‘Scientists Like Me’: Using Culturally Relevant Information Literacy Instruction to Foster Student STEM Identity

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Abstract

In this case study, two librarians reflect upon our efforts to design STEM-focused information literacy instruction for undergraduate students at an R1, land grant university. Designed around the principles of culturally relevant pedagogy, our curriculum integrates community-focused and regionally specific topics reflecting our students' lived experience, features the work of scientists from diverse backgrounds, and fosters discussions about equity in the library classroom. Our experience shows that this approach can help foster STEM identity development in students while strengthening inquiry-based learning through information research.

Keywords: STEM Identity, Culturally relevant pedagogy, Information literacy, First year seminar, Environmental justice

Recommended Citation:

Introduction

Despite decades of research focused on broadening participation in the science, technology, engineering, and math (STEM) workforce, women and racial/ethnic minorities continue to be underrepresented in STEM relative to the US population (Fry et al., 2021). Disproportionate attrition of diverse students from STEM majors continues to be one of the driving forces behind this disparity (van den Hurk et al., 2019). Research indicates that undergraduate students from underrepresented minority (URM) groups, historically comprised of African Americans, Native Americans, Alaskan Natives, Native Hawaiians, and non-white Latinx students, are equally likely to pursue STEM disciplines as their peers. However, gaps persist in the retention rates of URM students and degree completion rates in these fields (Estrada et al., 2016; Lane, 2016; van den Hurk et al., 2019).

Education researchers have identified various factors contributing to students' persistence in the STEM fields ranging from familial expectations to academic support services, participation in undergraduate research programs, involvement in STEM-related student organizations, and institutional recognition (Cromley et al., 2016; Fakayode et al., 2014; Gasiewski et al., 2012; Guo et al., 2021; Tibbetts et al., 2016; Xu & Lastrapes, 2021). There are likewise various ways in which educators can support student persistence—including how to foster STEM identity amongst students vulnerable to attrition.

Students who develop a strong STEM identity “think about themselves as science learners, as someone who knows about, uses, and contributes to science” (Center for the Advancement of Informal Science Education, 2018). STEM identity formation has been shown to play a decisive role in students’ success in educational environments, as well as their career goals (Estrada et al., 2016; Robinson et al., 2019; Taheri et al., 2018).

The impact of faculty, teaching assistants, peers, and mentors on URM student STEM identity formation has been extensively studied (Batz et al., 2015; Killpack & Melón, 2016; Oliver et al., 2021; White et al., 2021; Wilson et al., 2012). However, the role of librarians is often overlooked. As essential partners in the academic success of our students, it has become increasingly clear that librarians must engage in pedagogical practices that help contribute to students’ sense of belonging in the STEM disciplines. The following case study reflects efforts by a team of faculty and information professionals that exemplifies ways in which librarians can contribute to STEM identity formation to support students from historically underrepresented communities in pursuing STEM career pathways.

Institutional Context

Our institution is a public, land-grant R1 research university in northern California. Our undergraduate enrollment is typically thirty-two thousand students; the overwhelming majority—82%—are California residents. The school is known for its STEM programs, especially in health sciences, agriculture, and environmental science. 54% of undergraduates declare majors in the STEM disciplines, compared to 46% who declare
non-STEM majors (University of California Office of Institutional Research and Academic Planning, 2023).

In AY 22-23, students from historically underrepresented minorities (URM) comprise 27% of the undergraduate population and approximately 24% of STEM majors; 31% of undergraduates and 33% of STEM majors are first-generation students, while 59% of undergraduates and 54% of STEM majors identify as women. URM students made up 23% of undergraduates awarded Bachelor’s degrees in AY 21-22 while making up 20% of students awarded undergraduate degrees in the STEM fields. This data indicates that our university shows similar levels of STEM attrition as comparable institutions; URM students enroll with the intention of obtaining STEM degrees (i.e., they “think about themselves as someone who knows about, uses, and contributes to science”), but at some point during their educational experience, no longer see themselves someone who will contribute to science as a STEM professional.

One of the primary barriers for undergraduate students pursuing STEM degrees is introductory courses. The Sloan Equity and Inclusion in STEM Introductory Courses (SEISMIC) Collaboration, a project involving R1 universities that research interventions to advance equity and inclusion in STEM education, describes the problem: “At large research universities, these courses are taught to hundreds or even thousands of students a term…They are often taught in industrial ways, with little recognition of or response to the diversity of students. As a result, outcomes disappoint everyone involved” (SEISMIC, n.d.). The gatekeeping function of these courses disproportionately impacts women and students from historically marginalized groups. A recent study that examined over 110,000 student records indicates that “The probability of obtaining a STEM degree for a STEM-intending white male student with average academic preparation who receives grades of C or better in all introductory courses is 48%. In contrast, for an otherwise similar URM female student, the probability is merely 35%” (Hatfield et al., 2022).

Our institution is a participating member in the SEISMIC Collaboration project, which connects staff and faculty working to reduce equity gaps in introductory STEM courses where we see disproportionate attrition amongst URM students (National Center for Science and Engineering Statistics, 2023). Organic chemistry is among the most challenging courses for many STEM majors, with nationally reported attrition rates ranging between 15% to over 30% (Elbulok-Charcape et al., 2021; Harris et al., 2020). At our institution, the organic chemistry series often serves as a ‘gate-keeping’ course requirement for students pursuing degrees in the most popular majors, including biological sciences, neurobiology, molecular biology, and animal science.

This shared interest amongst undergraduate faculty, academic staff, and library professionals participating in SEISMIC initiatives and programming at our institution inspired a collaborative project to develop educational materials that promote a “sense of belonging” in STEM students and foster their science identity. In AY 21-22, our team designed a seminar course for undergraduate students to engage with, inform and help to shape the educational materials we developed. This case study presents our approach to creating the seminar course materials, the ways in which students enrolled in the seminar interacted with these materials, and how their feedback helped to shape
the implementation of these materials in both organic chemistry and the library classroom.

