common themes that emerged across the interviews. These profiles reflect students' assets, aspirations, and challenges and guided the design of the research lesson.

Focal Student	Competencies and Challenges
Student Name Teacher Grade	***Why chosen:*** Represents first-generation Latina STEM students who are highly motivated to pursue science careers but often report feeling that they do not "fit" the traditional image of a scientist. ***Assets:*** Strong intrinsic motivation to help others through science (medicine, nursing, veterinary medicine) • Strong family and community values • Persistent learner who seeks study groups and support • Recognizes connections between science and everyday life **Competencies and Challenges:** Although academically successful, this student frequently experiences imposter syndrome and rarely sees scientists or scientific examples that reflect her community or cultural background.

<table>
<tr><td></td><td>Content Goal: Recognize that chemistry has been practiced by diverse communities throughout history and identify chemistry concepts within cultural practices.
Agency Goal: Increase confidence that their own experiences, culture, and community are legitimate sources of scientific knowledge and belonging within chemistry.</td></tr>
<tr><td>Student Name
Teacher
Grade</td><td>Why chosen: Represents students who become highly engaged when chemistry is connected to real-world applications and storytelling.
Assets: Curious and reflective learner
Strong interest in practical applications
Learns best through examples, models, and narratives
Connects scientific concepts to future career goals
Competencies and Challenges:
Often perceives chemistry as abstract and disconnected from everyday experiences, reducing engagement during traditional lectures.

Content Goal: Connect cultural examples to foundational chemistry concepts such as materials science, acid-base chemistry, fermentation, and extraction.
Agency Goal: Actively contribute ideas during small-group discussions by drawing on personal experiences and observations.</td></tr>
<tr><td>Student Name
Teacher
Grade</td><td>Why chosen: Represents upper-division students who have developed confidence in STEM but reflected that this confidence emerged only after finding mentors, research experiences, or communities of practice.
Assets: Strong work ethic
Collaborative learner
Values teamwork and persistence
Views science as problem solving
Competencies and Challenges:
Initially believed that scientists were exceptionally gifted individuals rather than ordinary people who develop expertise through practice and collaboration.

Content Goal: Recognize that scientific knowledge develops collectively through communities rather than solely through individual "discoveries."
Agency Goal: Share their thinking publicly and recognize themselves as contributors to scientific knowledge.</td></tr>
<tr><td>Student Name
Teacher
Grade</td><td>Why chosen: Represents students from historically underrepresented backgrounds who expressed that they rarely encountered scientists or inventors who reflected their identities or communities.
Assets: Strong perseverance
Strong sense of purpose
Desire to give back to family and community
Values diverse perspectives</td></tr>
</table>

	Competencies and Challenges: Reports increased motivation when learning about scientists from diverse backgrounds but observes that these stories are largely absent from introductory science courses. ***Content Goal:*** Explain how chemistry has developed across cultures through community innovation and problem solving. ***Agency Goal:*** Develop a stronger sense of belonging by recognizing that people from many cultures have always contributed to chemistry.

2. Rehumanizing STEM dimension and goal

<Resources: Standards for Mathematics Practices, Teaching for Robust Understanding, Aguirre et al 5 EQUITY PRACTICES The Impact of Identity in K-8 Mathematics Aguirre, Mayfield-Ingram, Martin; Bartell>

Rehumanizing STEM dimension: Cultures & Our/Theirstories; Windows and Mirrors

Rehumanizing STEM Goal:

- Students recognizing that STEM has actors/ ancestors/roots; based on aesthetic choices
- Bring and incorporate other stories into our teaching
- General Chemistry often starts with the explanation of experiments done by all European males- we want to tell other stories
- Students being able to see themselves in the curriculum & in others
- Connecting with others

3. Content goal

Each student, especially focal students will understand:

- **That chemistry has been practiced globally for millennia in diverse cultural contexts.**
- **That chemical knowledge emerges through community needs, shared experimentation, and generational knowledge—*not* only through individual lab-based experiments.**

Each student, especially focal students will be able to:

- **Identify chemical principles (e.g., redox, fermentation, materials science, acid/base chemistry) in real-world, historical practices.**
- **Explain how scientific knowledge is developed collaboratively and contextually.**
- **Reflect on their assumptions about who does chemistry.**

4. Connecting the Rehumanizing STEM dimension and the Content goal: How can the RS dimension support learning of the content?

