Developing Students To See Themselves As STEM Thinkers And Learners

Oct 15, 2022

There are $6.022 \times 10^{23}$ ways to be good at chemistry
Welcome!

Agenda for today’s talk:

1. Introduction and our story
2. Stereotypes about Brilliance + Faculty Mindset
3. STEM Learning Community
4. Data Tasks and Student Outcomes
5. Closing Vignette
College of Marin—Paul Daubenmire, Hien Nguyen, Jennifer Claesgens
Diablo Valley College—Cory Antonakos, Ellen Beaulieu, Erin Palmer
Sonoma State University—Carmen Bustos-Works, Jennifer While-Lillig, Chase Clark
University of California-Berkeley—Angy Stacy, Michelle Douskey, Alexis Shusterman
“Some of these students just don’t deserve to be here.”

“You’re going to fail because you don’t belong here.”

“Can you believe that my students don’t know this?”

-Faculty at our institutions
Stereotypes About Brilliance Exclude Most of our Students

Leslie et al., 2015; Leonardo & Broderick, 2011; Nasir, Snyder, Shah & Ross, 2012; McGee & Martin, 2011

Carlone, 2004; Carlone et al., 2011
Science taught in classrooms incongruent with science as it’s practiced

School Science
- Body of known information and problem solving skills
- Content available to memorize
- Static
- Individualized learning

Science in Practice
- Set of practices for developing explanatory models
- Iterative, messy, creative process
- Collective sense-making

Potential for more inclusive meanings of science. (Rosemond, S.N. et al. 2020)

Carlone, 2004; Redish & Hammer, 2009; Sevian & Talanquer, 2014; Talanquer, 2015
“I’m a drop the class, I think. Yeah please, I think science isn’t for me. Like, I just don’t feel smart enough to continue.”  -Kristina

3 weeks into the semester

"When I was in my country, I did not want to go to school because I believed that I was a bad student. At COM, I'm discovering that I'm actually a good student, and I can still dream for a better future even though I'm not in my 20s anymore, and I have kids I need to provide for."
STEM Learning Community Initiatives

- “Professor is In” Office Hours
- Embedded Peer Tutors / Peer Mentors
- STEM Speaker Series
- Internship/Scholarship workshops (14 NASA & NSF acceptances)
- Collaborations with existing learning communities, community organizations (AAUW), Conference for Undergraduate Women in Physics (CUWiP)
How can we change the way we teach chemistry to support rich learning and new meanings about who counts and what counts as “good” at science?

Group-worthy Data Tasks

- Students do science
- Students benefit from thinking together
- Students have many opportunities to experience themselves as “smart” in science
What is a “data task?”

- Students investigate a big question by **doing science** with data
- Lets students see themselves as **competent chemical thinkers**
- Includes **multiple entry points** and opportunities to make connections to facilitate **working together**
- **One piece** of achieving our goal

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**Why do some solutions conduct electricity and others do not?**

<table>
<thead>
<tr>
<th>Formula</th>
<th>Molarity</th>
<th>Bonding</th>
<th>Lightbulb</th>
<th>Conducts?</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaCl(aq)</td>
<td>0.010 M</td>
<td>ionic</td>
<td>lights</td>
<td>yes</td>
</tr>
<tr>
<td>HCl(aq)</td>
<td>0.010 M</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Examples of Chem Avengers’ Data Tasks

- **Arsenic**
  - 33 protons
  - 42 neutrons
  - Tends to gain or share 3 electrons
  - Atomic radius: 115 pm

- **Aluminum**
  - 13 protons
  - 14 neutrons
  - Tends to lose 3 electrons
  - Atomic radius: 125 pm

- **Carbon**
  - Hard, clear solid (diamond)
  - Nonmetal or soft, black solid (graphite)
  - Metalloid
  - Does not react with oxygen
  - Found in CH₄ gas

- **Silicon**
  - Moderately hard, silvery solid
  - Metalloid
  - Reacts very slowly with oxygen
  - Found in SiH₄ gas
Data tasks in action

Course: Introductory Chemistry
Institution: Community College
Modality: Online

Video link: https://www.youtube.com/watch?v=vvXqzCatjg0
Shift Away From How Students Used to Think:
- Chemists are naturally smart
- Chemistry is gibberish and doesn’t make sense
- Chemistry is only math and problem solving
- Chemistry is scary

Shift Away From Chemistry Not Making Sense:
I absolutely hated chemistry. To me, chemistry was too much to handle, abstract at times yet precise and well calculated at others. It just didn’t make sense.

How can we measure the shift in student mindset?

Shift Towards Seeing Chemistry as Understandable
"After exploring this class I realized chemistry can be understood as long as you put those big fancy words into tiny chunks."