**Objective**

Our team included an organic chemistry professor, a library staff member with a doctorate in molecular biology, a STEM librarian, and our Library’s 2020-22 Diversity Fellow (working as a librarian in the department for undergraduate student services). We hypothesized that STEM identity formation for students from historically marginalized communities might be hampered by the lack of representation of role models in STEM fields (Aranda et al., 2021; Chakraverty, 2022; Morton & Parsons, 2018; Rodriguez et al., 2019; Schinske et al., 2016; Smith et al., 2014; Yonas et al., 2020). Our goal was to create lesson plans highlighting the work of scientists from historically marginalized backgrounds, whose research demonstrated connections between concepts explored in the organic chemistry curriculum and students’ lived experiences. We hoped these lesson plans would help affirm the diversity of the STEM classroom, both in terms of the students themselves, and the science and scientists they learn about.

The STEM Librarian joining this team was motivated by the opportunity to discover scientists and scientific topics that reflect local communities in California to incorporate into her information literacy instruction. As a practitioner of culturally responsive teaching, she recognized the value of using shared cultural referents to increase the relevancy of teaching and learning, so students engage with information research in meaningful ways. Because many of the STEM faculty she works with are unsure about how to teach scientific topics and methods through an equity lens, this project presented an ideal opportunity to demonstrate the ways in which our students recognize the intersections of science and social justice from their own lived experiences. Validating those experiences and highlighting the work of scientists seeking to address these systemic inequities helps students to see connections between their prosocial motivations and their scientific coursework.

For the Diversity Fellow, this project was a unique opportunity to help find solutions to the retention issue among both URM students in STEM – and with Black and African diaspora students at our institution more broadly – that are of particular concern as a Black librarian. Although her subject area specialization is in the arts and humanities, she recognizes that STEM-related topics are relevant to students regardless of major and that all students can benefit from understanding and discussing STEM topics and connecting them to their lived experiences as they address issues in their communities. The proposed seminar was an opportunity to apply the principles of culturally relevant pedagogy in an information literacy context beyond the traditional one-shot instruction session.

The project coincided with the development of a new strategic plan for the library, centered around diversity, equity, and inclusion. As a member of the Strategic Plan Steering Committee, the Diversity Fellow felt that the project reflected the values expressed in Priority 2: “Empower diverse campus communities to succeed via education, public engagement, and community partnerships,” and in particular, Goal
2.7, “Promote the adoption of best practices for culturally relevant teaching” (University of California Davis Library, n.d.).

**Literature Review & Theoretical Framework**

Research in persistence to STEM degree completion highlights a strong association between undergraduate students’ STEM identities (i.e., the extent to which they see themselves as someone “who knows about, uses, and contributes to science”) and their intentions to continue pursuing STEM careers (Dou et al., 2021; Guo et al., 2021; Xu & Lastrapes, 2021). The concept of STEM identity is tied to theoretical frameworks for understanding the psychological and developmental processes of identity formation more broadly. Social identity theory (SIT) asserts that an individual’s identity forms in relation to and through interactions with others (Tajfel & Turner, 1979; Turner & Oakes, 1986). STEM identity formation is, therefore, inherently social in nature—students’ experiences in educational settings, including their interactions with instructors, classmates, and materials, will affirm or deny their self-conception as someone “who knows about, uses, and contributes to science” (Kim et al., 2018).

Intersectionality is a further analytical framework of identity formation developed by Black feminist scholars which acknowledges that an individual may possess a multitude of social identities that combine in ways that result in experiences of discrimination or privilege (Collins, 2015; Crenshaw, 1989). As individuals categorize factors of their identity, they situate themselves within groups that align with those aspects of their identity. STEM students who identify as members of historically marginalized groups necessarily navigate the intersections of their science identity with a variety of factors, including race, ethnicity, gender, sexuality, socio-economic status, religion, or disability. The question of how educators can ensure that students continue to see themselves as belonging to a community of scientific practitioners in alignment, rather than in tension with their other social identities, has been a focus in contemporary STEM education research (Dou & Cian, 2022).

Education scholars began researching STEM identity formation utilizing the framework proposed by Carlone and Johnson (2007), which suggests three areas of analysis: competence (in scientific knowledge), performance (demonstrated use of that body of knowledge), and recognition (as a person who contributes to scientific knowledge). Importantly, this framework recognizes that a student may be able to “perform activities that scientists do, and show competence in that performance, but may not be recognized as a ‘science person’ by others” (Kim et al., 2018). Students identifying as members of historically marginalized groups may find that their experience of positive aspects of their STEM identity is constrained by the realities of social prejudice and systemic discrimination.

The limitations of Carlone and Johnson’s framework have been addressed in subsequent scholarship emphasizing the social nature of identity formation—exploring the impact of who provides recognition and through what modalities. In conducting this literature review, we did not identify any research investigating the impact of academic librarians on STEM identity formation. However, given the role of academic librarians in supporting students' scientific research and providing information literacy
instruction, the librarians in this study situated ourselves within the constellation of educators who provide recognition to our students and affirm their identities as contributors to scientific knowledge.

Science education research now investigates a spectrum of social factors that influence STEM identity formation, (e.g., the impact of familial expectations, peer interactions, access to mentorship programs, and faculty advising), including the importance of students ‘seeing themselves’ in the curriculum. The inclusion of scientists who are also members of historically marginalized groups, the range of work scientists perform both in and outside the lab (intersectional identities), and the prosocial nature of scientific research, in educational materials is another form of recognition. Research has shown that students’ outcomes in STEM coursework improve when they can relate to their coursework and visualize its importance to their communities (Fuller & Torres Rivera, 2021; Siritunga et al., 2011). While organic chemical compounds are everywhere in our environment and have huge economic and societal impacts, this connection is not always made explicit in organic chemistry textbooks and learning materials (Zambrano et al., 2020). As a result, students often find course topics abstract, with little relevance to their lives (Rein & Brookes, 2015). This is why STEM educators have long recognized the importance of connecting abstract scientific concepts and invisible biochemical processes with students’ lived experiences through supplemental course materials, including labs, case studies, and assignments (Cann & Dickneider, 2004; Chamany, 2006; Chamany et al., 2008; Glaser & Carson, 2005; King et al., 2008; Knight et al., 2021; Kozlowski, 1983; Lieu & Kalbus, 1988; Marinez & Ortiz de Montellano, 1998; Tanner & Allen, 2007).