The **Cultures & Our/Their Stories (Windows and Mirrors)** dimension supports students' learning of chemistry by positioning chemical knowledge as a global, collaborative, and deeply human endeavor. Rather than presenting chemistry solely through a sequence of discoveries made by a small number of European scientists, this lesson introduces students to examples of chemical innovation that emerged from diverse cultures in response to practical needs, community knowledge, and centuries of observation and experimentation.

Using global case studies (e.g., nixtamalization, Maya Blue, Vietnamese fish sauce fermentation, Wootz steel, color television) provides students with both **windows** into scientific practices from cultures different from their own and **mirrors** that reflect the knowledge, traditions, and problem-solving approaches found within many communities. These examples help students connect foundational chemistry concepts to familiar human experiences such as food preparation, materials, art, medicine, and technology.

By broadening whose stories are included in the chemistry curriculum, students are encouraged to recognize that scientific knowledge is built collectively across generations and cultures rather than solely through isolated discoveries by individuals. This framing supports students' sense of belonging while helping them understand that chemistry is not separate from everyday life—it is a way humans have always observed, experimented with, and transformed the world around them.

5. Choose the task and anticipate student responses <Do the task and anticipate how focal students will do the task>

Task:

Students will work in small groups (3–4 students) with a **Global Chemistry Case Card** (e.g., Nixtamalization, Maya Blue, Vietnamese fish sauce fermentation, Wootz steel, Color Television, etc.).

Each group will:

- Read the historical and cultural story.
- Identify the chemistry occurring in the process.
- Discuss the provided questions.
- Prepare one key takeaway to share with the class that connects the cultural practice to a chemistry concept and to the broader question of **who does chemistry and how scientific knowledge develops.**

The instructor will emphasize that there is not a single "correct" answer. Rather, students are expected to use evidence from the case card, prior experiences, and discussion with their peers to construct explanations.

Anticipated Student Responses”

Students are expected to identify familiar chemistry concepts embedded within everyday practices, including:

- acid-base chemistry (nixtamalization)
- fermentation and enzyme activity (fish sauce, kimchi, bread)

- oxidation-reduction (iron smelting, metallurgy)
- materials science (Maya Blue pigments, color television)
- extraction and solubility (coffee, herbal medicines)

Many students may initially describe the examples as "cooking," "crafts," or "traditions" before recognizing the underlying chemistry. Through discussion, students will begin reframing these activities as systematic observation, experimentation, and innovation.

Students are also expected to notice that:

- scientific knowledge often develops through communities rather than isolated individuals;
- chemistry has been practiced across cultures throughout history;
- many innovations were driven by practical needs such as food preservation, nutrition, materials, medicine, or communication.

6. Unit plan < Describe lessons surrounding your research lesson, with a goal and task. Identify which lesson is the research lesson.>

Lesson	Unit Learning Goal and Tasks
1 Re- Search Lesson	**Goal:** Students recognize chemistry as a global, collaborative human endeavor practiced across cultures and throughout history. Students begin to develop a sense of belonging by seeing chemistry connected to everyday life and diverse communities. **Task:** Analyze a Global Chemistry Story (case card), identify the chemistry concepts involved, discuss how knowledge was developed within communities, and reflect on how the lesson changes their understanding of who does chemistry.
2	**Goal:** Introduce chemistry as the study of matter and its transformations while connecting modern scientific practices to the historical examples explored in this lesson **Task:** Observe and classify examples of physical and chemical changes from everyday materials. Students revisit examples from the case cards (e.g., fermentation, nixtamalization, metallurgy) and identify evidence of chemical change.
3	**Goal:** Develop an understanding of measurement, precision, and the role of quantitative observations in chemistry. **Task:** Practice making measurements (mass, volume, density) and discuss how careful observation and measurement have always been important tools for understanding materials—even before modern laboratories.

