JOURNAL OF CHEMICAL EDUCATION

pubs.acs.org/jchemeduc

Commentary

Decolonizing the Undergraduate Chemistry Curriculum: An Account of How to Start

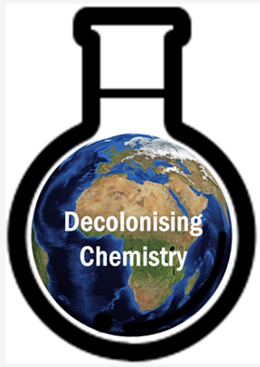
Caroline E. H. Dessent,* Ruhee A. Dawood, Leonie C. Jones, Avtar S. Matharu, David K. Smith,* and Kelechi O. Uleanya

Cite This: J. Chem. Educ. 2022, 99, 5−9

Read Online

ACCESS | Metrics & More | Article Recommendations

ABSTRACT: Discussions on decolonizing the curriculum are common in Humanities and Social Science Faculties but still rare in the Physical Sciences. In this commentary, we describe the work we have conducted to begin decolonizing and diversifying our undergraduate chemistry curriculum. We also discuss what it means to decolonize chemistry and reflect on why it is an important thing to do. Finally, we discuss a number of different strategic approaches that could be followed to decolonize an undergraduate chemistry curriculum.



KEYWORDS: *Curriculum, Inclusive Teaching, Minorities in Chemistry, Women in Chemistry, Inclusive Teaching, Cultural Relevance*

■ INTRODUCTION

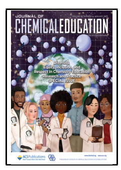
The Department of Chemistry at the University of York in the UK has an international reputation as a pioneer for gender equality, having gained four prestigious Athena Swan Gold awards since 2007.[1−3] (A summary of the demographics of the department can be found here.[4]) In early 2019, members of the department began work to decolonize its undergraduate curriculum. In this commentary, we share our thoughts on what it can mean to decolonize a chemistry curriculum, describe how we've begun this process, and reflect on why this was an important thing to do. We emphasize that, in writing this commentary, we hope to start a more open dialogue on how best to decolonize chemistry and stimulate widespread activity within our academic community toward this goal.

In the broadest sense, decolonization involves identifying colonial systems, structures, and relationships, and working to challenge them. For the field of science, it suggests that we should question our understanding of science as something that grew solely from the discoveries of a series of famous, western individuals. Instead, we should recognize that there are colonial roots in science that can arise from both commerce and imperialism. The aim of "decolonizing the sciences" is therefore to develop a more complete scientific perspective that better includes global voices.

This is not a purely historic exercise, however. Although formal colonial structures have largely been consigned to history, there remains very significant inequality on a global scale, some of it structurally embedded as a result of colonization.[5] The problems and concerns of wealthier nations are often very different from those in the developing world, as are the resources available to solve them. Funding disparities mean that scientists and politicians in wealthier nations predominantly make decisions about which societal problems should be addressed and control the scientific narrative. This can leave significant parts of the globe disenfranchised in terms of access to science in order to solve its problems. It is therefore a matter of urgency that scientists are educated with a truly global perspective, that reflects on historical biases and inequalities that are hard-wired into science and society.

For a practicing science department, it was important for us from the outset to recognize that decolonization should not just be about consideration of the curriculum itself, and aspects such as the inclusion of academic work from global cultures in our undergraduate course work. Decolonization should also provide a focus for us to think more generally about how we teach and assess, and it should allow for the possibility of a culture shift that provides a space for different views and ways of studying. While acknowledging this broader educational aspiration, we focus

Special Issue: Diversity, Equity, Inclusion, and Respect in Chemistry Education Research and Practice



Received: April 12, 2021
Revised: September 21, 2021
Published: October 18, 2021

here on describing our initial work which is aimed at starting to decolonize our curriculum.

WHY DID WE DECIDE TO START DECOLONIZING OUR UNDERGRADUATE CHEMISTRY CURRICULUM?