Utilizing culturally relevant examples can further motivate diverse students to persist in these disciplines (Maltese & Tai, 2011; Tanner, 2013). Culturally Relevant Pedagogy (CRP), first described by education researcher Gloria Ladson-Billings, is “a pedagogy that empowers students intellectually, socially, emotionally, and politically by using cultural referents to impart knowledge, skills, and attitudes” (Ladson-Billings, 1995). Geneva Gay expanded upon Ladson-Billings’s work by arguing that students’ lived experiences of culture and community should be embraced in the classroom rather than erased through white normative practices of ‘universalism’ in educational settings. Gay also asserted that “academic success and cultural consciousness are developed simultaneously,” and that incorporating diverse cultural referents improves learning outcomes among underrepresented students (2018). Characteristics of CRP in STEM education include valuing and validating students’ diverse backgrounds, using those differences as a strength in group work, using student-centered teaching strategies that encourage students to share lived experiences, as well as using inclusive curricular materials that reflect students’ intersectional identities (Favero & Van Hoomissen, 2019; Fuller & Torres Rivera, 2021; Hamstra et al., 2021; Jackson et al., 2016; Johnson & Elliott, 2020; McCarthy et al., 2020; Sanders Johnson, 2021; Siritunga et al., 2011; Stevens et al., 2016; Younge et al., 2021).

For that reason, educational reforms seeking to increase retention of URM students in the STEM fields often emphasize revising the curriculum both in terms of the cultural relevance of the learning materials (Horowitz et al., 2018; Johnson & Elliott, 2020; Tanner, 2013; White et al., 2021) and the extent to which the content itself offers cues
that increase students’ sense of belonging in STEM disciplines (Chakraverty, 2022; Clark et al., 2016; Gormally & Inghram, 2021; Herrmann et al., 2016; Perkins et al., 2018; Schinske et al., 2016; Sible et al., 2006). While the breadth of CRP efforts in STEM higher education is not always captured in the peer-reviewed literature, available case studies demonstrate the positive impacts of these curricular interventions.

Culturally relevant curricula can include a spectrum of topics and sociocultural frameworks. For example, food science and nutrition are fields replete with topics where students can draw parallels between their daily lives as well as see the inclusion of their cultural referents in the curriculum (Fuller & Torres Rivera, 2021; Meléndez, 2019; Sanders Johnson, 2021; Siritunga et al., 2011; Westenberg & Kopel, 2021; Wolpert, 2014; Yoshiyama et al., 2019). However, research has shown that URM students, especially female-identifying students, connect with materials that demonstrate how science can be justice-oriented. Materials that emphasize the prosocial value of science increase persistence in STEM disciplines for both URM and women (Allen et al., 2015; Boucher et al., 2017; Brown et al., 2015; Clark et al., 2016; Ford et al., 2021; Garibay, 2015; Jackson et al., 2016; McGee & Bentley, 2017; Smith et al., 2014; Steinberg & Diekman, 2018). In the context of chemistry education, green chemistry, environmental justice, and health equity have proven to be effective lenses to illustrate the connection between science and sociocultural issues (Ali et al., 2020; Astrof & Horowitz, 2018; Buckley & Fahrenkrug, 2020; Chamany, 2006; Gerdon, 2020; Hollond et al., 2021; Lane et al., 2023; Lasker & Brush, 2019; Posey & Lavik, 2021). In these examples, students experienced positive affirmation of their STEM identity, seeing themselves as members within a group that aligns with their prosocial values and motivations.

Ladson-Billings and Gay initially focused on K-12 education in their development of CRP, and over time it has been adopted in college and university settings. The 2012 Association of College & Research Libraries (ACRL) Diversity Standards signaled a desire within the profession to incorporate the principles of CRP into library instruction, but the reliance on one-shot instructional sessions has proved to be a challenge for academic librarians. The traditional one-shot session is limited by the librarian’s short-term connection with the students and a lack of familiarity with their cultural backgrounds, especially in diverse academic environments (Foster, 2018; Cowden et al., 2021). In addition, the lack of diversity within the profession contributes to a reinforcement of white cultural norms, as many academic librarians may lack training or experience in applying CRP in institutional settings that do not reflect the cultural values of their URM students (Quiñonez & Olivas, 2020).

Elizabeth Foster’s 2018 article “Cultural Competence in Library Instruction: A Reflective Practice” outlined a framework for incorporating CRP into one-shot instructional sessions, focusing on an ongoing process of reflection and self-assessment that positions student outreach and connection as part of an overall library instructional strategy. Cowden et al. expanded on Foster’s work by providing practical recommendations for culturally competent library instruction. Their framework focuses on preparation that includes reflection and awareness of implicit bias and cultural assumptions on the part of the librarian, communicating using clear language and active listening techniques, and using a facilitating approach that incorporates active learning rather than lecturing (2021).
Method

After conducting our literature review, we designed a framework for identifying potential topics to include in our lesson plans. First, the topics should be drawn from the organic chemistry curriculum—but also apply to a wider range of disciplines for use in information literacy instruction so that our lesson plans would be of use to both chemistry faculty and STEM librarians. Secondly, we wanted to connect the study of organic chemical compounds to ‘real world’ examples drawn from our California communities. We also wanted to highlight how these ‘real world’ examples demonstrate scientific evidence's efficacy in advancing healthier, safe, and inclusive communities.

It was also essential to highlight the contributions of diverse scientists whose work challenges stereotypes about the skills, attributes, and work environments necessary to achieving success in STEM fields (Gormally & Inghram, 2021; Schinske et al., 2016). We felt that these approaches—utilizing a diversity of ‘real world’ curricular examples; fostering discussions about inequity; countering stereotypes about who ‘does science’ and in what contexts—overlap and can be mutually reinforcing.

We also wanted to avoid the potential retraumatizing of URM students when addressing issues of environmental justice, health disparities, and systematic inequities. For example, during our literature search, we found an article outlining the history of the Flint Water Crisis as a ‘real world’ example instructors could use in chemistry coursework to discuss environmental justice. The accompanying learning materials in the article incorporated images of immiserated Black residents, juxtaposed with white scientists taking or analyzing water samples (Dingle, 2016). We suggest that educators instead use imagery that highlights the work of community members to organize and collect samples. Research suggests that for BIPOC populations, exposure to graphic imagery combined with lived experiences of discrimination can induce psychological harm reminiscent of post-traumatic stress syndrome (Katz et al., 2018). Instead, we directly tied the ways in which oppressive structures strategically disadvantage certain populations (Gilmore, 2011) with activist movements organizing within those communities using scientific research to seek justice.