4 Future Lesson	**Goal:** Understand atomic theory as one model that explains observations about matter and chemical change while recognizing that scientific models build on centuries of knowledge. **Task:** Introduce the historical development of atomic theory (Lavoisier, Dalton, Thomson, Rutherford, Bohr, etc.) while discussing how scientific understanding evolves through the contributions of many people and cultures.
5 Future Lesson	**Goal:** Apply particle models to explain physical and chemical properties of matter and connect microscopic models to macroscopic observations. **Task:** Use particle diagrams and simple laboratory demonstrations to explain observations from both traditional chemistry examples (e.g., conservation of mass) and the cultural case studies introduced during the first lesson.

7. Research Lesson Plan

Indicated time percentages are recommendations; adjust as necessary

Steps, Learning Activities Teacher's Questions and Expected Student Reactions	Teacher Support	Formative Assessment
ACT 1 :: IGNITE AND LAUNCH (15%)		
Ignite<Connect to prior knowledge, experiences, funds of knowledge, context of focal students> Students sit in groups of 3–5. Prompt: **"When you hear the word *chemistry*, what comes to mind?"** Students individually submit responses using Mentimeter to generate a live word cloud. Students briefly discuss their responses within their groups before sharing with the class. **Expected student responses:** • Atoms, molecules, reactions, labs, chemicals • Scientists in lab coats • Experiments, equations, explosions • Cooking, medicine, everyday products (some students) The instructor acknowledges all responses and asks students to notice any common themes.	<Connect to funds of knowledge, competencies, context> Use Mentimeter QR code to encourage participation from all students, including those less likely to speak publicly. (Mentimeter - join in with QR code Each of us has our own account: https://www.mentimeter.com/app/presentation/altnsaxq66gzvyhv94zkexcm7ewjdzff/edit?question=r999pp75gjzb) Validate all responses **without** labeling them as "correct" or "incorrect." Encourage students to build on classmates' ideas rather than evaluate them.	<Are students motivated to do the work?> **Evidence of engagement:** • Broad participation in Mentimeter. • Students contribute ideas during small-group discussion. • Word cloud reveals students' initial conceptions of chemistry. **Evidence of prior knowledge:** • Students primarily associate chemistry with laboratories and famous scientists. • Some students mention everyday experiences, cooking, medicine, or nature, providing opportunities to connect to the lesson. **Evidence students are motivated:** • Students ask questions or offer examples from their own lives. • Students begin connecting chemistry to familiar experiences. • Students demonstrate curiosity about examples shared by classmates.

Wondering <What question will students answer with this lesson, awaken their curiosity, motivate to engage?> Introduce the driving questions: • **"How have people around the world practiced chemistry throughout history?"** • **"What counts as chemistry?"** • **"Where do you see chemistry in your culture, family, or community?"** Students submit one response to Mentimeter and briefly discuss with their groups. **Expected student responses:** • Food and cooking • Family traditions • Medicine or herbal remedies • Cleaning products • Gardening or agriculture • Some students may respond that they are unsure.	If needed, ask probing questions such as: • "Where have you seen chemistry outside of school?" • "Who do you picture doing chemistry?" • "Can chemistry happen outside a laboratory?" Normalize uncertainty. Position students as experts on their own experiences by emphasizing that there are many ways chemistry appears in everyday life. Invite multiple examples from different cultural backgrounds. If students struggle, offer examples such as bread making, fermentation, dyeing fabrics, making soap, pottery, or preserving food.	
Launch Task < Describe the task as it will be presented to students. Give the exact phrasing of task with specific numbers used.> < How will students unpack the task so can access problem without being led to a strategy or solution>	< All students, especially focal students, access the task. What strategies support all students accessing the task? What prior knowledge will focal students bring to the task?>.	<Do focal students unpack the task?> **Evidence students unpack the task:** • Students identify the central problem addressed in the case study. • Students begin discussing possible chemistry concepts.

