Catalyzing the Advancement of Diversity, Equity, and Inclusion in Chemical Education

By Reginald Rogers and Todd Pagano

Only a relatively small number of students from underrepresented groups enter the field of chemistry, complete their degrees, and enter the workforce. There are ethical and practical concerns when we lose out on diversifying the chemical sciences and benefitting from the greater contributions of thinkers from diverse backgrounds working together in the classroom and workplace. The principles of diversity, equity, and inclusion are critical for resolving the current imbalance. Continuous reflection by faculty is an essential component for the improvement process, as are understanding value and embracing change. Strategies for making students feel a sense of belonging in a course, research laboratory, and discipline include ensuring the educational climate is safe, accessible, and respectful; making the learning experience relatable and providing access to role models; and providing research experiences and exposure to the field. While the focus of this Point of View is on chemical education, the conversation and best practices are applicable and extend to teaching and mentoring in other fields of science.

Dr. Henry McBay knew what it took to succeed as a student from an underrepresented background in the field of chemistry when he earned his doctorate from the University of Chicago in 1945 (Manning, 1994). Dr. McBay began an illustrious career dedicated to providing education and career growth opportunities to students who also came from underrepresented backgrounds. He went on to co-found the National Organization for the Professional Advancement of Black Chemists and Chemical Engineering (NOBCChE) and was awarded the American Chemical Society’s (ACS) Award for Encouraging Disadvantaged Students Into Careers in the Chemical Sciences. The NOBCChE award that bears his name honors those who emulate his love and passion for inclusive teaching. Correspondingly, more than a couple decades ago, Stanley Israel was an ally in supporting those who were underrepresented in the chemical sciences. As an educator, he advocated for equality and increasing diversity in the field, and the ACS award with his name recognizes those who have supported and championed the success of underrepresented groups in chemistry. Many of the ideals advocated by these two distinguished educators resonate with the core principles of diversity, equity, and inclusion (DEI). Unpacking all of the components of DEI is crucial and requires a fuller analysis and discussion beyond what we can provide here, but Brooks et al. (2021) offer a good overview of DEI in the context of developing guidelines for the advancement of DEI in chemistry programs.

We are humbled to be among the distinguished company of community members who have received the NOBCChE Henry McBay Outstanding Teaching Award, the ACS Award for Encouraging Disadvantaged Students Into Careers in the Chemical Sciences, and the ACS Stanley C. Israel Award. And we do not take lightly this opportunity to share our thoughts on the ever-important DEI conversation. Like Drs. McBay and Israel, we come from different backgrounds and different perspectives (one as a person who identifies as an underrepresented minority and one as an ally) toward the education of students who are underrepresented in chemistry, but we share the same passion and sense of calling. Certainly, there is a far greater wealth of knowledge out there than we possess—and, like everyone, we are still learning how to adapt, grow, and contribute in an ever-changing world.

The idea of DEI should not be viewed as simply another item to address on a checklist. Rather, actions must be sincere and purposeful to avoid a sense of having empty
words or intentions. DEI must also be a shared responsibility. To borrow from thermodynamics (as we will do several times in this article), there is only so much energy our colleagues from underrepresented backgrounds can burden in this work. Allies are important to the process, especially when they help lift the voices and positions of those from the underrepresented community. Progress will ultimately require everyone’s collective energy input. At institutes of higher education, when we work together to promote DEI, we not only help our colleagues and students feel welcome but also inherently improve the retention of students from underrepresented populations (Wilson et al., 2014; Goethe & Colina, 2018; Adams & Lisy, 2007). The students can build a level of confidence and belonging (White et al., 2021) that propagates beyond their college years and, in turn, inspires the next generation of students. (The elegance of this cyclical process not only helps address current problems but also ensures the sustainability of solutions.)

The broader outcomes of obtaining a degree in chemistry can be positive and life-changing, especially when one is able to then build a career in chemistry. However, studies have cited the underrepresentation of certain groups among those who pursue STEM degrees and enter the workforce (Wilson et al., 2014; Goethe & Colina, 2018; Hurtado et al., 2009). Remediying this lack of diversity is critical to the chemistry community. It is important to note that the practice of DEI is not only relegated to normative rationale when, in fact, outcomes transcend moral motives. For example, while an intentional, deep-rooted adoption of DEI principles certainly has ethical foundations and is imperative for addressing the stated disparities in the field, it also makes good practical sense when thinkers from different backgrounds and varied experiences work and problem solve (Goethe & Colina, 2018) together in academia and industry. These tenets also hold true in the other fields of science.