First-Year Seminar course content selection criteria:

1. Culturally relevant (i.e., current news and events, popular culture phenomena, social media trends) and regionally specific curricular examples.
2. Prompt discussions about structural inequities
3. Counter stereotypes about who ‘does science’ and in what contexts
4. Balances lab, field, and community work
5. Provide pathways for future study on campus to promote institutional belonging
6. Identify local organizations to prompt immediate involvement and action

One of the challenges in developing a culturally relevant curriculum is that educators often do not reflect the same diversity as the students they teach. This is why it is essential to include students in the content creation process. We felt a non-exploitive way to collaborate with students as content creators would be through for-credit
coursework. This approach has been shown to benefit students engaged in content creation as project-based learning (Aranda et al., 2021; Favero & Van Hoomissen, 2019; Gal, 2020; Grieger & Leontyev, 2020). Collaboration with Library professionals provided additional opportunities to support students’ information literacy skills in navigating the research process while helping to identify topics for development (Jones & Seybold, 2016; Knight et al., 2021; Mitchell et al., 2017).

To this end, we designed a seminar course aimed at teaching scientific research and communication skills that thematically tied social justice concepts to organic chemistry. We modeled the use of culturally relevant educational materials by focusing on topics like environmental justice, workplace safety, opioid addiction, as well as health and food disparities. Students in this course applied our framework to identify and present on a topic of their choice, demonstrating an understanding of particular biochemical processes while also expressing compelling connections to social justice.

**Course Design**

At our institution, the First-Year Seminar (FYS) program is designed to give undergraduate students—especially first-year and incoming transfer students—a small-class experience focused on topics of interest that are not necessarily related to a major. Academic staff can teach in the program, provided a faculty member serves as the Instructor of Record. We were fortunate to have established precedence of librarians collaborating with faculty to teach in the FYS program.

Our seminar, “Humanizing Science with Community Narratives,” was taught in the Fall Quarter of 2021 with 18 students enrolled, and again in the Winter Quarter of 2022 with 13 students enrolled. Class demographics were similar in both terms and reflected the overall student population with regard to race and gender; one-third of the students were declared STEM majors, and nearly all were in their first year at the university. Due to the subject matter and the emphasis on connecting science to the lived experience of students in their communities, the course was designated as a Community Engaged Learning Seminar.

**Class Assignments**

- Participation (in-class activities) - 25%
  - In-class research sessions
  - Critical reading activity
  - Peer-feedback for presentations
- Weekly assignments (out-of-class activities) - 25%
  - Research Process Log entries
  - Discussion board prompts
- Final Project - 50%
  - Topic Selection (5%)
  - Initial Bibliography (10%)
  - Annotated bibliography (15%)
  - Topic Write-Up (10%)
  - Topic Presentation (10%)
As a one-unit course, we met once weekly for 50 minutes. Due to the 10-week timeframe of the quarter system, the class was tightly structured. Following the course introduction in the first session, Weeks 2-7 focused on scaffolded information literacy instruction connected to specific community issues and science-related topics. Each module during these six weeks highlighted the research of BIPOC scientists working in a related field, similar to the ‘Scientist Spotlights Initiative’ at the Science Education Partnership & Assessment Laboratory of San Francisco State University, which “aims to promote diversity and inclusion in science through the development, assessment, and dissemination of curriculum supplements that bring science role models to students in the context of learning science content” (Scientist Spotlights Initiative, n.d.).

During the Week 8 session, students had the opportunity to discuss their topics with our library staff collaborator, who has a background in molecular biology. Week 9 was devoted to in-class work time, with instructors available for assistance and suggestions for incorporating visual resources into presentations. For the final session in Week 10, each student gave a five-minute presentation to the class on their chosen topic.

“Humanizing Science Through Community Narratives” Course Outline

Each Canvas module during Weeks 2-7 was structured with learning goals, key terms, and pre-class materials (videos, articles, podcasts, and a scientist spotlight).

- **Week 2**
  - Information literacy focus: (P)researching research topics using background [reference] sources; narrowing research topics; identifying information needs.
  - Community Narrative topic: Tree Equity
  - Biochemistry connection: Phytoremediation
  - Scientist Spotlight: Dr. Eboni Hall, American Forests

- **Week 3**
  - Information literacy focus: Lateral reading, evaluating correlation vs. causation and research ethics.
  - Community Narrative topic: Nutrition fads and the dissemination of health research in the media
  - Biochemistry connection: Probiotics
  - Scientist Spotlight: Jessica Wilson, MS, RD, UC Davis Student Health & Counseling Services

- **Week 4**
  - Information literacy focus: Database search strategies (Boolean operators and search filters); searching for secondary literature.
  - Community Narrative topic: Prescribed burning in CA
  - Biochemistry connection: Fire ecology, Traditional Ecological Knowledge (TEK)
  - Scientist Spotlight: Dr. Frank K. Lake, US Forest Service

- **Week 5**
  - Information literacy focus: Searching for gray literature (government & NGO publications).
Community Narrative topic: Nail salon workplace safety activism
Biochemistry connection: Green chemistry; formaldehyde
Scientist Spotlight: Dr. Roselin Rosario-Melendez, L’Oreal Cosmetics

Week 6
- Information literacy focus: Evaluating source credibility; authority is constructed and contextual.
- Community Narrative topic: Pain management & the opioid crisis
- Biochemistry connection: Venom therapeutics
- Scientist Spotlight: Dr. Mandé Holford, Hunter College & CUNY-Graduate Center

Week 7
- Information literacy focus: Primary literature in STEM research; evidence synthesis.
- Community Narrative topic: Monocultures in California agriculture
- Biochemistry connection: Biodiversity
- Scientist Spotlight: Ernesto Sandoval, UC Davis Botanical Conservatory

Following the class session, students were asked to complete a graded discussion post using the information sources covered in the week’s lesson. The module also included the materials from the information research presentation in class.