Introduce several images (or a short video) representing examples from the case cards (Maya Blue, nixtamalization, Vietnamese fish sauce, Wootz steel, color television, etc.). Provide each group with one **Global Chemistry Story** case card. Prompt: **"As you read your case, think about three questions:** 1. What chemistry is happening? 2. What problem was this community trying to solve? 3. What does this story teach us about who does chemistry?" Groups read their case card together and clarify unfamiliar vocabulary before beginning discussion.	Use visuals to support comprehension, especially for students unfamiliar with the cultural contexts. Circulate to answer vocabulary questions without giving away the chemistry. Encourage students to first discuss the story before focusing on identifying chemistry concepts. Support focal students by inviting all group members to contribute observations before moving toward explanations.	• Students ask clarifying questions about the cultural practice rather than waiting for the instructor to provide answers. • All group members participate in reading or discussing the case card.
Steps, Learning Activities Teacher's Questions and Expected Student Reactions	**Teacher Support**	**Formative Assessment**
ACT II :: WORK TIME (50%)		
Workshop ≅20 mins <Students choose how they will work on the problem and what strategies to use. How will solo and group work build on anticipated focal student strengths? solutions?> Students work collaboratively in groups of 3–5 to analyze one **Global Chemistry Story** case card. Each case card includes: ● A historical and cultural story ● A chemistry connection	<Support students' multiple competencies> The instructor prepares: ● Google Slides presentation ● Shared Google Slides deck (one slide per group) ● Canvas page containing:	**Evidence of Student Thinking** Observe whether students: ● correctly identify at least one chemistry concept within their case study.

• Discussion prompts Groups prepare a brief (1–2 minute) summary that addresses: 1. **What was happening in this community?** 2. **What chemistry concepts are involved?** 3. **What problem was being solved?** 4. **What does this example teach us about how chemistry knowledge develops?** Students may choose to organize their thinking through: • verbal explanation • annotated notes • simple diagrams • concept maps (future implementation)	○ digital copies of each case card ○ supplemental resources ○ Images (optional) ○ short videos (optional)	• explain how the chemistry helped solve a real-world problem. • distinguish between describing the cultural practice and explaining the chemistry. • connect historical practices to modern chemistry concepts.
• **Anticipate student solution responses** <What are common issues / errors that may arise for this content?> < What are anticipated focal student solutions and representations and what questions will be asked to support students through productive struggle?> Students will likely identify chemistry concepts such as: • fermentation • acid-base chemistry • oxidation-reduction • materials science • extraction • light and color	<What teacher moves – model participation, accountable talk, position as capable and competent, use of representations and tools > While circulating, the instructor: • asks open-ended questions rather than providing answers • acknowledges multiple valid observations • connects student ideas back to chemistry concepts • prompts students to support claims with evidence from the case card Examples:	<Are these the anticipated responses? Do others emerge?> **Evidence of Rehumanizing STEM Goals** Look for students beginning to shift their thinking by expressing ideas such as: • "Chemistry has been practiced for a long time." • "People were doing chemistry without calling it chemistry."

Students may initially focus more on the historical story than the chemistry or vice versa. Through discussion, they are expected to connect the cultural practice with the underlying chemical principles. **Anticipated Challenges** **Challenge:** Students focus only on the historical story and overlook the chemistry. **Teacher prompts** • "Where is matter changing?" • "What substances are interacting?" • "What evidence tells you chemistry is occurring?" **Challenge:** Students believe chemistry only happens in laboratories. **Teacher prompts** • "What problem was this community trying to solve?" • "How might people have improved this process over generations?" • "How is this similar to what scientists do today?"	"What evidence supports that idea?" "Can you connect that observation to the chemistry?" "What changed during the process?" "How do you think people discovered this?"	• "Communities contributed to scientific knowledge." • "Science isn't only done in laboratories."
• **Anticipate focal student exercise of agency** < How will encourage, recognize, and support focal student contributions to collective understanding of the content>	<What teaching practices might be used for each focal student? Other potential moves used to respond?>	<What are the effects of on focal students?>