Unpacking “value” and “change”

“Value” is an indispensable term in the mission of DEI. Using it as a verb, you can value the input and perspectives of students from diverse backgrounds. When the word is used as a noun, it can have many accompanying prepositions, all of which are as important as the notion itself. There is a value of students from underrepresented groups to the field of chemistry, your institution or company, your classroom or laboratory, and so on. Value to students who are underrepresented in chemistry is gained from their instructors and institutions (e.g., in the form of intellectual wealth, career prospects, enculturation to the field, self-confidence, etc.). One of the great things about working in higher education is the reciprocal nature of learning, meaning that faculty constantly learn from their students. Through that reciprocity, there is undoubtedly value from students that is rewarded to their instructors in the form of experiencing diverse thinking, lessons in overcoming obstacles, and insight into different backgrounds and cultures. This reciprocity is most rewarding to faculty who put in the effort to create a positive educational experience in which students embrace value in themselves. There is an abundance of value by, for, among, and between everyone when DEI is practiced.

“Change” involves the person and broader community. How do we, as faculty, change our mindset toward DEI in chemistry (or any field, for that matter)? The first step requires undertaking deep, intentional reflection to internalize who you are and what changes you would like or need to make. Reflection involves taking a deep look at yourself and your curriculum, mentoring style, values, beliefs, and so on. Although you might have changed something after past reflection (e.g., a lesson plan), it does not mean the modification will work again or with new groups or individuals. Reflection and the implementation of change are continuous processes that require being flexible and sometimes stepping outside one’s comfort zone (which is often not a trivial task).

Change to the chemistry classroom or laboratory could occur via the implementation of several strategies, but it is important to note that a one-size-fits-all solution does not exist. Every student or group is different (e.g., strengths, weaknesses, backgrounds, values), and care must be taken to ensure the right strategies are implemented for the given audience. This will allow you to tailor the educational experience to fit students’ specific interests and experiences and hopefully help students feel a sense of belonging in the field. This process also gives students a clear indication that you care about their success and want to help them achieve their goals (in the classroom, in the workplace, and in life).

DEI strategies for the chemistry classroom and laboratory

There are several strategies that can be applied to help make the academic classroom and laboratory more inclusive and foster greater
student growth (Goethe & Colina, 2018; White et al., 2021). Of utmost importance is that the overall educational climate is welcoming, accessible, and respectful. This foundational aspect is simply a must, and faculty need to proactively work to dismiss prior assumptions, put aside any biases (Nilsson, 2017), and break down stigmas as they work toward the singular goal of doing what is best for the students. A self-assessment on what you do to make your classroom or laboratory inclusive is a critical component of this process. It is imperative to avoid forcing a fit (by merely inserting students into existing frameworks) when students do not feel they truly belong in the environment. To create a more welcoming climate, “humanizing” yourself can be a useful practice. Regardless of your background, students will naturally perceive their professors as authoritative with regard to either chemistry knowledge or power (e.g., power over grades, graduation, etc.). You could have open discussions about your own pathway to your career, including the struggles and doubts you faced along the way. This discussion can help students see that you are certainly not without challenges, and while everyone’s experiences are quite different, there may be some things the students find relatable.

Openness and accessibility in an educational environment are always needed, and accessibility can take on additional meanings for students with disabilities. Making course materials and the lecture and laboratory environment accessible with appropriate support services and accommodations is obligatory. A general resource for teaching chemistry to students with disabilities can be found in Teaching Chemistry to Students With Disabilities (Redden et al., in press). Universal design for learning (Scanlon et al., 2018) further enhances accessibility and is helpful for all students, regardless of their backgrounds or whether they have a disability. Instructors find that accommodations they make for students with disabilities often benefit all students in the classroom or laboratory. Examples of accommodations include preparing better and more self-explanatory visuals as part of the lesson materials, providing course documents in different formats, and taking turns in group meeting discussions.

Once you have considered the classroom climate, you can turn your attention to the curriculum. One approach to improve DEI is to place successful scientists who are from underrepresented groups in the forefront of lessons (Williams & Karim, 2020; Collins, 2021); examples could include Percy Julian (Tyson, 2007), Anders Ekeberg (Weeks, 1932), and Evangelina Villegas (Renard, 2017). By telling the story of the people behind the science (and each field has their exemplars), you can help students from underrepresented populations better visualize how they, too, can fit and flourish in the chemistry field. The context of the chemical concepts can also be selected to resonate with students’ lives. To show how the content relates to the students, relevant case studies and current events with chemistry backing should be used in teaching (Goethe & Colina, 2018). It can be challenging for faculty to find space in an already full curriculum to add more material, but when possible, these DEI concepts and stories can be incorporated in support of important existing course material. Still, adding these DEI components may require instructors to take a critical look at their curriculum and make tough decisions about material that might need to be eliminated. Such decisions can sometimes result in course restructuring that also benefits the students by allowing them a deeper understanding of more focused course content.