Tree Equity Lesson Plan

The topic for the first content module in Week 2 of the seminar was phytoremediation and tree equity. This case study will focus on this lesson plan because we had positive student engagement and because the interdisciplinary nature of the topic made it easy to develop into an information literacy session for library instruction. We chose this topic for the initial content model because it combined an interdisciplinary science focus on phytoremediation, wildlife habitat conservation, and urban forestry with an equity and social justice emphasis on urban planning and housing discrimination within a local northern California context.

Figure 1. FYS Canvas module for Week 2
Class Preparation

The student learning goals for this lesson centered on understanding environmental remediation and connecting it to environmental justice and structural inequities, specifically race and class. The information literacy component of the module examined the use of reference sources such as encyclopedias and dictionaries to gain background knowledge of a topic. The learning goals were linked at the beginning of the module so that the expectations were clearly stated:

- **Phytoremediation & Tree Equity**
  - Gain awareness of how green spaces improve our health and quality of life
  - Recognize how decisions related to urban planning and housing policies impact citizens' quality of life and create inequalities within our communities
  - Acknowledge the challenges of applying environmental remediation equitably and the importance of making policy considerations that address rather than reproduce inequality.

- **Information Research**
  - Utilize reference sources (encyclopedias, dictionaries, etc.) as a resource to gain insight and introductory knowledge on topics you may be unfamiliar with
  - Identify key terms and vocabulary associated with a topic you're investigating
  - Connect with additional readings/information sources on your topic

The next section of the module identified and defined the key terms for the lesson: phytoremediation, urban forestry, and tree equity, and environmental justice. Providing explanations of key terms helped ensure that instructors and students were all working from a common understanding of the topic.

As this was a 1-unit course, we wanted to avoid burdening the students with heavy amounts of reading, so we selected course materials that were short, accessible, and in a variety of formats, including newspaper articles, YouTube videos, and podcasts. For this lesson, we chose three videos: a 5-minute TedEd video on the importance of trees in urban settings (TED-Ed, 2020), a 4-minute video on urban forests by American Society for Landscape Architecture (2012), and a 6-minute video on Tree Equity from the Recount (2021). We also included an article describing the implementation of an environmental vegetation barrier at an elementary school located near a freeway in Oakland, CA (Costley, 2017).

Dr. Eboni Hall, Senior Manager of Urban Forestry Education at American Forests, was the highlighted scientist for this lesson. The spotlight included a brief biography, a link to a paper she authored, and a link to an interview in which Hall explained, “People of color don’t have a reflection of themselves in this field, and they get discouraged...Maybe if people see I’m able to do it, they’ll think they can” (Heim, 2021). We felt this exemplified the goal of the Scientist Spotlight and made Hall an ideal choice for the tree equity and urban forestry lesson.
The course materials page in Canvas also included links to optional resources, including the American Forests Tree Equity Score tool, local urban forestry organizations, and the campus Plant Sciences and Landscape Architecture departments.

**In-class Activities**

The class session began with a discussion of the videos and articles. We asked the students to list some of the benefits of trees in urban areas; “shade” and “cooling,” were mentioned, along with “creating a pleasant environment” and “wildlife habitats.” Temperature and pollution mitigation are especially relevant to students from the local community; nearby Sacramento averages 90 days over 90 degrees per year with frequent poor air quality.

Sacramento also provided a local example for the discussion of tree equity. Due to the city’s robust tree canopy, it has been nicknamed the “City of Trees”, but tree coverage is not equally distributed throughout the city. We were able to introduce the concept of redlining and help students understand how racial discrimination in housing affected tree planting using the American Forests Tree Equity Score Map tool to compare a neighborhood with a tree equity score of 98 to one with a score of 48 (American Forests, n.d.).

Local connections were also important when we examined the case of Brookfield Elementary School in Oakland (Costley, 2017). The vegetation barrier was implemented to mitigate traffic-related air pollution from the nearby freeway. Students were able to connect the problem to the issues of housing discrimination raised earlier in class, questioning why an elementary school would be located near a busy highway. The article noted that the school relies on volunteers to maintain the barrier because they cannot afford staff to tend to the vegetation full-time, leading to a conversation about the equity issues involved in sustaining mitigation efforts, and the long-term questions of focusing on individual solutions like vegetation barriers, rather than addressing structural problems like traffic-related air pollution and environmental racism.

Following the discussion of the materials on phytoremediation and tree equity, we engaged students in the information research segment of the class. We used the “Scholarship as Conversation” frame of the ACRL framework as a starting point to
introduce the concept of research as an iterative process. This lesson formed the base of the scaffolding, focusing on using reference sources for background information as the first step in research. As an active learning element, students searched online for background resources on phytoremediation and added the ones they found to the class Padlet.

Course Outcomes

Overwhelmingly, students excelled in the class, demonstrating effective scientific research and communication skills to connect organic chemistry and social justice activism in California. We were especially pleased with how the students from non-STEM majors engaged with the scientific research on their topics, with many expressing that this experience made them more confident about studying scientific subject matter in the future.

Components of Final Project Presentation

- **Topic Introduction**
  - Describe the context of your topic. Provide some information about your topic's discovery, use, and application, as well as historical or ongoing debates/controversies.
- **Biochemical Connection**
  - Describe the 'science' related to your topic. Provide a brief explanation about the biochemical process related to your topic. Remember that you only need to explain biochemical processes at the introductory level.
- **Societal Impact**
  - Describe how your topic impacts society at large, as well as certain communities and individuals. Provide any information related to health or environmental impacts. Are there scientists, activists, or organizations trying to remedy these impacts? What challenges or barriers need to be overcome in order to effect change or promote health/safety?
- **Personal Impact**
  - Share one way researching this topic has impacted you. Did you learn something that will change your behavior or perspective? Do you plan to learn more about this topic in the future, through coursework or joining a lab on campus, or by pursuing a hobby or activism?