The instructor intentionally positions students as knowledge contributors. Possible teacher moves: • Invite students to connect examples to family, community, or cultural experiences. • Validate multiple ways of knowing and problem solving. • Encourage quieter students to contribute observations before explanations. • Rotate spokesperson responsibilities so different students share.	Teacher intentionally: • invites multiple voices before accepting responses • validates cultural knowledge as evidence • positions students as experts on their own experiences • encourages collaborative rather than competitive discussion	**Evidence of Student Agency** Observe whether focal students: • contribute ideas during group discussion. • connect chemistry to personal or cultural experiences. • ask questions or build on peers' ideas. • volunteer to share or contribute to the group's presentation.

• **Monitor and Sequence** <Monitor focal student work deciding who will share and in what order. How will you handle misconceptions during sharing? > While circulating, the instructor notes: • chemistry concepts identified • evidence students use • connections students make between chemistry and culture • questions students raise Groups are selected to share in a purposeful sequence that builds conceptual complexity. Possible order: 1. Food chemistry (nixtamalization, fermentation) 2. Materials chemistry (Maya Blue, glass) 3. Metallurgy 4. Modern technology (color television)	< Smith and Stein's note taking guide with anticipated solutions and teacher assessing and advancing questions> Instructor notes: • chemistry concepts identified • misconceptions • interesting student connections • examples to highlight during discussion	< Are students explaining, justifying, questioning?> **Evidence of Sense Making** Listen for students asking questions such as: • "Why did that happen?" • "How did they figure that out?" • "That's basically chemistry!" • "They were experimenting even without modern equipment."
Steps, Learning Activities		

Teacher's Questions and Expected Student Reactions	Teacher Support	Formative Assessment
ACT III :: BRINGING IT ALL TOGETHER **(35%)**		
Share and Connect ≅10 mins < What content do you want to elicit from student work, especially focal student's work? What content will you make sure is clear to students? How will you make connections between the different representations used?> ● Each group presents a 1-minute "lightning summary" that answers: ○ What was your example? ○ What chemistry was occurring? ○ What problem was this community solving? ○ What does this example teach us about how scientific knowledge develops? ● The instructor records common themes across groups. ● Expected themes include: ○ Chemistry solves real-world problems. ○ Communities build knowledge over generations. ○ Experimentation often occurs through observation, trial-and-error, and refinement. ○ Similar chemistry concepts appear across many cultures. ○ Scientific knowledge continues to evolve.	● Assign competence ● Position students as source and expertise ● Distribute authority ● Validate knowledge, skills, strategies, dispositions ● Accountable to self and class ● Generate content questions ● Analyze, compare, justify ● Justify using evidence Intentionally assign competence by highlighting valuable ideas from multiple groups, especially quieter students or those whose contributions connect chemistry to lived experiences. Encourage students to compare examples: • "What similarities do you notice between these stories?" • "How were these communities acting like scientists?" • "What chemistry ideas appeared in more than one case?" Press students to justify claims using evidence from their case card rather than personal opinion.	<What connections do student make> **Evidence of Conceptual Connections** Look for evidence that students are making connections such as: • Chemistry exists beyond laboratories. • Scientific knowledge develops through communities as well as individuals. • Cultural practices often involve sophisticated chemical understanding. • Modern chemistry builds upon knowledge developed across many cultures.