So why did we decide to do this? The project began at the outset because a group of our undergraduate students asked us think about it. As in most universities, there were already active discussions at York around decolonizing curricula, which were being coordinated centrally by the student union group. These spread into our department via our student representatives. Following initial discussions, the message from our students was clear: Decolonizing the curriculum was something that we should be doing, and something that they strongly wanted us to do.

We were also motivated to embark on this work by the growing body of evidence that reflects the fact that not all students are having equivalent higher educational experiences. In the UK, there is a 16.1% attainment gap between the number of high-quality degrees (1st or 2:1) awarded to White UK-domiciled students compared to UK-domiciled students from ethnic minority groups.[6] Furthermore, 42% of Black UK students say that the curriculum does not reflect issues of diversity, equality, and discrimination. Ultimately, this contributes to underrepresentation of ethnic minorities in chemistry,[7] with a Royal Society of Chemistry study showing that the proportion of chemistry students from minoritized ethnic groups falls from 26% at the undergraduate level, to 14% at the postgraduate level.[8] This problem was particularly marked for Black chemists; indeed, by the professorship level, there were too few Black chemistry professors in the UK for the data even to be reported.[9] Beyond ethnic minorities, problems persist for other underrepresented groups in chemistry, including, for example, women and trans individuals.[5] We note that similar problems are acknowledged to exist in the USA.[10,11] As a department that welcomes students from all backgrounds and countries, we strongly believe that our courses should not disadvantage any student because of their background or characteristics, and we have an ongoing commitment to ensuring that all of our students should have equal opportunities to thrive.

Universities UK published a key report in 2019 on closing the attainment gap.[12] The report made a strong case that campuses need to become "racially diverse and inclusive environments" if students from ethnic minorities are to succeed academically. When students from these ethnic groups were surveyed for the review, they reported that they did not feel a "sense of belonging" at university. The report made clear that decolonization should apply as much to science as it does to arts and humanities. Taken together, the views of our students, and the broader recognition that decolonizing the curriculum could play a role in addressing racial inequalities in university education, provided a compelling impetus to begin the project.

WHAT HAVE WE DONE TO START DECOLONIZING OUR UNDERGRADUATE CHEMISTRY CURRICULUM?

The first formal step of our decolonizing project was to form a steering group. This group was open to all staff and students who were interested in decolonization and was advertised widely before its first meeting. (The group has a fluxional membership, with meetings typically attended by 5 members of academic staff and 8−10 students.) At its first session, terms of reference for the group were agreed to, and an initial discussion took place around what decolonizing could mean for our Department. The group agreed that, over the medium term, decolonizing should be a broader department-wide activity, and should not solely be a revision of the undergraduate curriculum, although this would be the initial focus. It was agreed that the first action of the group should be to communicate with the department about decolonizing chemistry and explain why we believe that this was an important action for the department to undertake.

Communication is essential at the outset of a decolonizing project. Although decolonizing is commonly discussed in EDI (equality, diversity, and inclusion) arenas, knowledge of it among science academics is likely to be sparse and potentially controversial.[13] There is a belief among some scientists that to decolonize STEM would involve removing the teaching of well-established parts of science or somehow "dumbing-down" the curriculum. Furthermore, some scientists feel that because science teaches "objective truth", well-established "discoveries", and "facts", it does not suffer from colonial influences and attitudes, and that such a treatment is unnecessary. We encountered such objections early in the project in our own department, despite EDI being well-established and widely accepted. As we will outline below, the view of science as "objective" and "factual" is a simplistic one, which fails to recognize the way in which science developed, the environment in which scientists work, and the societal contexts in which science continues to this day. It is therefore essential to communicate clearly about the aims, objectives, and strategies of efforts to decolonize the sciences.