Students were given an extensive range of possible topics from broad subject areas that we pulled as examples from our literature review of culturally relevant chemistry education, including environmental justice, green chemistry, Traditional Ecological Knowledge, food science, and nutrition. Students could select one of the suggested topics or explore a topic of their choosing. Interestingly—and perhaps due to our coastal communities in California—of the 31 students across both sections of the course, seven students chose topics related to ocean health, such as bioremediation of plastic and petroleum pollution, ocean acidification impacts on shell life, coral bleaching, and toxoplasmosis in the otter population of Monterey Bay. Neurochemistry was also a popular category, with five students examining the impact of anxiety, sleep, exercise, and caffeine on hormones and neurotransmitters. Five students—all women—explored
organic compounds in skincare and beauty products and the associated health impacts on consumers, salon workers, and the environment. One student’s presentation on hair straightening prompted a very profound discussion amongst the class about the health impacts of beauty standards, with several students noting that they were unaware of the toxicity of chemicals like formaldehyde and sodium hydroxide prior to conducting research for their Final Project. The most popular category was food science and nutrition, with 10 students investigating topics ranging from fermented foods, lab meat, and sugar substitutes to nitrates and ketones.

**Student Feedback**

From reviewing student feedback collected in the course evaluations, students overwhelmingly had a positive experience. Course evaluations at our institution provide students with several open-response questions, including What key ideas did you take away from this seminar? and What was most valuable to you about the seminar or instructor?

Feedback from student course evaluations:

- “A valuable skill I learned from this seminar was how to effectively gather and analyze reliable sources of scientific evidence for any sort of research I will have to do in the future.”
- “What was valuable to me about this seminar was I never really did scientific research work and I learned a lot by taking this seminar.”
- “I learned a lot about how to research effectively and discuss scientific topics with others.”
- “This class made me feel better about researching science topics. I had done research in my high school English classes but never did research for science. I feel more confident about researching the science around the chemicals in the products I use and foods I eat.”

Students were also asked, What was the least valuable about the seminar or instructor? and What changes in the course could make it more valuable to first-year students?

Feedback from student course evaluations:

- “More group work. Interacting with peers is important especially after Covid.”
- “More discussion between peers and small group work.”

This feedback from FYS students was collected in their anonymized course evaluations conducted by the university’s Academic Course Evaluation Committee. This data is collected for the purpose of improving user instruction and is not intended to engage in systematic investigation and is therefore not considered research requiring IRB review.

**Discussion**

In assessing the results of our intervention, it is important to note both the unique opportunities of the First-Year Seminar program, and the challenges and limitations of
traditional one-shot library instruction. The FYS program allowed us to develop a full-term curriculum using a scaffolded approach to information literacy instruction, something that is not typical in library instruction.

Academic library instruction is largely centered around one-shot instructional sessions, which have inherent limitations that can serve as barriers to librarians’ attempts to promote equitable instruction practices. In their examination of equity issues surrounding this modality, Zoe Bastone and Kristina Clement note that “...in LIS literature surrounding the one-shot...researchers and practitioners generally agree that the one-shot is one of the least effective methods of teaching information literacy concepts,” adding that “the very logistics of the one-shot model creates an inequity of information by assuming that students have enough time and resources provided in the session to obtain the information literacy skills that their instructors expect” (Bastone & Clement, 2022).

In most academic libraries, faculty initiate classroom instruction requests; the one-shot is often the only opportunity instructors have time for in the curriculum. With the emphasis on squeezing in as much skills-based material as possible, it can be challenging to find space to include culturally relevant materials and concepts (Horowitz et al., 2018). Some instructors we spoke with have also expressed concern that the classroom is not an appropriate place to discuss “political” issues and that instructors in science-related disciplines should present as neutral and objective, suggesting that diverse representation is inherently political or activist (Goldsmith et al., 2021).

Our response is that the presumption of neutrality supports the status quo in perpetuating existing inequalities and therefore is inherently not objective. Research indicates that students value diverse representation in instruction; if culturally relevant instruction improves student outcomes, there is no tension between teaching skills-based material in a way that acknowledges students' grounding in their communities and cultures.

Applications of Culturally Responsive Pedagogy in the STEM Library Classroom

Building on social identity theories and principles of culturally responsive pedagogy, as well as the theoretical framing for critical information literacy proposed by Foster (2018), Cowden, et. al (2021), Drabinski and Tewell (2019) and Hicks (2013) we have identified the following recommendations for STEM Librarians applying culturally relevant teaching into their instruction. These practices are based on the experience of our STEM Librarian using culturally responsive teaching principles as a white librarian seeking to decenter white normative standards in academia through her information literacy instruction.

Prepare Students for Success

As noted in Bastone & Clement (2022), the one-shot library presentation is an instructional modality that replicates many of the inequities inherent to higher
The absence of information literacy instruction, or access to a school librarian in under-resourced secondary schools, leaves many undergraduate students, especially from historically marginalized communities, at an information literacy disadvantage (Quiñonez & Olivas, 2020). Utilizing a ‘flipped classroom’ strategy can help to mitigate these inequities by providing preparatory materials for students to engage with prior to the library session. This STEM Librarian encourages colleagues to frame the library instructional session as a ‘Research Lab’ and preparatory materials, which may include video tutorials, readings, and learning activities, as ‘pre-lab’ work so that the instructor, librarian, and students all have a shared reference for the role of these materials. Sharing presentation slides, resource links, and handouts prior to the presentation is also an accessibility best practice that benefits all students (Marsh & Sink, 2010). It is also important that any LIS disciplinary concepts or terminology that the librarian uses in their instruction are clearly identified and defined in these materials. This strategy helps students to arrive for the session with a clear understanding of what topics, skills, and resources will be covered, with the additional benefit that these materials are available to them after the session for review.

**Share Your STEM Identity**

Prioritizing introductions is an essential way to humanize academic librarians. For example, this STEM Librarian introduces herself by discussing her STEM career pathway, the role of librarians in supporting undergraduate research, and how this work shapes her own scientific research interests. She also makes clear connections between her scholarship in textile science to her identity as a fiber artist, and her interest in plant science and mycology to her identity as a forager. In under five minutes, this introduction builds rapport with students and helps to contextualize the librarian’s credibility as a source of academic support. “Trust and contextual authority are classroom centerpieces, but rarely are students given a reason to trust us or see us as research experts” (Cowden et. al, 2021). Introductions also affirm that librarians possess a multitude of social identities that can overlap with and reinforce our identity as STEM professionals.