Summarize ≅5 mins <Build on focal student work to bring clarity to the content of the lesson. Use a concise summary statement.> Instructor synthesizes student ideas rather than introducing new information. Summary statement: **"Chemistry is a global, collaborative, and continually evolving way of understanding and transforming the world. Long before chemistry became a formal scientific discipline, communities around the world were observing, experimenting, solving problems, and sharing knowledge across generations. The chemistry you will learn this semester builds on that long human story."**	Position students' work as the source of today's learning by explicitly referencing ideas generated during discussion. Connect today's examples to upcoming course topics: "Throughout this semester, we'll learn the scientific models that help explain many of the chemical processes you explored today."	<Is the content clear? Concise? Connected to student work?> **Evidence of Rehumanizing STEM Goals** Look for statements indicating students: • broadened their image of who practices chemistry; • recognized chemistry in their own lives or communities; • appreciated multiple pathways to scientific knowledge; • expressed increased curiosity or belonging.
Reflect ≅5 mins Student reflection prompt .. i.e., What did you learn from a friend today? What strategy will you try? What was the purpose of the lesson? Students complete an Exit Ticket in Canvas or on paper. Possible prompts: • How did today's lesson change or expand your idea of who does chemistry? • What surprised you most?	Encourage honest reflection; emphasize there are no "right" answers. Invite students to continue noticing examples of chemistry in their own communities throughout the semester.	**Evidence Content Was Understood** Students accurately connect at least one chemistry concept to a cultural example and explain how that chemistry addressed a practical problem. Students use evidence from the case cards to justify their thinking rather than simply recalling facts.

• What chemistry example would you like to learn more about? • How might today's lesson influence the way you think about chemistry this semester?		

8. "Board" plan < How will the board be designed to reveal the history of the lesson? Make visible student thinking? Help students make connections across representations? To make sense of the content? >

The board (or projected Google Slides) will document the progression of students' thinking throughout the lesson, making both the chemistry concepts and the development of scientific knowledge visible.

Initial Thinking (ACT I)

Question: *"When you hear the word chemistry, what comes to mind?"*

- Display Mentimeter word cloud.
- Record several student ideas that emerge during discussion (e.g., atoms, reactions, laboratories, scientists, medicine, cooking).

Purpose:
Capture students' initial conceptions of chemistry and provide a reference point for later reflection.

Global Chemistry Stories (ACT II)

As groups work, create a class summary table.

Case Study	Chemistry Concept	Community Problem Solved	What does this teach us about chemistry?
Nixtamalization	Acid-base chemistry	Nutrition	Communities developed chemical knowledge through observation and experimentation.
Maya Blue	Materials chemistry	Durable pigments	Innovation can emerge through artistic and cultural practices.
Fish Sauce	Fermentation	Food preservation	Chemistry develops from practical needs and shared knowledge.
Wootz Steel	Metallurgy	Strong tools	Materials were engineered long before modern laboratories.
Color Television	Light & materials	Communication	Scientific innovation continues across cultures today.

—OR— the table could look like:

What chemistry is happening?	How did people figure it out?	What does this teach us about chemistry?
Fermentation	Observation & experimentation	Chemistry solves human problems
Acid-base chemistry	Community knowledge	Science is collaborative

Materials science	Trial and refinement	Innovation happens globally
Light & color	Building on previous ideas	Chemistry belongs to everyone

Purpose:
Help students compare examples and recognize common chemistry concepts across different cultural contexts.

Big Ideas (ACT III)

Record themes generated during whole-class discussion.

Examples:

- Chemistry solves problems.
- Communities build knowledge over time.
- Observation and experimentation happen everywhere.
- Scientific knowledge develops collaboratively.
- Chemistry exists in everyday life and across cultures.

9. Observation question(s) <What question (about the lesson hypothesis) does the team want answered by the commentators and observers? Does the evidence from the points of assessment in the lesson plan lead to answering this question?>

How do students use evidence from the case studies to connect cultural practices with chemistry concepts?

Observers should note whether students:

- identify the chemistry within the case study,
- explain the chemistry using evidence,
- connect chemistry concepts across multiple examples.

How do students' ideas about who does chemistry and how scientific knowledge develops change over the course of the lesson?

