Editorial: Sustainable Chemistry and Education

Outi Haatainen, Emmi Vuorio and Johannes Pernaa

The Unit of Chemistry Teacher Education, Department of Chemistry,
Faculty of Science, University of Helsinki, Finland

In the face of rapid societal and cultural changes influenced by the global challenges related to sustainability, the concept of sustainable transition has become paramount. The sustainability transition involves swift transformations that impact our economy, society, culture, and every individual, aiming to secure the resilience of our environment. Each of us is a participant in this transition. Understanding the interdependence between humans and nature, and how we, as members of society, can influence and support sustainability within the constraints of natural systems, requires research-based knowledge, sustainability skills, and the courage to experiment and make an impact. These elements are integral in education for sustainability (e.g. Burmeister et al., 2012; Cotton & Winter, 2010; Vuorio et al., 2024) that has understandably been incorporated in curricula across the world. Therefore, educational sector is a powerful change agent in promoting sustainability skills throughout the world.

This special issue addresses this important topic from the specifics of chemistry education. Chemistry educational scientific discussion on the topic is important because chemistry has a key role in solving all wicked sustainability challenges. LUMAT special issue “Sustainable Chemistry and Education” delivers up-to-date information of the latest research conducted on the field.

Defining sustainability in chemistry education

Integrating sustainability into education is a comprehensive goal (Burmeister et al., 2012; Sterling, 2004). Sustainability content in chemistry education is described as encompassing green chemistry and the integration of socio-scientific issues. In sustainable chemistry, a broader perspective is required than merely designing chemicals to be benign for users and the environment. As Horváth (2018) emphasized in his editorial, not all green chemistry is sustainable, nor is all sustainable chemistry green. A key element of sustainability is to use raw materials and generate waste at a slower rate than they are consumed and produced. Anastas, one of the founders of Green Chemistry, along with his colleague Zimmerman, has also stressed the importance of understanding the complex interconnections and contexts in which chemistry is practiced and its products are used (Anastas & Zimmerman, 2018).

LUMAT Vol 12 No 2 (2024), i. https://doi.org/10.31129/LUMAT.12.2.2495
Received 3 October 2024 / Accepted 3 October 2024 / Published 3 October 2024
Published by the University of Helsinki, Finland and LUMA Centre Finland.

In addition to these content areas, acting as a responsible citizen requires specific skills and attitudes. According to Burmeister et al. (2012), important skills to be learned include interdisciplinarity, critical thinking, problem-solving abilities, and engagement. One framework for the necessary knowledge, skills and attitudes for sustainability is sustainability competencies (e.g. Jegstad & Sinnes, 2015; Wiek et al., 2011). Furthermore, the teaching must incorporate diverse pedagogical methods that support the development of these skills (Cotton & Winter, 2010; Lozano et al., 2017). While significant progress has been made in this area, the journey is ongoing.

This special issue addresses the challenges of chemistry education for sustainability through three international research articles that focus on teacher education and provide tools for teaching chemistry for sustainability.

Teachers play a crucial role in delivering quality sustainability education. In this special issue the article by Cabello et al. (2024), investigates Chilean preservice science teachers' perceptions regarding teaching sustainable citizenship, specifically focusing on the climate crisis and earthquakes-tsunamis. The study highlights the importance of supporting teachers' professional competence in teaching interdisciplinary socio-scientific issues. The team designed a podcast series, which the participating preservice teachers found to be a valuable new epistemic and pedagogical resource that can support their efforts to teach sustainable citizenship and implement pedagogical strategies.

The two other articles focus on student learning and providing teachers a tool for sustainable chemistry education. First, Danckwardt-Lilliestöm et al. (2024) describe process drama as a tool for enabling student engagement with wicked problems in upper secondary chemistry education. Process drama allows students and teachers to explore wicked problems, such as plastic pollution and plastic use, from multiple perspectives, including scientific knowledge, values, and societal and social science viewpoints. The second article by Prayitno et al. (2024) focus on training students to develop their competencies through chemoentrepreneurship-based chemistry learning, where chemistry is learned through projects in product manufacturing and marketing. Results with Indonesian students indicate this learning method is especially promising in supporting students' vocational competencies.

Conclusion

As we navigate the sustainability transition, the role of education, particularly in the natural sciences, becomes ever more critical. By integrating sustainable chemistry and education for sustainability into our curricula, we can equip future generations with the tools they need to address the complex challenges of our time. This special edition of our research journal aims to contribute to this vital endeavor by providing insights and practical tools for chemistry educators worldwide.

References

Anastas, P. T., & Zimmerman, J. B. (2018). The United Nations sustainability goals: How can sustainable chemistry contribute? *Reuse and Recycling / UN SGDs: How Can Sustainable Chemistry Contribute? / Green Chemistry in Education*, *13*, 150–153. https://doi.org/10.1016/j.cogsc.2018.04.017

Burmeister, M., Rauch, F., & Eilks, I. (2012). Education for Sustainable Development (ESD) and chemistry education. *Chemistry Education Research and Practice*, *13*(2), 59–68. https://doi.org/10.1039/C1RP90060A

Cotton, D., & Winter, J. (2010). 'It's Not Just Bits of Paper and Light Bulbs': A Review of Sustainability Pedagogies and Their Potential for Use in Higher Education. In D. Selby, S. Sterling, & P. Jones, *Sustainability education: Perspectives and practice across higher education* (pp. 39–45). London : Earthscan 2010.

Horváth, I. T. (2018). Introduction: Sustainable Chemistry. *Chemical Reviews*, *118*(2), 369–371. https://doi.org/10.1021/acs.chemrev.7b00721

Jegstad, K. M., & Sinnes, A. T. (2015). Chemistry Teaching for the Future: A model for secondary chemistry education for sustainable development. *International Journal of Science Education*, *37*(4), 655–683. https://doi.org/10.1080/09500693.2014.1003988

Lozano, R., Merrill, M. Y., Sammalisto, K., Ceulemans, K., & Lozano, F. J. (2017). Connecting competences and pedagogical approaches for sustainable development in higher education: A literature review and framework proposal. *Sustainability*, *9*(10), 1889. https://doi.org/10.3390/su9101889

Sterling, S. (2004). An Analysis of the Development of Sustainability Education Internationally: Evolution, Interpretation and Transformative Potential. In J. Blewitt & C. Cullingford, *The sustainability curriculum: The challenge for higher education* (pp. 43–60). Earthscan. http://site.ebrary.com/id/10128892

Vuorio, E., Pernaa, J., & Aksela, M. (2024). Lessons for Sustainable Science Education: A Study on Chemists' Use of Systems Thinking across Ecological, Economic, and Social Domains. *Education Sciences*, *14*(7), Article 7. https://doi.org/10.3390/educsci14070741

Wiek, A., Withycombe, L., & Redman, C. L. (2011). Key competencies in sustainability: A reference framework for academic program development. *Sustainability Science*, *6*(2), 203–218. https://doi.org/10.1007/s11625-011-0132-6