**Create Authentic Learning Environments**

Authentic learning environments create educational settings where student learning is situated in the context of use beyond a particular class or assignment. Librarians can emphasize the importance of cultivating information research and science communication skills for students’ future work as STEM professionals—as well as their current work as members of campus research labs. Many undergraduates are actively supporting our universities’ research output; acknowledging this by highlighting how the strategies, resources, and tools students engage with in the library classroom will advance their scientific research, affirms their identity as contributors to scientific knowledge, and articulates why information literacy is relevant to their STEM identity. While time-intensive, utilizing a discussion board prompt or survey distributed prior to the library instructional session asking students to share their research interests is a way to assess their existing expertise and pursuits, which can be incorporated into the session.
**Utilize Problem-Based Learning**

Problem-based learning is another practice that creates authentic learning environments. By identifying existing scenarios in which scientists apply information literacy skills, librarians prompt students to reflect on the utility of the research strategies and tools covered in the library instructional session. This STEM librarian encourages colleagues to set aside time for active learning where students gather, evaluate, and synthesize information to address a problem that a scientist might be asked to solve. For example, in our Tree Equity lesson plan, we had students consider how a scientist working for the State Water Resources Control Board would conduct research in order to recommend particular tree species for use in the remediation of contaminated groundwater. Problem-based learning is process-focused, meaning students shift their attention to navigating the research process rather than identifying a finite answer; STEM students appreciate that a scientist cannot simply Google a solution without evidence-based rationale but must ‘show their work.’

**Teach to Empower**

When identifying real-world scenarios in which scientists apply information literary skills, use this as an opportunity to demonstrate how science can be justice-oriented. Gloria Ladson-Billings and Geneva Gay envisioned culturally responsive pedagogy as a means of empowering students to use their cultural background and lived experiences as a “vehicle for learning.”

It is important to clarify that in many educational settings, the term ‘culture’ is often used to signify ‘non-white,’ but ‘culture’ encompasses a spectrum of social identities that intersect and overlap. This is not to say that STEM librarians should sidestep conversations about racial inequities. Rather, we want to stress that focusing on the experiences of one cultural group does not necessarily alienate students who are not members of this group.

For example, our First-Year Seminar lesson plan about using Green Chemistry to address worker safety in nail salons included readings centering Vietnamese nail technicians, since an estimated 80% of nail salon workers in California are Vietnamese immigrants (Quach et al., 2011). This lesson plan highlighted work done within the Asian American communities of the Los Angeles and Bay Areas, where activists partnered with scientists to craft workplace safety legislation and developed campaigns to educate salon owners and technicians about mitigating health risks. While the majority of our students did not identify as part of the Vietnamese immigrant community, many could identify with other immigrant communities working in similarly unregulated environments that expose them to toxic chemicals. Crucially, the learning materials developed for our Green Chemistry lesson plan provided empowering narratives of scientists collaborating with impacted communities to improve workplace safety.

This helped to introduce students to the ethics of, “Nothing about us without us,” a slogan coined by disability activists asserting that no policy should be decided without the full and direct participation of members of the group(s) affected by that policy.
Hence students also recognized how scientific research and outreach empower others to make informed decisions about their health and safety. While Gay implores educators not to ‘sanitize’ issues of racism and inequities, STEM librarians should never use the oppression of vulnerable communities to shock or evoke pity. Neither should they cast scientists as saviors who rescue vulnerable communities from their plight. Instead, demonstrate how communities are empowered through organizing and the role of scientists in partnering with these organizations to advance justice. Juxtaposing real-world problems resulting from systemic inequities, with both scientists and communities engaged in providing solutions, is intended to affirm the STEM identity of students from historically marginalized groups whose decisions about the type of career they pursue are influenced by a desire to contribute to society and give back to their communities through their work.

**Decentering the Instructor**

When librarians incorporate discussion into the library ‘one-shot’ session, they create opportunities for peer-to-peer instruction, providing students agency in the classroom to direct their own learning. However, this requires instructional librarians to “give up control of the learning process to the students in order to create new layers of meaning within the course material” (Bradham, 2023). Instead of directing the session as a ‘sage on the stage,’ librarians facilitate discussion among students by adding context and making disciplinary connections for students to engage with related scholarship. Decentering also frees the instructor to practice active listening and informally assess comprehension (Cowden et al., 2021). However, librarians should be mindful when assessing student learning not to ‘correct’ students, but rather when necessary, reframe their comments to situate beliefs and perceptions within the wider body of knowledge found in current scholarship.

Any plan for classroom discussion requires extensive preparation. To be an effective facilitator, the librarian must be knowledgeable and informed about the topic of discussion and engage in self-reflection about their own positionality. It is also important to think carefully about how the topic of discussion connects with instructional learning goals. In our Tree Equity lesson plan, the discussion about redlining and discriminatory housing policies tied directly to our goal of demonstrating the need for scientists to partner with scholars across disciplines whose expertise in sociopolitical issues should inform their own scientific research.

It is imperative to create safe and respectful learning environments that do not put students at risk of degradation or stigmatization. Below are the discussion guidelines we developed for our First-Year Seminar adapted from Guidelines for Planning and Facilitating Discussions on Controversial Topics by the Center for Research on Teaching and Learning at the University of Michigan (n.d.) and Talking Circles by First Nation Pedagogy (n.d.).

Discussion guidelines for peer-to-peer learning:

- Commit to learning, not debating.
- Challenge or criticize ideas, not individuals or communities.
Comment with the goal of sharing information.
Avoid blame, speculation, and inflammatory language.
Be careful about putting fellow students on the spot. Do not demand that others speak for a group that you perceive them to represent.

The opportunity for discussion may be fostered in a variety of ways (think-pair-share, post-it comments, etc.) that enable students to use their cultural background and lived experiences as “funds of knowledge” to provide analysis and contribute to collective learning. As Alison Hicks argues, “…if librarians want to engage their users in meaningful and student-centered [information literacy] programs, they must understand that their real value lies in facilitating the complex and reflective inquiry that a machine cannot provide” (2013). Despite the time-intensive nature of preparing to facilitate classroom discussions around equity and social justice, incorporating peer-to-peer learning into library instruction is one of the best ways for students to be exposed to a diversity of perspectives and experiences.