We communicated with our staff and students through a number of different channels including an article in the departmental monthly newsletter,[14] brief items in the staff and student weekly bulletins, oral presentations at staff meetings, and shout-outs at the start of undergraduate lectures. All of these communications ended with an invitation to individuals to get involved. In this way, the project was owned by the whole department from the outset. As with any EDI activity, the support of senior leaders was essential for the project to be seen positively by the department. The EDI-lead led the communication efforts, the head of department provided open support for the project in a number of forums, and several senior academics acted as vocal allies for the project in staff meetings where decolonization was discussed.

As the project developed, we decided to group together our decolonization work with efforts to diversify the curriculum. This encompasses expanding the curriculum to be inclusive and intersectional, for example, by including the scientific work of individuals from a broad range of underrepresented backgrounds. We decided to work to include both strands of activity together, since this approach would be the most inclusive.

These are the initial activities we conducted to start decolonizing the University of York chemistry curriculum:

- Fact finding and gathering of best practice on what decolonizing a curriculum means for a science department.
- Collection of examples of good practice from current lecture courses delivered in our department, compiled into a document, and circulated to all academic staff with encouragement to consider refreshing lecture courses using similar examples.

https://doi.org/10.1021/acs.jchemed.1c00397
J. Chem. Educ. 2022, 99, 5−9

- Compilation of a set of examples highlighting the work of Black chemists, circulated to academics to provide further examples for incorporating in lecture material.
- Compilation of a resource on internationally recognized scientists from the Indian continent by Professor Dame Pratibha Gai that was shared with the department.
- Commissioning of a set of photographic images to be displayed in the department, highlighting the work of historic global chemists.
- Black History month celebrated by activities open to all students and staff.
- Departmental culture survey conducted of our undergraduate students, with results analyzed by ethnicity, leading to an action plan for greater inclusion.

Some specific examples of global chemistry that have emerged through this exercise were the codification of early knowledge of papyrus produced by the ancient Egyptians,[15] which is discussed in a course on colloid chemistry that covered applications of micelles and gels in, for example, cleaning and lubrication. In a medicinal chemistry course, a global approach to the history of medicine is taken,[16] highlighting contributions from Ancient China, India, the Arab world, and indigenous aboriginal cultures.

The work of individual nonwestern chemists is also covered in several teaching activities, for example, the Chinese scientist Tu Youyou, who was the first scientist working in China to receive the Nobel Prize. Her work developing the antimalarial drug artemisinin fused knowledge of traditional Chinese medicine with modern approaches to pharmaceutical drug discovery.[17] Importantly, this work is featured in a year 1, semester 1 module, with the goal of demonstrating how knowledge drawn from diverse sources can lead to significant breakthroughs. In biological chemistry, the work of Punjab-born biochemist Har Gobind Khorana in decoding the genetic code is highlighted.[18] A green chemistry module highlights the work of George Washington Carver, who, having originally been born into slavery, became the most prominent Black scientist of the early 20th century.[19] His development of agricultural chemistry, and role as a champion of environmentally sound methods of production, is used as an exemplification of sustainable development.

In a third-year module teaching supramolecular chemistry, the work of Sri Lankan-born scientist A. P. de Silva in developing sensors for blood chemistry is presented.[20] Notably, these sensors have been of particular relevance in low-income countries, where their low cost, and easy fabrication into simple devices, has seen them incorporated into point-of-care devices in ambulances. This therefore encourages students to think about the different contexts in which science can be applied, and to reflect that specific chemistries may be needed to solve problems in the developing world. In this way, an awareness of global context and needs can change the very nature of science itself. Other areas of teaching in the department that are particularly well-suited to this globalized approach are atmospheric science and green and sustainable chemistry. Indeed, our work on decolonization is a step toward a fairer society for all through the provision of high-quality education as it directly connects with the United Nations Sustainable Development Goals, in particular Quality Education (SDG 4), Reduced Inequalities (SDG 10), and Partnerships for the Goals (SDG 17).

■ IS IT POSSIBLE TO TAKE A STRATEGIC APPROACH TO DECOLONIZING CHEMISTRY?

One of the points to arise from our reflections on the decolonization work we've conducted to date is that there are a number of different approaches that could be taken to group together examples for use in teaching material, and this goes significantly beyond a simple historic view of decolonizing the history of science.

