Inclusive STEM Environments Inside & Outside the Classroom

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THE SHARING CYCLE OF SCIENCE LEARNING
Connecting Chemistry at Tribal Colleges to Tribal History, Language, and Culture

Mark Griep, PhD, University of Nebraska
with facilitators
Beverly DeVore-Wedding, PhD, Adams State University
Jessica Periago, PhD candidate, University of Nebraska-Lincoln
Abstract

...Dr. Mark Griep shows us how to apply an ethnoscience approach to introductory STEM courses by describing his team’s partnership with two tribal colleges and their work indigenizing chemistry laboratories.
A. Introductions

B. Workshop Outline
1. NSF Grant goals and outcomes; Tribal Colleges and Tribal Sovereignty
2. Interconnectedness and Ethnoscience
3. Selected chemistry lab experiences
4. Chemistry lab gratitude
Introductions
1. What is your State?
2. What do you teach (or why are you attending)?
National Need: American Indian students are underrepresented in all science and engineering fields by almost 50%. At the same time, the fastest growing occupations for the past half century require knowledge of science and mathematics.

Local Need: NICC had not offered a chemistry course in the past five years and LPTC’s chemistry enrollment was consistently low at 1 to 4.

Goal: Create sustainable chemistry laboratory experiences at NICC and LPTC. An enrollment of 6 is considered sustainable at both.

Hypothesis: American Indian students will be more inclined to engage and persist in chemical education when lessons and laboratory activities are framed within the context of community-relevant topics because of the students’ strong sense of kinship and place.

Objectives: see elsewhere

Evaluation: Mixed methods to learn about the attitudes and engagement of the tribal college students, faculty, and administrators.
The Sharing Cycle of Science Learning

Little Priest Tribal College

Janyce Woodard  Hank Miller  Bev DeVore-Wedding
Tribal Colleges

2014 Enrollment from Cappex.com

Griep, DeVore-Wedding, Woodard, Miller (2016) Great Plains Quarterly 36, 131-146
https://www.researchgate.net/publication/303953260
Project Objectives

The project can be visualized as a cycle of four objectives and outcomes:

1. A list of topics important to the community and greater dialog between the communities and their tribal colleges.

2. Connections between these community topics and any science discipline at the tribal colleges to provide context for inquiry-based science laboratory experiences and improved attitudes toward chemistry.

3. A sustainable, two-semester chemistry sequence at NICC in which the lecture and laboratory experiences are integrated and have a community focus through the use of the connections. The outcome will be an ability to use scientific tools to address community topics.

4. Dissemination of the laboratory experiences from NICC to LPTC, as well as from chemistry to other science courses at those colleges, and by raising awareness locally and regionally through workshops, outreach, and recruitment.
2. Interconnectedness of Community Topics

- Community Topics
- Holistic/Interconnectedness
  - Trust Lands
  - Environ. Racism
  - Economic Development
  - Factors of Disease
  - Current
  - New
  - Historical
  - Renewable Energy
    - Compressed
    - Wind
    - Solar
  - Wood Chips
  - Community Health
  - Genetics
  - GMO
  - Food Sources
  - Medicinal Plants
  - Ownership/Stewardship
  - Remediation Programs
  - Natural Disasters
  - Water Sheds
  - Policy
  - Testing
  - Landfills
  - Solids
  - Hazardous
  - Animal Habitat
  - Waste
  - Natural Resources
  - Soil, Land
  - Forests
  - Fire Management
  - Ecosystems
  - Climate Change
  - Historical Knowledge
  - Trends
  - Air Quality
  - Biopiracy
  - Water Sources
  - Remediation Programs
  - Natural Disasters
  - Water Sheds
  - Policy
  - Testing
2. Interconnectedness of Community Topics

Community Topics (Holistic/Interconnectedness)
Renewable Energy (Solar, Wind, Compressed Wood Pellets)
Community Health (Genetics, GMOs, Food Sources)
Medicinal Plants
Ownership/Stewardship
Water Sources (Natural Disasters, Remediation Programs, Metals, Testing, Policy, Watersheds)
Air Quality
Biopiracy
Climate Change (Trends, Historical Knowledge, Ecosystems)
Natural Resources (Soil, Land, Forests, Fire Mgmt)
Waste (Hazardous, Landfill)
Animal Habitat
Oral Histories
Economic Development (Environmental Racism, Trust Lands)
Food Sovereignty (added in 2017)
Advisory Board Recommendations (2016)