**Translating the Tree Equity lesson plan into ‘One-Shot’ Library Instruction**

After the first offering of the seminar course in Fall 2022, the STEM Librarian on our team set to work translating our lesson plans into one-shot information literacy instruction. This librarian’s liaison responsibilities include working with undergraduate students in agriculture and environmental sciences. Our seminar lesson, “Environmental Justice, Phytoremediation and Tree Equity,” is ideally aligned with information literacy instruction in these disciplines.

Librarians have rightly criticized the efficacy of ‘one-shot’ instruction as a practice to advance critical inquiry. ‘One shots’ can produce a false sense of accomplishment—to the librarian providing instruction, the faculty requesting the session, and students in attendance—that acknowledging inequities in our society is somehow a sufficient step towards addressing those harms (Leung, 2022). It was therefore important for this STEM librarian to introduce the topic of ‘Tree Equity’ not as something novel or “external to the work at hand” but as a salient example to future scientists of interdisciplinary research, informed by the ‘real world’ context in which their work will be applied and in dialogue with impacted communities.

Urban forestry presents an ideal sample research topic for ‘one-shot’ instruction, as students engage the lesson with a variety of shared cultural referents about the benefits of urban forests. As with the First-Year Seminar, the STEM Librarian begins the session by asking students to concept map these benefits (shade, improved air, soil, and water quality, wildlife habitat, etc.) as well as who experiences these benefits (humans, plants, and animals).
Students are then broken into small groups to brainstorm potential indicators of these benefits, how they would be measured, and by whom. This brainstorming exercise is used to segue into information literacy instruction around the importance of identifying disciplinary terms and methods. For example, students who work on identifying the measurable benefits of shade provided by urban tree canopy point to lower temperatures in neighborhoods with more tree coverage. The benefit of lower temperatures is one that students can reliably draw upon their own lived experience to discuss; shaded environments are less dependent upon air conditioning for cooling, and vulnerable populations are less at risk for heat-related illness. When working with students in the ‘shade’ group, the librarian uses the ‘urban heat island effect’ to introduce the importance of cross-disciplinary terminology. Concept mapping is a strategy to help students identify how scholars might collect and analyze data tied to particular phenomena. But to retrieve that data, students must also identify the terminology used by scholars to describe that phenomenon. The goal of this exercise is for students to recognize the ‘urban heat island effect,’ ‘transpiration cooling,’ and ‘hyperthermia’ as disciplinary terms they will use when searching for scholarly literature examining the benefits of urban tree canopy they discussed.
With research topics and search terms at hand, students then explore the library’s databases to discover scholarly articles. This presents an ideal opportunity to highlight the role of primary literature and evidence synthesis in scientific research. The librarian also encourages students to consider how scientific research informs public policy using the example of a hypothetical urban municipality seeking to increase its tree canopy. We revisit our discussion from earlier in the session about the types of scholars and scientists whose work might shape public policy using the example of Dr. Eboni Hall, whose research is conducted in partnership with scholars in public health, urban planning, climate science, and wildlife conservation to think about how scholars across different fields collaborate to address unmet social needs.

This focus on interdisciplinary approaches informed by diverse teams of scientists throughout the session helps to build upon our investigation into the benefits of urban forestry to discuss why these benefits are not experienced equally. Here we recall the concept of “urban heat islands” explored earlier in the session in relation to the shade provided by tree canopy. The librarian then plays The Recount video, “What is Tree Equity?” (<5 mins).

Students, who have by this point in the session used the library’s subject databases to search for scientific evidence on the benefits of urban forests, are asked to discuss why it is in everyone’s interest to have those benefits distributed equally, rather than concentrated in certain parts of the urban environment. Having experienced multiple extreme heat waves and wildfire events, students almost immediately note overburdened electricity grids and hospital surges. They also point to the impacts of chronic health issues related to respiratory and cardiovascular illness that could be measurable in terms of school and workplace absences, and the increased benefits to wildlife with more widespread habitat and biodiversity. Students often speak very poignantly about the ways in which verdant and vibrant spaces increase the quality of life for society as a whole.

The goal of incorporating ‘Tree Equity’ into one-shot instructional sessions is to make explicit how the work of scientists can be collaborative, interdisciplinary and contribute to advancing more equitable and vibrant communities. The session concludes by examining the bibliometrics of Dr. Eboni Hall’s work (via the context of governmental and NGO publications) and its use in crafting legislation, including the Inflation Reduction Act. The librarian also posts links to the same resources featured in the ‘More to Explore’ section of the “Environmental Justice, Phytoremediation and Tree Equity” lesson plan with coursework, lab, and local community organizations in the area of urban forestry in the class course guide.

While participation in one class session or workshop with a librarian will not be the watershed moment in a student’s STEM identity formation, the hope is that it will be one touch point among many for students to be inspired and invigorated by the role of scientists in shaping a more equitable future.
Conclusions

This collaborative project to identify culturally relevant STEM educational materials benefited both the faculty and librarians on our team. The organic chemistry professor utilized feedback from the First-Year Seminar to create course materials that feature the work of Dr. Mandë Holford’s research on peptides derived from cone snail venom to develop pain therapeutics, in addition to incorporating student research topics in food science into her curriculum. The STEM Librarian continues to refine the ‘Tree Equity’ one-shot information literacy workshop and hopes to design similar lesson plans centering prescribed burning practices in California and student research topics on ocean health. Although the Library Diversity Fellow is focused on non-STEM related subject areas, working on the course has emphasized the importance of being able to communicate about and understand science for students in all disciplines. She has incorporated the principles of CRP into her instructional sessions, using examples that connect to the lived experiences of URM students and their communities.

In looking at future directions for library-based interventions in STEM Identity formation and information literacy instruction for URM students, we identified several areas where we would like to expand our work. As part of our commitment to accessibility and Open Educational Resources, we plan to adapt the content modules developed for the course into Canvas Commons learning objects that can be shared and used by other librarians and instructors.

In the longer term, based on our experience with students identifying topics of interest, we would like to have students assist with building out curricular materials through paid internships. One example could include having students conduct in-depth video interviews with the scientists to contribute to the Scientist Spotlight Initiative. We hope to continue sharing our ongoing efforts with colleagues through future scholarly presentations and publications.

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