- *Impacts of Chemistry in Different Global Contexts*. Applications of chemistry can depend on where they are applied. Understanding the diversity of global contexts better equips students to innovate in ways which will benefit different people across the world.
- *Diverse Histories of Chemistry and Science*. The history of science is often taught in a simple linear way, focused on European and North American experiences. It is important to accurately present the different global thoughts and influences that have contributed to scientific development. This can engage the interest of all students and also produce graduates with a degree of literacy in science history.
- *Role Model Scientists from Different Backgrounds and Cultures*. The importance of role models is well-established in STEM:[21] Inclusion of such role models, either as educators or examples, can foster a sense of belonging among minoritized groups and encourage them to see that they too can achieve success.
- *Science as a Global Endeavor*. In much science education, there is a focus on the "inventor" as a "lone genius", well-known to be somewhat of a myth. There is a vital need to reflect on the importance of teamwork, and the global nature of science, both in terms of the diversity of teams, and the collaborative nature of modern science across borders. This can be partly taught through teamwork exercises, for example in teaching laboratories.
- *Ethical Considerations of Applying Science in a Global Society*. The needs of different parts of the world are very different, yet science and its applications are still largely chosen by scientists and politicians in the wealthier nations. There is increasing focus on global development from some funding agencies. We need a next generation of scientists who are able to think globally about how their science can be applied, ensuring that as many people as possible can benefit from breakthrough technologies and allowing science to target truly global development. This is often in tension with political desires, in which wealthy nations want to maintain their own positions of strength; good scientists need to be aware of these tensions. Such issues, as well as being explored in lectures when applications of chemistry are discussed, can also readily be incorporated into courses on scientific ethics.
- *Structures and Hierarchies in Science*. Structures and hierarchies in science exist and often operate against minoritized groups.[22] We need to educate the next generation of scientists to be inclusive and equitable in their approach. The value of listening to diverse voices should be emphasized. This can be fostered through teaching students about "Being a Professional Chemist" and through group exercises.
- *Student Voice and Leadership*. Our own student body has played a key role in encouraging us to start the decolonization process. It is essential that the student

https://doi.org/10.1021/acs.jchemed.1c00397
J. Chem. Educ. 2022, 99, 5−9

voice is heard and fostered. This can be achieved academically and pastorally. For example, in a year 1 course on polymer chemistry, students in York make YouTube videos on topics that matter to them, in their day-to-day context.[23] These videos then go on to influence others around the world. This challenges traditional structures and hierarchies in science and also centers the voice and concerns of the individual students, many of whom are from minoritized groups. In our Green Chemistry & Sustainable Industrial Technology Masters program, the internationally diverse cohort of students celebrated "World Earth Day" by listening to one another talk about their own lived experiences, and the need to work collectively in order to solve global environmental issues.

It is important to note that, in taking an approach to decolonization, we are in no way advocating that chemistry departments should de-emphasize the key principles and theories of science; obviously, these are vital. The scientific theories are not "wrong". However, we are encouraging educators to reflect critically on the context in which they teach these principles, and the applications with which they choose to exemplify them. We suggest that where it is possible to present a meaningful global view with diverse influences and applications, and reflect on ethics, structures, and hierarchies, alongside the science, then this opportunity should be taken.

Our approach to decolonization impacts on all aspects of EDI, as it also applies to other minoritized groups such as women, LGBT+ communities, or those with disabilities, many of whom have historically been overlooked both in the history of science, and also in the way that modern science seeks to apply its knowledge and methodology to solving world problems. By keeping a checklist of where such "decolonization" and inclusion of diverse viewpoints are happening in their degrees, chemistry departments can ensure balance in their teaching and also target areas for enhanced coverage.