1. Continue to indigenize the curriculum
2. Find more ways to connect to all stakeholders
3. Hire more Native faculty and TAs

Advisory Board Recommendations (2017)

1. Add “Food Sovereignty” to the Community Topics
2. Regarding enrollments, remember that the Native Worldview is that we are all connected — When one succeeds, we all succeed
3. Start a monthly Science Night. Invite native scientists as guests to speak and interact with the students, faculty, and community
4. Form a science club — SACNAS or AISES
2. Interconnectedness of Community Topics

Community Topics (Holistic/Interconnectedness)
Renewable Energy (Solar, Wind, Compressed Wood Pellets)
Community Health (Genetics, GMOs, Food Sources)
Medicinal Plants
Ownership/Stewardship
Water Sources (Natural Disasters, Remediation Programs, Metals, Testing, Policy, Watersheds)
Air Quality
Biopiracy
Climate Change (Trends, Historical Knowledge, Ecosystems)
Natural Resources (Soil, Land, Forests, Fire Mgmt)
Waste (Hazardous, Landfill)
Animal Habitat
Oral Histories
Economic Development (Environmental Racism, Trust Lands)
Food Sovereignty (added in 2017)
2. DENSITY

I. Objectives
   1. To measure mass of irregularly shaped materials.
   2. To measure the volume of irregularly shaped dry matter.
   3. To calculate the densities of native seeds, both bulk and true seed density.

II. Facts to Know
Density

   The density of an object is equal to its mass divided by its volume:

   \[ \text{density} = \frac{\text{mass}}{\text{volume}} \]

   which can also be written using symbols as:

   \[ \rho = \frac{m}{V} \]

   where \( \rho \) is the Greek letter rho.

   Different sets of units are used to specify density. Here is how they are related:

   \[ 1,000 \, \text{kg/m}^3 = 1,000 \, \text{g/l} = 1 \, \text{g/cm}^3 = 1 \, \text{g/mL} \]

   Density is not only useful for measuring purity and predicting buoyancy but also for useful things such as packaging requirements. It is used to determine purity because pure materials have uniform and characteristic density (Table 1). Buoyancy is the ability to float in liquid or air. A material with lower density will float above one with higher density. With regard to the design of packaging materials, the mass of the material determines how strong the packaging material needs to be, whereas its volume determines the size of the package.

   Many commercial products have irregular shapes so that we need to distinguish bulk density \( (\rho_{\text{bulk}}) \) from mass density \( (\rho_{\text{mass}}) \). If we consider objects such as dried peas, their
3. Lab Manual

III. Community Connection
    Density is a unique measurement of a known substance. For example, one can identify pure gold based on its density. Food is more complicated but knowing the density of foods may come in handy. Review the community topics (Appendix B) to identify possible community connections.

IV. Safety Concerns
    1. Wear eye protection at all times.

V. Materials
    **Equipment**
    - Electronic balances
    - Graduated cylinders, 3-6 100 mL
    - Weighing paper or boats
    - Internet or scientific calculator

    **Samples and Reagents**
    - Variety of dried native corn kernels
    - Popcorn kernels (seeds)
    - Dried beans: pinto, fava, lima, green
    - Dried squash seeds: acorn, butternut

VI. Procedures:
    We are thankful for the bounty of food that we are able to use the corn, beans, and squash seeds in this lab.

A. Bulk Density
    1. Collect your equipment and materials, including your safety gear. Each person or group will select one corn sample, one dried bean sample, and one squash seed sample.
    2. Turn on the electronic balance and tare to 0.0 g. Mass an empty, dry weigh boat. Record
3. Lab Manual

First Semester Chemistry Experiments
1. Safety, Equipment, and Measurement
2. Density
3. Chocolate Density
4. Liquid Density
5. Period Table of Videos
6. Water Quality Analysis

Proposal for End of First Semester Project
7. Water Purification
8. Soil Quality Analysis
9. Herbicide Bioassay
10. Plant Pigments: Extraction, Chromatography, & Spectrometry
11. Endothermic and Exothermic Reactions — Hot & Cold Packs
12. Molar Mass of Butane in Lighters
13. First Semester Creative Project and Presentation