Observers should listen for statements indicating that students recognize:

- chemistry occurs outside laboratories,
- communities contribute to scientific knowledge,
- experimentation happens through observation, iteration, and shared knowledge

How are focal students participating in collaborative sense-making?

Observers should pay particular attention to whether focal students:

- contribute ideas during group discussion,
- connect chemistry to their own experiences or communities,
- ask questions

- build on classmates' thinking,
- participate in whole-class discussion.

10. **Reflections** < What was learned from the research lesson? About content? About access and agency? About the lesson hypothesis? About pedagogy? About focal students?>

Content

Students were highly engaged by the global chemistry examples and were able to identify many of the chemical processes occurring within the case studies. However, the team observed that students often focused on understanding the chemistry itself—sometimes beyond the level expected in a first-semester General Chemistry course—rather than the broader lesson goal of examining **how chemical knowledge develops through communities and cultures**. This observation led the team to recognize that future iterations of the lesson should simplify the chemistry presented on each case card while strengthening the discussion prompts that emphasize knowledge development, problem solving, and human stories.

Access and Agency

Students actively participated in small-group discussions and frequently connected examples to their own experiences, cultural traditions, and interests. The lesson created opportunities for students to recognize that chemistry exists in everyday life and within many cultural practices. The team observed that positioning chemistry as a human endeavor helped broaden students' perspectives about who practices chemistry and where scientific knowledge originates.

Lesson Hypothesis

The lesson supported the hypothesis that introducing chemistry through culturally grounded examples broadens students' understanding of chemistry as a global, collaborative human endeavor. Students demonstrated curiosity about examples from different cultures and engaged in meaningful discussions about innovation, experimentation, and problem solving. At the same time, the lesson revealed the importance of intentionally guiding students toward the **human story of chemistry**, rather than allowing discussion to become dominated by scientific details.

Pedagogy

One of the most important findings from the research lesson was the need to more clearly balance chemistry content with the lesson's Rehumanizing STEM goals.

Specific revisions identified by the team include:

- Simplifying the chemistry presented on each case card so it is appropriate for first-semester General Chemistry students.
- Revising discussion prompts to focus more explicitly on **how knowledge was developed** rather than only on the chemistry.
- Providing clearer guidance for student presentations (e.g., one-minute lightning talks or six-word thesis summaries).
- Exploring alternative methods for sharing student work that fit within a 50-minute class period.
- Continuing to develop case studies that are historically accurate, culturally grounded, and chemically appropriate for introductory students.

The team also recognized that developing these case studies required significant interdisciplinary work. Finding historical examples, verifying their cultural context, and accurately connecting them to chemistry concepts often extended beyond traditional General Chemistry expertise.

Focal Students

The lesson provided opportunities for students to connect chemistry with their own experiences and communities. Although participation varied, students engaged thoughtfully with the case studies and demonstrated curiosity about examples that expanded the traditional narrative of chemistry. The team hopes that continued refinement of the lesson will further support students in seeing themselves reflected within the chemistry curriculum.

- Commentaries from public lesson (commentator)
  < synthesize findings from public lesson evidence and commentaries >

The commentator observed that while students were interested in the chemistry presented in the case studies, many discussions centered on understanding the scientific details rather than exploring the broader goals of the lesson. This feedback prompted the lesson study team to reconsider the balance between chemistry content and the Rehumanizing STEM dimension.

Based on the commentary, the team plans to:

- emphasize the human stories behind the chemistry,
- simplify technical content,
- revise discussion prompts to foreground community knowledge, experimentation, and innovation,
- maintain chemistry rigor while ensuring that the chemistry serves the larger learning goals rather than becoming the primary focus.

- Team reflection < Professional learning of lesson study team >

Working collaboratively across three CSU campuses was one of the most valuable aspects of the lesson study process.