SUMMARY

We share this account of our decolonizing the curriculum work very much aware that we have started a project that is certainly not yet finished. Our steering group will move to discussing how to monitor progress (e.g., through course audits, student feedback, focus groups), and how we can continue to challenge all our academics to revise and broaden the examples they use in their teaching year on year. We are actively working toward decolonizing our student experience in other ways, including carrying out a major study funded by the Royal Society of Chemistry on the lived experience of our ethnic minority students.[24]

We have demonstrated that a decolonized curriculum can be embraced as part of an inclusive and supportive undergraduate environment. Student campaigners have been lobbying for this change for years, and advocating for more representative and supportive curricula to improve the trajectories of marginalized groups through the academic pipeline. We hope that by sharing our progress at this point, we can inspire greater momentum toward a vibrant decolonized and diversified curriculum across the international chemistry community.

AUTHOR INFORMATION

Corresponding Authors

Caroline E. H. Dessent − *Department of Chemistry, University of York, Heslington, York YO10 5DD, United Kingdom*; orcid.org/0000-0003-4944-0413; Email: caroline.dessent@york.ac.uk

David K. Smith − *Department of Chemistry, University of York, Heslington, York YO10 5DD, United Kingdom*; orcid.org/0000-0002-9881-2714; Email: david.smith@york.ac.uk

Authors

Ruhee A. Dawood − *Department of Chemistry, University of York, Heslington, York YO10 5DD, United Kingdom*; orcid.org/0000-0003-0292-4883

Leonie C. Jones − *Department of Chemistry, University of York, Heslington, York YO10 5DD, United Kingdom*; orcid.org/0000-0003-0950-5075

Avtar S. Matharu − *Department of Chemistry, University of York, Heslington, York YO10 5DD, United Kingdom*; orcid.org/0000-0002-9488-565X

Kelechi O. Uleanya − *Department of Chemistry, University of York, Heslington, York YO10 5DD, United Kingdom*; orcid.org/0000-0003-2017-1360

Complete contact information is available at:
https://pubs.acs.org/10.1021/acs.jchemed.1c00397

Notes

The authors declare no competing financial interest.

ACKNOWLEDGMENTS

We thank all the members of the Department of Chemistry's "Decolonizing and Diversifying the Curriculum" Steering Group for their contributions to the project. We also thank Dr. Derek Wann and Professor Duncan Bruce for their strong support of the project, and Jess Penn and Jan Ball-Smith of the University of York's Inclusive Learning Team for useful discussions. Finally, we acknowledge financial support from the Royal Society of Chemistry's Inclusion and Diversity Fund (ref 147622640) to further our work to decolonize and diversify our department.

REFERENCES

(1) Phipps, A. *Women in Science, Engineering, and Technology: UK Initiatives from the 1970s to the 2000s*; Trentham Books: Stoke, 2008.

(2) Equality Challenge Unit Athena SWAN Charter. https://www.advance-he.ac.uk/equality-charters/athena-swan-charter (accessed 2021-09-18).

(3) Barnard, S., The Athena SWAN Charter: promoting commitment to gender equality in higher education institutions in the UK. In *Gendered Success in Higher Education: Global Perspectives*; White, K., O'Connor, P., Eds. Palgrave Macmillan: London, 2017; pp 155−174.

(4) Department of Chemistry, University of York. Athena SWAN Department Application, Gold Award, November 2018. https://www.york.ac.uk/media/research/documents/athenaswan/York-Chemistry-Gold%202018%20for%20publication.pdf (accessed 2021-09-18).

(5) Roy, R. D. Decolonise science − time to end another imperial era. https://theconversation.com/decolonise-science-time-to-end-another-imperial-era-89189 (accessed 2021-09-18).

(6) National Union of Students, Race for Equality: a report on the experiences of Black students in further and higher education, 2011. https://www.nusconnect.org.uk/resources/race-for-equality-a-report-on-the-experiences-of-black-students-in-further-and-higher-education-2011 (accessed 2021-09-18).

(7) Menon, B. R. K. The missing colours of chemistry. *Nat. Chem.* **2021**, *13* (2), 101−106.