Second Semester Chemistry Experiments
14. Acid & Base Indicators
15. Ascorbic Content in Traditional Native Foods
16. Qualitative Tests for Alcohols
17. Qualitative Tests for Aldehydes and Ketones
18. The Effect of Alcohol on Betacyanin Extraction
19. Preparation and Identification of Esters

Proposal for End of Second Semester Project
20. Synthesis of Aspirin and Wintergreen Oil
21. The Science of Soap Making
22. Transesterification of Oils in Native Plants
23. Extraction of Caffeine from Yerba Mate
24. The Effect of Heat on Enzymes Found in Native American Fruits
25. DNA Extraction
26. Second Semester Creative Project and Presentation
Indigenous Plant Pigments
Atomic Structure of Neon
Painted Using Watercolors Made from Indigenous Nebraska Plants
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17 State Abbreviations the same as Chemical Element Abbreviations

Al = Alabama & Aluminum
Ar = Arkansas & Argon
Ca = California & Calcium
Co = Colorado & Cobalt
Fl = Florida & Flerovium
Ga = Georgia & Gallium
In = Indiana & Indium
La = Louisiana & Lanthanum
Md = Maryland & Mendelevium

Mn = Minnesota & Manganese
Mo = Missouri & Molybdenum
Mt = Montana & Meitnerium
Nd = North Dakota & Neodymium
Ne = Nebraska & Neon
Nh = New Hampshire & Nihonium
Pa = Pennsylvania & Protactinium
Sc = South Carolina & Scandium
Native Plants:

I. Purpose

The students will learn a simple extraction method of pigments from natural plants—leaves, fruits, and flowers. These extracts will provide materials for a paper chromatogram and then the following week will use absorption spectrometry to separate and identify the different pigments present in their extracts. The students will also set up another serial dilution of the extracts.

Native plants were essential for food and textile dyes prior to discovering the ability to synthesize dyes. Chromatography and spectrometry are tools for identifying individual compounds, as in this lab, the different pigments present in the plant extracts.

Comparison of the two methods gives students an understanding that the peaks in an absorption spectrum are different compounds with the chromatogram providing a visual representation of the different pigments/compounds.

These extracts may be refrigerated and saved for a textile-dying lab. Add a few drops of isopropyl alcohol to prevent the growth of bacteria and/or fungus.
4. Chemistry Lab Gratitude

Giving Thanks: We are thankful for the bounty of food that we able to use the corn, beans, and squash in this lab
Thank You!

**Presenter**
Mark Griep

**Breakout Facilitators**
Beverly DeVore-Wedding
Jessica Periago
“There's a Much Bigger Picture”: How STEM Student Organizations Can Catalyze Inclusivity for Undergraduate Women in Engineering

Annie M. Wofford, Ph.D. | annie_woff
Postdoctoral Scholar, Northern Arizona University
AAAS-IUSE Workshop | March 30, 2022
Today and everyday, I learn from and celebrate the work of the Indigenous peoples of the lands I settle in my research and teaching, so that future generations can thrive.

I honor the legacies of the original peoples of this land—past, present, and future.
Objectives

Overview of Workshop
Objectives

- Understand the **discriminatory spaces that women navigate** in engineering
- Describe how **student organizations can be spaces of resistance** for women and in engineering
- Reflect and **discuss commitments to disrupt inequitable policies or practices** in your local STEM environments
Overview

- Background and Context
- Examples from current study
- Interactive Google JamBoard
- Discussion and Q&A
Dr. Katie N. Smith, Dr. Annie M. Wofford, and Dr. Breann Branch

We thank ACPA Foundation for their funding support of this empirical study.
Research Study

Overview of Study and Example Findings
% Bachelor’s degrees across all fields earned by women in 2018-2019 (NCES, 2020)

57%

% Bachelor’s degrees in engineering earned by women in 2018 (NSF, 2021)

22%
Women’s sparse representation is consistently associated with oppressive structures that threaten their access to and success in college engineering (Corbett & Hill, 2015).