Shift Towards Seeing Learning Requires Peers:
"Second, I learned that science is a subject that can be learned by teamwork. If I felt difficulty when I was in class, at first I struggled to solve myself. But I realized debating or asking each other is more helpful to learn faster and remember the concept longer."

Shift Towards
Table 3. GPA Data from Introductory Chemistry at SSU from 2019–2020

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Spring 2019</th>
<th>Fall 2019</th>
<th>Spring 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Students, N</td>
<td>30</td>
<td>31</td>
<td>27</td>
</tr>
<tr>
<td>USM&lt;sup&gt;b&lt;/sup&gt; GPA&lt;sup&gt;c&lt;/sup&gt; Gap, GPA units</td>
<td>0.21</td>
<td>0.07</td>
<td>−0.76</td>
</tr>
<tr>
<td>USM&lt;sup&gt;b&lt;/sup&gt; Students, N</td>
<td>15</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>NUSM&lt;sup&gt;d&lt;/sup&gt; Students, N</td>
<td>25</td>
<td>21</td>
<td>17</td>
</tr>
<tr>
<td>USM&lt;sup&gt;b&lt;/sup&gt; GPA&lt;sup&gt;c&lt;/sup&gt;, GPA units</td>
<td>1.93</td>
<td>2.03</td>
<td>2.81</td>
</tr>
<tr>
<td>NUSM&lt;sup&gt;d&lt;/sup&gt; GPA&lt;sup&gt;c&lt;/sup&gt;, GPA units</td>
<td>2.14</td>
<td>2.10</td>
<td>2.05</td>
</tr>
<tr>
<td>DFW&lt;sup&gt;e&lt;/sup&gt; rate for USM&lt;sup&gt;b&lt;/sup&gt; Students, %</td>
<td>33</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>DFW&lt;sup&gt;e&lt;/sup&gt; rate for NUSM&lt;sup&gt;d&lt;/sup&gt; Students, %</td>
<td>40</td>
<td>24</td>
<td>30</td>
</tr>
</tbody>
</table>

<sup>a</sup>See ref 4. <sup>b</sup>USM, underserved minority student. <sup>c</sup>GPA is the grade-point average on a scale of 0–4. <sup>d</sup>NUSM, nonunderserved minority student. <sup>e</sup>DFW indicates a final course grade of “D” (GPA = 1.0), “F” (or “fail”, GPA = 0), or Withdrawn from the course.
Success rates for introductory chemistry students at DVC taught by the same instructor

<table>
<thead>
<tr>
<th>Category</th>
<th>Not using data tasks</th>
<th>Using data tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial aid</td>
<td>156</td>
<td>50</td>
</tr>
<tr>
<td>recipients</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female students</td>
<td>173</td>
<td>45</td>
</tr>
<tr>
<td>Hispanic students</td>
<td>90</td>
<td>21</td>
</tr>
<tr>
<td>All students</td>
<td>305</td>
<td>79</td>
</tr>
</tbody>
</table>
Success rates for Introductory Chemistry students at DVC

- Financial aid recipients: Not using data tasks (n = 188), Using data tasks (n = 88)
- Female students: Not using data tasks (n = 215), Using data tasks (n = 92)
- Hispanic students: Not using data tasks (n = 103), Using data tasks (n = 53)
- African American students: Not using data tasks (n = 17), Using data tasks (n = 3)
- All students: Not using data tasks (n = 354), Using data tasks (n = 168)
The Story Continues...

The upper division chemistry elective course at Sonoma State in Fall 2019 was focused on student-designed data tasks for intro chem students (taught during the same semester)

Topics taught: Growth mindset, Innate abilities, Gender bias
Tools used: Reflection, Skill Trackers, Writing to Learn
Capstone: Developing curriculum project

During the class, students developed interest in working with intro learners and in how to design multiple entry points into an experiment.
During the Semester, Students will learn chemistry and about themselves.

### Overall Project Structure

<table>
<thead>
<tr>
<th>Data Tasks Chemistry Curriculum</th>
<th>Matter Understanding Properties</th>
<th>Change Predicting Change</th>
<th>Measurement Measuring Matter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Student Mindset Shifts</strong></td>
<td>Science Skills Development Tracker</td>
<td>Scientist Spotlight (bouncing back from setbacks)</td>
<td>End of term reflection paper</td>
</tr>
</tbody>
</table>

#### Faculty Development Workshops

1. Sense of Belonging
2. Why Use Data Tasks
3. Promoting Teamwork
4. Launching and Closing a Lesson
5. Summative Assessment Strategies
Conclusion + Q&A

We’re happy to answer any questions y’all might have!

Here’s how to reach us:
Chemavengers101@gmail.com

Summer institute for faculty
July 24-28 2023 at UC Berkeley!