(8) Royal Society of Chemistry. Diversity Landscape of the Chemical Sciences: A Report by the Royal Society of Chemistry. https://www.rsc.org/globalassets/02-about-us/our-strategy/inclusion-diversity/cm-044-17_a4-diversity-landscape-of-the-chemical-sciences-report_web-2.pdf (accessed 2021-09-18).
(9) Krämer, K. UK chemistry pipeline loses almost all of its Black, Asian and other ethnic minority chemists after undergraduate studies. *Chemistry World*; 2020. https://www.chemistryworld.com/news/uk-chemistry-pipeline-loses-almost-all-of-its-black-asian-and-other-ethnic-minority-chemists-after-undergraduate-studies/4012258.article (accessed 2021-09-18).
(10) National Academy of Sciences, National Academy of Engineering, Institute of Medicine and Committee on Underrepresented Groups the Expansion of the Science Engineering Workforce Pipeline. *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*; The National Academies Press: Washington, DC, 2011; DOI: 10.17226/12984.
(11) Sanford, M. S. Equity and Inclusion in the Chemical Sciences Requires Actions not Just Words. *J. Am. Chem. Soc.* **2020**, *142* (26), 11317−11318.
(12) Universities acting to close BAME student attainment gap. https://www.universitiesuk.ac.uk/news/Pages/Universities-acting-to-close-BAME-student-attainment-gap.aspx (accessed 2021-09-18).
(13) Karodia, N. Weaving people and history into STEM education. https://www.advance-he.ac.uk/news-and-views/Weaving-people-and-history-into-STEM-education (accessed 2021-09-18).
(14) Dessent, C. Why is EDG trying to motivate the Department to decolonise its undergraduate curriculum?. https://www.york.ac.uk/media/chemistry/news/chemistryupdate/June%202020.pdf (accessed 2021-09-18).
(15) Bierbrier, M. L. *Papyrus: Structure and Usage*; British Museum Press: London, 1986; Vol. *60*.
(16) *Encyclopaedia of the History of Science, Technology and Medicine in Non-Western Cultures*, 3rd ed.; Springer: Netherlands, 2016.
(17) The Nobel Prize. Women Who Changed Science: Tu Youyou (Nobel Prize in Physiology or Medicine in 2015). https://www.nobelprize.org/womenwhochangedscience/stories/tu-youyou (accessed 2021-09-18).
(18) Sakmar, T. P. Har Gobind Khorana (1922−2011): Pioneering Spirit. *PLoS Biol.* **2012**, *10* (2), e1001273.
(19) American Chemical Society National Historic Chemical Landmarks. George Washington Carver: Chemist, Teacher, Symbol. https://www.acs.org/content/acs/en/education/whatischemistry/landmarks/carver.html (accessed 2021-09-18).
(20) de Silva, A. P. https://impact.ref.ac.uk/casestudies/CaseStudy.aspx?Id=38360 (accessed 2021-09-18).
(21) Kricorian, K.; Seu, M.; Lopez, D.; Ureta, E.; Equils, O. Factors influencing participation of underrepresented students in STEM fields: matched mentors and mindsets. *International Journal of STEM Education* **2020**, *7* (1), 16.
(22) Wilson-Kennedy, Z. S.; Payton-Stewart, F.; Winfield, L. L. Toward Intentional Diversity, Equity, and Respect in Chemistry Research and Practice. *J. Chem. Educ.* **2020**, *97* (8), 2041−2044.
(23) Smith, D. K. iTube, YouTube, WeTube: Social Media Videos in Chemistry Education and Outreach. *J. Chem. Educ.* **2014**, *91* (10), 1594−1599.
(24) Jones, L.; McWhinnie, S.; Dessent, C. Surveying the lived experiences of BAME chemistry students and staff. *White Rose Research Online*; 2020. https://eprints.whiterose.ac.uk/168994/1/Surveying%20the%20lived%20experiences%20of%20BAME%20chemistry%20students.pdf (accessed 2021-09-18).

https://doi.org/10.1021/acs.jchemed.1c00397
J. Chem. Educ. 2022, 99, 5−9