Outnumbered in many settings, women may face challenges in cultivating an “engineering identity” and feeling like they belong in the discipline / industry (Hatmaker, 2013).
Guiding Research Question

How do undergraduate women make meaning of their engineering identity within STEM student organizations?
Science Identity

Competence
Understanding scientific concepts

Performance
Social ways of exhibiting scientific practices

Recognition
Self-identification and external identification as a “science person”

Engineering identity recognition (Rodriguez et al., 2019)

Carlone and Johnson (2007)
Methodology and Methods

- Feminist phenomenology
  - Focused our study on how social reality, individual perceptions, and meaning making were affected by gender (Garko, 1999)

- Larger study about women’s internships in engineering
  - One research institution on the west coast
  - Recruitment in spring 2021, through STEM student organizations
  - Written timeline
  - One interview, 60-min.
Meet the Participants

- 24 participants, all undergraduate women in engineering

Types of student orgs:
- Content (18 participants)
- Identity (12 participants)
- Humanitarian or leadership (7 participants)
Findings Overview

- Seeing oneself as an engineer: “I have a place here in engineering”
- Possibility models in peers and a critical mass: “She really broke our own stereotypes”
- Being recognized as an engineer: “They hired me immediately”
Seeing oneself in engineering

- Women noticed organizations’ actions to create inclusive opportunities, and first impressions had a lasting impact on how participants recognized themselves as engineers.
- Participants revealed how they felt “more welcomed” and “a lot more comfortable” in their organizations than any other curricular environment.
I am the only CS major on the board because I was electrical engineering, and I'm not anymore... even though I'm not in the same major, I like that this community is very supportive, that we are all women in STEM. We are all having the same problems, and we're all going through the same struggle of finding internships, of going through our classes, of trying to determine what we want, and that has helped.

-Grace, an Asian woman who left electrical engineering for CS
Possibility models in peers and a critical mass

- Seeing advanced peers be themselves prompted women to feel they “didn’t really have to hide a part of who I was”

- Multiple women spoke about the same peer as a possibility model of agency and gender presentation in engineering (e.g., ”bright pink suit”)

- A critical mass of women in organizations made participants aware of how much easier it was to have their voice heard
Personally, all of the building I’ve done prior to college has been mostly independent, so it’s really nice to actually be in a group and develop together and learn from each other since we’re all developing different features and we’re all piecing that together. Overall, I think the collaborative environment within the communities I’m a part of has definitely contributed a lot.

-Alana, a Filipina woman majoring in CS
Being recognized as an engineer

- Organizations provided women space to access professional opportunities, acting as a vehicle of social capital

- Women were recognized as emerging engineers, with “people in power” (e.g., professors, industry professionals) recognizing their contributions with a new sense of legitimacy

- Participants were more comfortable at career events hosted by their organization rather than the institution-wide events
I think the most meaningful [sources of recognition] are people in power...a teacher or a mentor sees it in a bigger scope...more relative to others rather than just relative to yourself

-Sydney, a white woman majoring in bioengineering
Google JamBoard for a Reflexive Pause

We commit to reflecting openly, honestly, with courage and accountability.

We prioritize safety over comfort, learning over perfection.

We recognize and are attuned to the power dynamics that may be present in this space.
In what ways have you witnessed or personally experienced gendered, racialized, or otherwise inequitable learning environments through your participation in higher education?
Our Study’s Implications for Practice

- Practitioners can help student leaders craft inclusive recruitment policies and community building strategies.

- Institutions can create opportunities for countercultures of organizations to become dominant cultures of engineering (e.g., institutional training and accountability for faculty to draw from feminist perspectives on ethics of care as one starting point).
Takeaway

There is great power in reflexively considering exclusionary norms in curricular STEM spaces, and it is crucial that faculty, staff, and policymakers use their discretionary power to change broader norms.
Discussion Questions

- What component of a STEM program, policy, or practice will you commit to evaluating for equity-minded change?

- How can lessons from women’s experiences in student organizations contribute to your evaluation process?
Thank you!

Any questions?

You can find me at @annie_woff and annie.wofford@nau.edu
Facilitated Breakout Rooms:

1. Navigate to the bottom of your screen and click “Breakout Rooms” button
2. Self-select into your breakout group based on your topic interest and last name

Note: If you do not see the Breakout Rooms button, please post in the chat to ask to be placed in a breakout room.
Discussion Breakout Room Recap
Thank you for attending!

Slides and recording will be available in the coming weeks.

We value your feedback, please take a few minutes to complete the survey.