Although collaboration occurred primarily through Zoom, the team appreciated the opportunity to exchange ideas with colleagues teaching chemistry and chemical engineering in different institutional contexts. Despite differences in campus culture and student populations, the team found that many instructors shared similar questions about how General Chemistry is introduced and how to better support students' sense of belonging.

The collaborative development of the Global Chemistry Stories strengthened the lesson and highlighted the value of interdisciplinary perspectives when designing culturally responsive STEM curriculum.

The team also recognized that developing these instructional materials is an ongoing process. Locating historically accurate examples, understanding their cultural significance, and translating them into chemistry appropriate for first-year students requires continued collaboration and scholarship.

- Students—especially focal students'—reflections < Exit slips, surveys, meet and greet :: What was learned during this research lesson? How did you learn? In what ways was the lesson challenging?>

Student reflections indicated that the lesson broadened students' understanding of chemistry as a human endeavor while increasing curiosity about the discipline.

Analysis of the exit tickets (n = 18) revealed evidence across the three targeted Rehumanizing STEM dimensions:

Mirrors (Identity & Access)

More than half of the students (56%) described chemistry as something that is accessible and present in everyday life rather than limited to laboratories or professional scientists.

Common themes included:

- "Chemistry is everywhere."
- "Chemistry can be done anywhere."
- "Not just in labs."

Representative student comments included:

> *"Chemistry can be done anywhere."*
>
> *"Many kinds of people, not just scientists."*
>
> *"Today made me less scared of chemistry."*

These responses suggest that students began to see chemistry as something that is relevant to their own lives and communities, supporting the lesson's goal of increasing students' sense of belonging within chemistry.

Windows (Culture & History)

Nearly half of the students (44%) explicitly referenced learning about chemistry through different cultures and historical traditions.

Students frequently described:

- learning about chemistry from different cultures,
- expanding their ideas about who contributes to scientific knowledge,
- recognizing Indigenous and community knowledge as valuable forms of scientific understanding.

Representative comments included:

> *"Chemistry came from many different cultures."*
>
> *"It expanded my idea of who does chemistry."*
>
> *"They didn't know about chemistry, but they knew the process."*

These reflections indicate that students began to recognize chemistry as a global and collaborative human endeavor rather than a discipline developed by only a few individuals or cultures.

Curiosity Shift

The strongest outcome observed was an increase in student curiosity.

Eighty-three percent of students expressed greater interest in chemistry following the lesson.

Repeated themes included:

- "More curious"
- "More engaged"
- "Want to learn more"

Representative student comments included:

> *"This makes me want to look more in depth."*
>
> *"I want to know what other things chemistry can be in."*
>
> *"I definitely got more curious."*

These responses suggest that introducing chemistry through culturally grounded stories not only broadened students' perspectives but also increased motivation to continue learning chemistry.

Overall Student Reflection

Student reflections suggest that the lesson successfully reframed chemistry as a discipline that is accessible, culturally situated, and deeply connected to everyday life. Rather than viewing chemistry solely as a collection of concepts discovered by a small number of scientists, many students recognized that chemistry has been practiced by communities around the world through observation, experimentation, innovation, and shared knowledge.

While students demonstrated strong engagement with the stories and expressed increased curiosity, the lesson also revealed that some case studies contained chemistry concepts that were more advanced than expected for first-semester General Chemistry students. Future iterations of the lesson will simplify the scientific explanations while preserving the historical and cultural narratives that supported students' engagement, curiosity, and sense of belonging.

- Administrator(s) reflection < What teacher and student learning was noticed? How does this inform site or district initiatives? >

The research lesson demonstrated that culturally grounded examples can be integrated into rigorous General Chemistry instruction while promoting student engagement and participation.

Administrators noted that the lesson aligns with institutional priorities related to student success, belonging, inclusive excellence, and active learning. The collaborative lesson study process also served as a model for cross-campus faculty learning and curriculum development.

The team concluded that this work has the potential to inform future efforts to redesign introductory STEM instruction so that students encounter chemistry not only as a body of scientific knowledge but also as a rich human story.