It is important to properly assess student knowledge in an unbiased way. Exams remain among the most common assessment tools, though they can often assess knowledge from a place of bias. While instructors should attempt to supplement assessment schemes with alternative assessments, they should also seek feedback on exam questions from peers who are knowledgeable in pedagogy and DEI concepts. Even changes in the wording of questions can improve the exam, and students can assist in the generation of practice exam questions (in which instructors can see the type of language students prefer and use while students are thinking about course material). While logistically challenging in lectures with large enrollments, alternative assessments such as interviewing (Burrows et al., 2021) and concept mapping (Francisco et al., 2002) can provide means of diversifying assessment types. Faculty who wish to strengthen exam design or learn more about alternative assessments should seek professional development opportunities on these topics.

Historical role models are great, but faculty can also call on their professional network to invite passionate colleagues from underrepresented groups to engage with students. Having more faculty who are underrepresented in chemistry in front of students from the same population can increase the likelihood of a feeling of “fit” and improve retention in the field. The era of remote education has made it easier than ever to connect
Encouraging students who are from underrepresented groups to get involved in research can also be a useful strategy for engaging, promoting, and retaining students. Participation in research often helps students not only strengthen their subject knowledge but also improve their self-confidence (Hurtado et al., 2009; Fakayode et al., 2014; Russell et al., 2007) and sense of belonging in the field (Pagano et al., 2015). Students who conduct research should be encouraged to publish and present their findings at professional conferences, which gives the added benefit of early exposure to professional organizations. Costs associated with joining professional organizations and travelling to conferences could be obtained by working with institutional development offices to solicit direct donations for these expenses; donors are often happy to put a name and story to their contributions (Pagano et al., 2015). Additionally, students could leverage scholarships or awards from professional organizations to support travel expenses with strong support from the research mentor or adviser.

Additional barriers may exist for students from underrepresented groups to engage in undergraduate research. Students may lack familiarity with the concept or conduct of research or the process for getting involved with faculty-guided research or lack the confidence to approach a potential faculty mentor; additionally, the makeup of the research group may not be diverse (in either the faculty or student membership of the group or the presence of members who clearly value DEI), making this work less attractive to students who might otherwise wish to participate. If you happen to be a faculty member who has shown passion and success for involving students who are from underrepresented groups in your research initiatives (and these students likely flock to your group), you could mentor your colleagues and help them make their research groups more inviting. Soliciting student researcher recommendations from colleagues can help you build a more diverse research group. Another solution would be for research mentors to adjust their advertising of both their research topics and the availability of opportunities in their groups to better address students from underrepresented groups. Department-wide events where all potential research mentors present to all students in a program (instead of select groups) ensure that the opportunities are being broadcast in an inclusive manner. Training for research group members related to DEI and accessibility should be part of the research group’s operations and will inherently create a more inviting group. Furthermore, student researchers might benefit from not being the only students from an underrepresented group on the team, so it can be preferable to have a broadly diverse group.

The conduct of the research is often in more of an “apprenticeship” model in which one or a few students work under the guidance of a faculty member. As mentioned, this type of setup does not always generate an inclusive environment, nor does it allow for large numbers of students to get a taste of the research process. Course-based undergraduate research experiences (CUREs) can open the research experience to a greater number of students, including those coming from underrepresented groups (Rodenbusch et al., 2016; Vater et al., 2021). CUREs are a great way to foster growth in students’ problem-solving and critical-thinking skills (Kerr & Yan, 2016; Mutambuki et al., 2019; Muna, 2021).

Conclusion
Imagine the field of chemical education on a reaction pathway curve. On our path toward full DEI, we find ourselves looking directly at an activation barrier. It will require a lot of well-placed energy to overcome the societal barrier in front of us so that we can revel in all of the benefits of DEI in the chemistry community. Diverse luminaries in chemistry, such as Percy Julian (Satyanarayana et al., 2019), Henry McBay (Manning, 1994), Marie Daly (Satyanarayana et al., 2019), and more could leverage their energy and influence to help create a more inclusive environment in the chemistry field.
et al., 2019), Jon Cornforth (Amato, 2006)—and allies such as Stanley Israel—have contributed invaluable energy to the cause. We must continue the energy investment and ultimately overcome systemic barriers in the field. Although this proposed reaction curve might be a bit oversimplified—as the pathway will likely require a level of maintenance energy input to achieve and sustain success—the metaphor demonstrates the importance of people coming together and investing energy in this cause. Employing strategies for generating student interest, retention, and success in the field; self-reflecting; and fully embracing value and change are among the catalysts that will help along the pathway.

References


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